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IIM
SAMBALPUR

INTERNATIONAL MANAGEMENT PERSPECTIVE CONFERENCE (IMPeC-25)

Digitalization, Entrepreneurship, and Sustainability

VOLUME - II

Dates: January 30 - February 1, 2025

Editors
Prof. Mahadeo Jaiswal
Prof. Saumyaranjan Sahoo
Prof. Padmavathy Dhillon

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Message from the Director

Keeping in line with the vision of Viksit Bharat@2047: Transforming the Nation's Future, the Indian Institute of Management Sambalpur is proud to organize its Annual Flagship Conference, International Management Perspective Conference (IMPeC) 2025. This year, the conference emphasizes the transformative themes of Digitalization, Entrepreneurship, and Sustainability, which are pivotal for shaping the future of management and societal progress.

IMPeC 2025 is designed to unite a diverse array of participants—academicians, practitioners, policymakers, scholars, and students—from various management-related domains. The conference serves as a dynamic platform for knowledge sharing, fostering research collaborations, enhancing institutional pedagogy, and disseminating global business best practices. Through its vibrant sessions, thought-provoking discussions, and engaging activities, we aim to inspire participants and spark potential interdisciplinary and linear collaborations that drive impactful change.

In today's rapidly evolving landscape, three key drivers—Digitization, Decarbonization, and Democratization—are reshaping industries and societies, including the startup ecosystem. Digitization leverages cutting-edge technologies such as AI and blockchain to streamline operations and enable data-driven decision-making, although it brings challenges like cybersecurity. Decarbonization pushes for sustainable practices and green technology adoption to combat climate change, balancing economic opportunities with regulatory demands. Democratization, meanwhile, empowers individuals and smaller entities through access to technology and knowledge, fostering innovation and competition but raising concerns about data integrity. These drivers are interconnected; digitization fuels democratization, and decarbonization benefits from digital advancements. Addressing these complexities requires a holistic approach that blends technology, ethics, and innovation. IMPeC 2025 aims to delve deeply into these critical themes and explore innovative strategies and solutions to shape a sustainable and interconnected future.

Central to the conference agenda is the theme of entrepreneurship focusing on unleashing the potential of forward-thinking ventures to drive progress and prosperity. Additionally, the conference will highlight sustainability, showcasing how cutting-edge technologies and innovative practices can foster sustainable growth and development. By facilitating collaboration and knowledge exchange among diverse stakeholders, this conference seeks to inspire policies, strategies, and initiatives that tackle societal challenges while leveraging opportunities in a digitally connected world.

Ultimately, IMPeC 2025 aspires to shape a brighter future rooted in inclusivity, sustainability, and progress. Through shared expertise and innovative thinking, we aim to pave the way for a more equitable, resilient, and prosperous world. Your active participation in this transformative event will be instrumental in forging a better tomorrow for our interconnected global community.

Warm regards,

Prof Mahadeo Jaiswal
Director
Indian Institute of Management Sambalpur

PREFACE

We are pleased to present the proceedings of the International Management Perspective Conference (IMPeC) 2025, held on January 30 to February 1, 2025, at the Indian Institute of Management, Sambalpur.

The theme of the conference was dedicated to exploring the transformative themes of **Digitalization, Entrepreneurship, and Sustainability**. These interconnected domains represent the driving forces shaping the future of global business, governance, and society. As the world embraces digital innovation, seeks sustainable solutions, and champions entrepreneurial spirit, this conference has sought to provide a platform for fostering meaningful dialogue, sharing innovative practices, and advancing scholarly and practical knowledge.

Digitalization continues to redefine how organizations operate, creating opportunities for efficiency, innovation, and connectivity. Entrepreneurship fuels economic growth and resilience, serving as a cornerstone for creativity and problem-solving. Sustainability, now an imperative rather than an option, challenges us to reimagine development through responsible resource use, inclusive practices, and a long-term vision. Together, these themes form the foundation of IMPeC 2025, providing insights into navigating complex challenges and opportunities in a rapidly changing global landscape.

This two-volume compilation reflects the conference's focus on these transformative themes. **Volume I** highlights diverse research and ideas on **Sustainability**, addressing critical issues such as sustainable business models, green innovation, and the role of organizations in fostering environmental stewardship. **Volume II** presents cutting-edge contributions on **Digitalization and Entrepreneurship**, exploring topics like digital transformation strategies, entrepreneurial ecosystems, and the intersection of technology with business and society. All papers included in this collection underwent a rigorous peer-review process to ensure academic and practical relevance, showcasing innovative methodologies and emerging trends in these fields.

The event featured dynamic technical sessions, expert keynote addresses, panel discussions, and interactive workshops that encouraged deep exploration of these themes. Through collaborative discussions, participants exchanged perspectives and cultivated ideas aimed at addressing pressing global issues and advancing management practices.

We extend our heartfelt gratitude to the contributors for their exceptional research and insights, which have enriched these proceedings. We also express our appreciation to the reviewers and program committee for their diligence in upholding the quality of this publication. The success of IMPeC 2025 was made possible by the commitment of the organizing team, sponsors, and volunteers, as well as the active participation of attendees who engaged in thoughtful dialogue and meaningful collaboration.

We hope that the ideas and perspectives presented in these proceedings will inspire further research, innovation, and action in the domains of **Digitalization, Entrepreneurship, and Sustainability**, contributing to a more equitable, innovative, and sustainable future.

Sincerely,
The Editors

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TRACK 1: MARKETING PRACTICE AND RESEARCH

1

Impact of Storytelling on Consumer Behaviour

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ABSTRACT

This research paper explores the impact of storytelling as a strategic marketing tool, focusing on its ability to influence consumer behavior, enhance brand loyalty, and drive purchase decisions in the context of today's digital era. Utilizing Zaltman Meatphor Elicitation Technique, the research delves into the subconscious perceptions and emo- tional associations that shapes a brand identity. The popular nutritional brand, BournVi- ta, has been chosen for the same. Through a multi-phase process involving visual meta- phors, in-depth interviews, and sensory analysis, the study uncovers themes such as nostalgia, warmth, accomplishment, and emotional connection, which underpin BournVita's brand identity. The findings reveal that storytelling enhances brand recall and creates strong emotional bonds, positioning the product as both a comforting ritual and an aspirational companion in personal growth. Digital storytelling, amplified through social media, user-generated content, and sensory-focused campaigns, is identi- fied as a potent strategy to connect with consumers. The research concludes that story- telling is more than a branding tactic; it is a transformative tool that bridges emotional and cognitive consumer needs, fostering deeper relationships and ensuring brand rele- vance in competitive markets. While the findings are contextually rooted in the Indian market, they offer a blueprint for leveraging storytelling to resonate with diverse audi- ences globally. This study underscores the enduring power of storytelling in shaping consumer perceptions and driving brand success.

Keywords Storytelling, Consumer Behaviour, Brand Loyalty, Purchase Intention, ZMET, Sensory and Emotional Appeal, Brand Perception, Brand Extension, Marketing Strategy, Brand Recall, Brand Advocacy, Digital Storytelling, Digital Media, Brand Identity, Digital brand narratives.

1. INTRODUCTION

Stories have a powerful effect on the human brain. When we listen to stories, our brains release oxytocin, a hormone that promotes feelings of trust and bonding. Stories can also activate the parts of the brain associated with empathy and imagination. This allows consumers to connect with the characters in a story and see themselves in the brand's narrative. Storytelling has be- come a source of human connection, an important force in marketing and advertising.

Storytelling weaves narratives that resonate deeply with consumers, allowing brands to forge emotional bonds with their audience. This approach transcends traditional advertising and el- evates brands from just showcasing their functional needs to becoming relatable memorable characters with depth having compelling journeys.

According to Forbes, 80% of consumers are more likely to buy a product or service from a company that tells a good story. By crafting narratives that show emotions like empathy, aspi- rations, nostalgia, joy etc done through sharing of human experiences, brands can position themselves as an integral part of the consumers' lives (moving beyond product-centric mes- saging). Such a connection makes the consumers invested in the brand's story and its evolu- tion – creating a high chance of increasing loyalty and advocacy.

In an era of information overload, memorable stories have become a must have, especially for new brands to create an imprint on the consumer's mind – thereby building brand recognition and driving purchase decisions. According to Sprout Social, 72% of the consumers say that they would share a positive brand story with friends and family. This shows that storytelling increases the probability of spreading awareness through word-of-mouth (which is the most trusted source of information by most consumers).

There are many different types of brand storytelling that brands can use to address the customers. The most used are aspirational stories where the stories depict the lifestyle that the brand repre- sents and cause-related stories where the brands highlight their commitment towards a social cause, environmental cause, improving the lives of the consumer. Further, customer storiesthat showcase real customers using and the loving the brand's product or service (like Dove) and brand origin stories that showcase the history and founding of the brand (like Bare Essentials) are also some ways to build an image about the brand and make consumers associate a particular quality (for example here sincerity and trust) with the brand.

Storytelling has now evolved as a strategic tool that enables brands in this digital age to create personalized and interactive experiences. With the proliferation of digital platforms, brands can leverage data-driven insights to craft narratives tailored to specific audience segments, enhancing relevance and emotional engagement. Digital tools such as social media, influencer marketing, and user-generated content, amplify the reach and impact of brand stories,

fostering a sense of community and shared values among customers..

Storytelling influences the behaviors of the consumers. This can be advantageous for the brands in the following ways: first and foremost, it increases brand awareness and recall as stories are more memorable than traditional advertising messages. Secondly, it enhances the brand image and reputation as a positive emotional association is created with the brand. Thirdly, it also strengthens brand loyalty by fostering a sense of connection and association. Finally, it per- suadesthe consumer to experience something new and thus increases the purchase intention.

Brands can leverage storytelling to create a competitive advantage. This can be done in the following manner:

Develop a compelling brand narrative: What is the story of your brand? What are your brand values? How can you communicate this story in a way that resonates with your target audience.

Use a variety of storytelling formats: Stories can be told through text, video, images, and even social media posts.

Be authentic: Consumers can spot inauthentic stories a mile away. Make sure your stories are genuine and reflect the true values of your brand.

Focus on the emotional connection: The most effective stories are those that evoke emotions in consumers.

Measure the results: Track the impact of your storytelling efforts to see what is working and what is not.

Further, technologies like augmented reality and virtual reality provide immersive storytell- ing provide immersive storytelling opportunities, allowing consumers to engage with a brand's journey in innovative ways. This integration of technology and storytelling not only strengthens brand recognition but also builds deeper, more lasting consumer relationships, essential for sustained success in the digital era.

Essentially, in marketing - storytelling is an art that creates meaningful connections, builds trust, and ultimately cultivates brand advocates. It is a strategic approach that transcends mere promo- tion by positioning brands as cultural beacons to inspire lifelong relationships with consumers. Thus, the ability to evoke empathy, inspiration, and entertainment, stories deeply resonate with the consumers making brands more memorable and relatable.

2. LITERATURE REVIEW

Stories are a fundamental part of human communication. They have the power to transport us, engage us, and shape our perceptions of the world around us. Brands have long recognized the power of storytelling, using narratives to connect with consumers on an emotional level and build brand loyalty. The impact of storytelling on consumer behaviors, purchase decisions, and loyalty has been explored using the different types of brand storytelling, the psychological mechanisms underlying its effectiveness, and how brands can leverage storytelling to create a competitive advantage.

Stories have always fascinated people as they are much more memorable than facts. In recent years, there has been an increasing use of storytelling in branding and marketing (Adaval & Wyer, 1998; Benjamin, 2006; Mattila, 2000). Stories have several potential benefits for brands; they catch consumers' interest (Escalas, 2004; Mossberg & Nissen Johansen, 2006), help con- sumers understand brand benefits (Kaufman, 2003), generate positive emotions (Escalas, 2004), increase brand trust and awareness (Kaufman, 2003; Kelley & Littman, 2006), and make brands more memorable (Mossberg & Nissen Johansen, 2006). Stories also add favourable and unique associations to a brand, potentially increasing customer-based brand equity (Keller, 1993;Leone et al., 2006).

Most research on brand stories has examined consumer-created narratives or advertising content, with less focus on company-originated brand stories (Lundqvist et al., 2013). There remains a shortage of empirical research on how brand stories crafted by companies affect consumer per- ceptions and responses.

Lundqvist et al. (2013) sought to address this gap by conducting an experiment comparing brand experiences between two groups: one exposed to a company-created brand story and one not exposed. Their results showed a marked impact - participants who heard the story viewed the brand more positively, formed more favourable associations, and expressed willingness to pay higher prices. The story appeared to function as a perceptual filter, altering how consumers evaluated and perceived the brand.

This research provides important empirical support for the potential influence of company- cre- ated stories in shaping consumer brand experiences. While storytelling shows promise as a branding approach, additional research is needed to fully understand its effects and applications in different contexts. The work by Lundqvist et al. (2013) offers a valuable empirical starting point, but numerous questions persist regarding how and when brand stories can most effectively influence consumer perceptions and behaviours.

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The role of storytelling in advertising

This study examines the effectiveness of storytelling in advertising, focusing on how narrative elements impact consumers' emotional responses and word-of-mouth intentions. The authors draw on several key concepts from narrative persuasion literature to develop their hypotheses and experimental design.

Identification Drawing on social cognitive theory and advertising research on spokesperson credibility, the study explores how identification with ad characters impacts responses. The authors compare ads featuring a company founder versus a customer as the storyteller, connecting to concepts of wishful identification and perceived similarity.

Emotion and Word-of-Mouth The role of emotion in motivating word-of-mouth is a key focus, building on research showing emotion as an influential factor in content sharing (Berger & Milkman, 2013). The authors examine how emotional responses to storytelling ads mediate ef- fects on word-of-mouth intentions.

Storytelling in Advertising The study contributes to research on storytelling as an advertising technique, which has found narratives can make messages more memorable and persuasive (Adaval & Wyer, 1998; Padgett & Allen, 1997). However, the authors note gaps in empirical evidence on storytelling effectiveness in commercial advertising contexts specifically.

The Role of Storytelling in age of Digital Marketing

Storytelling has emerged as a powerful tool for brand development in the digital marketing age, deeply influenced by consumer behaviour. Behzadi and Bakhtiary (2023) highlight how storytelling integrates emotional narratives with digital tools, creating engaging and relatable content that reso- nates with consumers and fosters brand loyalty. By aligning brand values with consumer experi- ence, storytelling enhances authenticity and builds trust, positioning brands as solutions to consum- er needs. Digital storytelling appeals to consumers' emotional and rational dimensions, reducing resistance and encouraging positive perceptions of brands. Furthermore, by focusing on societal benefits over financial gains, storytelling creates a unique identity that differentiates brands in competitive markets. This interplay between consumer behaviour and storytelling underscores its transformative role in shaping meaningful consumer experiences and driving brand development in the digital landscape.

Consumer behavior and Decision Making

Consumer behavior is the study of how individuals, groups, and organizations select, purchase, use, and dispose of goods, services, ideas, or experiences to satisfy their needs and desires (American Marketing Association). Purchase decisions are complex and influenced by a variety of factors, including:

- Brand associations: The thoughts, feelings, and perceptions that consumers have about a brand.
- Brand trust: The consumer's belief that the brand is reliable and will deliver on its promises.
- Brand value and positioning: The way the brand is differentiated from its competitors in the marketplace.
- Emotional appeal: The ability of the brand to evoke positive emotions in consumers.

Storytelling can influence these factors. By crafting compelling narratives, brands can create strong brand associations, build trust, communicate their value proposition, and connect with consumers on an emotional level.

Mathews and Wacker (2008: 99) draw attention to the power that great stories have on people:

Good stories touch your imagination. Great stories steal your soul. Good stories resonate with us and may even cause a tear to involuntarily form in the corner of our eyes. Great stories cause that twist of gut or bowel. They make our blood boil and drive us blindly into a battle. Great stories fire our rage or bring us peace. They can inspire people, companies, movements, and sometimes even nations. Good stories inspire action. Great stories build industries.

Therefore, it can be concluded that stories hold astonishing amounts of power. That is why we decided to conduct this research and understand the extent of this influence on various factors like purchase intention, brand loyalty, emotional appeal etc.

Brand Storytelling in digital media: an emerging perspective

Storytelling has become a cornerstone of brand communication, profoundly shaped by consumer behaviour in the digital age. Gupta (2022) emphasizes that storytelling is not merely a narrative tool but a strategic mechanism for conveying symbolic meanings, emotional resonance, and brand herit- age. Digital storytelling, enabled by platforms like Instagram, YouTube, Facebook allow brands to engage with consumers through visually immersive and interactive narratives. These narratives transform conventional brand communication by emphasizing experiences over products, aligning brand values with consumer aspirations and fostering emotional connections.

The study identifies consumer behaviour as a critical determinant of storytelling's effectiveness. Brands that craft authentic, concise, and emotionally compelling stories not only enhance consumer engagement but also encourage brand loyalty and advocacy. For instance, campaigns like Vogue's #VogueEmpower and Airbnb's visual storytelling illustrate how aligning narratives with consumer emotions and experiences strengthens the customer-brand relationship. By enabling consumers to see themselves in these narratives, storytelling stimulates mental connections, deepens trust and solidifies brand identity.

However, maintaining consumer interest and avoiding saturation with excessive brand narrative still remain as a challenge. Not all consumers connect equally with the stories and have the same perspective or understanding, so it is essential for brands to align their storytelling strategies with the target audience preferences. The interplay between storytelling and consumer behavior thus un-derscores its significance as a dynamic and impactful approach in digital marketing.

Brand Storytelling in the digital media: an emerging perpective

Brand Storytelling has become an essential marketing tool, deeply influenced by consumer behav-iour. Baakli (2023) emphasizes that storytelling leverages frameworks like narrative transportation theory to emotionally engage consumers, creating stronger connections between brands and their audiences.

The study highlights that 76% of respondents reported making purchases is influenced by brand storytelling. Authentic, visually engaging narratives are pivotal in fostering brand loyalty and in-fluencing decision-making. Emotional appeals, relatable characters, and multimedia elements such as videos and images create immersive brand experiences, driving consumer engagement.

Baakli concludes that storytelling, shaped by consumer preferences, is a transformative tool for brand development in the digital marketing age. By employing emotionally compelling and visual- ly rich narratives, brands can foster lasting relationships and drive sustained growth.

The Zaltman metaphor-elicitation technique (ZMET)

ZMET is a qualitative market research tool designed to delve into the depths of consumer con- sciousness. Unlike traditional methods that primarily rely on conscious responses, ZMET ex- tracts the subconscious motivations, emotions, and perceptions that drive consumers to take a decision.

This technique can be used to create a collective cognitive map for a group of consumers to gain greater insight into consumers' product knowledge and perception. Further, it can be used to elicit the personal relevance or meaning of a brand for the consumer and then map those meanings as mental models. The term 'mental models' is used here (instead of cognitive struc-ture) as this broader term allows other meanings to be included such as attitudes, emotions and feelings, actions, goals, personal values, images, memories of past consumption events, andrep-resentations of sensory experience such as touch, taste, and smell.

This in-depth exploration transcends surface-level responses and reveals the underlying emotion- al connections and cultural associations that shape consumer choices. By analyzing consumers' mental models, marketers can check the effectiveness of the marketing efforts used inpositioning a brand, creating a perception, building an image. The use of qualitative techniques can help brands to understand the effectiveness of the storytelling in advertising to check if the consum-er's opinions match the intended positioning aimed at to be achieved by the marketer.

This technique offers a powerful lens into the consumer's mind, enabling brands to refine their storytelling strategies and optimize their marketing efforts for maximum impact.

Therefore, ZMET empowers businesses to make informed decisions based on a deep under- standing of consumer psychology. This helps to bridge the gap between conscious andun- conscious influences on purchase behavior.

The Gaps:

The field of storytelling is predominantly Western-centric with minimal exploration of its ap- plicability or importance in Indian organizational settings. Despite India's rich cultural diversi- ty, which presents significant potential for organizational storytelling, there appears to bea lack of studies examining this topic within Indian companies. The last comprehensive review of sto- rytelling literature dating back over a decade shows the need for an updated examination.

Our research aims to bridge this gap by conducting a contemporary review of storytelling lit- erature and subsequently investigating its applicability within Indian organizational settings.

Furthermore, while the ZMET technique has been extensively utilized in consumer research, particularly in retail store experiences, its application in managerial contexts, especially within marketing, is relatively unexplored. Our research endeavors to extend the boundaries of ZMET by investigating its potential to uncover the impact of storytelling on products.

Taking Bourn Vita as a case study, we aim to employ ZMET to understand consumer percep-tions, emotional connections, and potential avenues for repositioning the product through effec-tive storytelling. This research will provide valuable insights for both academics and practition-ers, offering a deeper understanding of the role of storytelling in organizational successand providing actionable recommendations for leveraging this powerful tool.

Research Methodology

The researchers sent invitations to 30 people they had chosen using purposive sampling. Pur-posive sampling enables researchers to choose study participants from the public using their discretion (Patton 2002).

With this sampling technique, the researchers could choose participants from the college campus and respondents who have previously used Bourn Vita. Out of the 30 respondents, 15 respond- ents were chosen to take part in the research's next phase. All the chosen respondents fallunder the age category of 20-30.

The prime reason for such a target respondent selection was to get the participants who belong to the era where Bourn Vita was still an energy drink and the basis of the usage, awareness, and growth of Bourn Vita as a brand, during the late 2000s and most of 2010s timeline and deliber- ately to ensure a maximum understanding of experiential marketing approaches, as suggested by (Chebat et al. (2009)). **A brief profile of the participants is presented in Table 1.**

Each researcher decided to take 4-5 participants for non-bias interview of ZMET and perception of brand people now. This provides a rich source of meaning, to draw findings for the demon- stration of ZMET cognitive mapping. Because of the popularity of malt drinks among thechosen target respondents, it was a willing subject pool.

ZMET has four guiding principles, grounded by several important facts about how the brain functions and how the human mind operates (Zaltman, 2003). Olson et al. (2009) commences with the unconscious mind, exploring unconscious meanings, customers reveal, "What they don't know they know." Secondly, it is argued that images are central "components" of the mind, thus the human mind operates visually rather than through words. Thirdly, the brain manipulates these images to create 'Meaning patterns' at a deeper, fundamental level. Finally, using images as metaphors to symbolize an individual's thoughts is the key to unlocking these unconscious meanings.

The following sections will now explain how we followed and elaborated on these four stages in our study-:

Stage 1: The Participant Briefing Phase

Prior to the interview, each respondent will be asked to consider Bourn Vita as a brand and choose 8-10 images that express their thoughts and feelings about the brand, which they will bring to the interview. Each image will include a one-liner explanation or just their thoughts about the photo in a word that is a metaphor for one or more major ideas regarding "Bourn Vita" or "a chocolate energy drink". highlight the initial thinking of the participant. They were then shown all photos collectively, on one slide showing how the images related to one another.

Building a relationship with participants in qualitative research, it is suggested, can encourage empathy and affiliation between the interviewer and interviewee thus leading to a more suc-cessful, rich discussion (Prior, 2018). After the participants had received their full brief, each participant was told to select six to eight pictures or images. This is the suggested amount in the ZMET process as it encourages the participant to focus their thoughts and be selective when choosing their images. (Khoo-Lattimore and Prideaux, 2013) The participants were told that the images should evoke their feelings towards the following statement:

"How do you perceive your experience using Bourn Vita as a drink?"

An important point to note and concurs with Zaltman's (2003) guidance that procedure allows respondents to project

their mental model onto a series of photographs and communicate key cognitive (thoughts) and emotional (feelings) features of that mental model.

Finally, the participants were informed that they must return for the interview stage in about seven to ten days' time and bring with them a PowerPoint presentation with the 7-8 images, including a one-line summary that summarized that particular picture. This period has not been specified in the literature; however, it felt by the researchers that it was sufficient for the par- ticipant to source appropriate images. It also ensured that the interviewee could recall their rea- sons for choosing the picture.

Stage 2: The Depth Interview

One week later, the students were invited for a 90 minute one- to -one 'ZMET' interview. Each interview was conducted on google meet platfom which also enabled the participants to view their images. This technique provided an unobtrusive way of recording accurately the participant's discussion, the images selected and any non-verbal actions, for example, through body language and facial expressions.

Each interviewee was asked to load up the images onto the screen and then the participant-led interview commenced. The images created the stimulus for questioning of the candidate and a range of questioning techniques were adopted based on the limited guidance present in the literature (Zaltman, 2003; Zaltman and Coulter, 1995).

The researchers found that nine steps are associated with the ZMET. During which they will share their thoughts and feelings as depicted by the photos they bring with them. The images provide a stimulus for interrogating the candidate, and a variety of questioning tactics will be used. Respondents will be encouraged to share their stories because people analyze and record the experiences as narratives, and metaphors inspired by the visuals will emerge from the dis- course. Respondents will be asked if there are any pictures they do not wish to exhibit or could not find, as well as why.

The investigation of the missing images will help understand thesub- conscious feelings that may arise. The study of the meanings of the different images chosen will enable responders to compare them, resulting in deeper thinking and a more holistic view of the thoughts. The queries will be framed as "how does, have you, or could you?" These questions will be phrased neutrally and will have no bearing on the participants' perceptions of the image. An effective probe will urge respondents to contemplate what the image means to them, and the laddering of questions will result in more in-depth responses.

During the probing process, responders will be urged to describe what goes beyond what the picture now depicts, as well as what else may be there outside of the existing frame that the image hasn't recorded.

Finally, respondents will be asked to analyze their images in terms of sensory symbols such as color, smell, touch, taste, and sound.

3. THE INTERVIEW STEPS

1. The Use of Storytelling

Storytelling is a fundamental aspect of the Zaltman Metaphor Elicitation Technique (ZMET) be- cause it aligns with the notion that people process and record their experiences as narratives (Martin, 2010). Zaltman (2003) emphasizes that storytelling helps participants naturally open and share their interpretations of the images they select. Through storytelling, metaphors emerge, providing deeper insights into participants' perceptions of BournVita. An example below illus- trates how they will use storytelling-: "Participant might choose an image of a cozy living room to represent their feelings about BournVita."

Participant's Story: *"Whenever I think about BournVita, it reminds me of my childhood evenings spent with family. The warm, comforting taste of BournVita makes me feel safe and happy, just like those family gatherings. It's a moment of togetherness and love."*

2. Sensory (Non-Visual) Metaphors

Encouraging participants to consider their images in relation to sensory symbols such as color, smell, touch, taste, and sound can uncover deeper associations with BournVita. An example below illustrates how they will use storytelling-:

- **Researcher:** "If you were in that picture of a cozy living room, what would you smell?"
- **Participant:** "It would smell like warm chocolate and spices. It's comforting and makes me feel at home."

The Vignette

Participants are asked to create a story about their experience with BournVita, including them- selves, the product, and what happened. This method captures their overall thoughts and feel- ings. However, creating such a vignette can be challenging, so participants are encouraged touse several images together. An example below illustrates how they will use storytelling-:

Vignette: "I am at the end of a long workday, feeling exhausted. I come home, make myself a cup of BournVita, and instantly feel the stress melting away. It's like a warm hug in a cup, giving me the strength to unwind and recharge for the next day."

Insight: BournVita serves as a comforting ritual that helps transition from work stress to relaxation.

4. The Mind Map.

A mind map visually represents the interconnected thoughts and feelings about BournVita. These connections often reveal

shared themes among different participants, creating an emotional value map (EVM).

Stage 3: The Visual Executive Summary/Montage

The interview should conclude on this step, in addition to the previously mentioned phases, with the construction of a "visual executive summary" (Zaltman, 2003) that shows the relationships between the photos and how they would appear together in a collage or montage. This phase is crucial because it offers what Zaltman (2003) refers to as a "snapshot, " or window, of their thoughts regarding the phenomena under investigation. In addition to emphasizing how crucial the visual executive summary is, the However, there isn't much advice in the literature on how to go about doing this. We -decided to draw the pictures to put together a montage when the participant ends the interview. Post inter- view, the participant was then sent the image via email, to confirm that this represented their views accurately. This process, which we adopted is in-line with other qualitative approaches to respondent validation, whereby participants are asked to review, for example, interview tran- scriptions for accuracy (Brewis, 2014). They were also asked to title the montage to capture the essence of their overall feelings of the subject. The montage is an important step of the process for the researcher, because it captures all the thoughts together ending the interview.

Stage 4: Transcribe, Data Analysis and Develop Constructs

As suggested in Stage 4, all the interviews were mostly transcribed, and any relevant non-verbal actions were noted. These were collated with the participant's chosen images, the visual execu- tive summary (montage) and mind maps (EVM). This rich data was analyzed in its entiretyto identify metaphors and related constructs with the aim of creating a 'consensus map' which high- lighted the common themes to emerge from the ZMET (Zaltman, 2003). 'Consensus' is defined by Zaltman and Coulter (1995) as a frequency level for each individual construct so that at least one-third of the participants mention any given construct. They also suggest that a quarterof par- ticipants should indicate a relationship between constructs, before it can be added to the consen- sus map.

The aim should be, therefore, to capture 'what people know, they do not know they know'. (Zaltman and Zaltman, 2008, p.) Whilst studies have explored how to conduct visual imagery analysis (Cederholm, 2004; Symon and Cassell, 2012), beyond these guidelines, there is little information on how the actual ZMET analysis should be conducted. The researchers there- fore drew upon more well-established qualitative data analysis techniques which propose that da- ta should be reduced through, for example, coding, theme identification and clustering (Huber- man and Miles, 1998). But the technique which we adopted was to create conceptual maps to deduce common themes and understand the positioning of Bourn Vita in the minds of consum- ers, and how more the brand must work to build a re-positioning itself and provide managerial implication.

ZMET Analysis

A ZMET (Zaltman Metaphor Elicitation Technique) analysis was conducted to delve into the subconscious perceptions and associations linked to BournVita consumption. The study involved a sample of 15 participants. To initiate the exploration of participants' mental models, they were asked to create a digital collage using Canva, incorporating images that represented their thoughts and feelings about BournVita. Following this, participants were presented with a series of images and prompted to elaborate on their reactions, the reasons behind image selection, and the associated thoughts and emotions.

This projective technique allowed for the uncovering of implicit and often unspoken associations linked to the brand. The second phase involved in-depth interviews to further elucidate participants' experiences and perceptions. Questions focused on personal experiences with BournVita, memorable advertisements, and potential product exten- sions. This stage aimed to uncover conscious and deliberate thoughts about the brand. The final phase delved into the sensory dimensions of BournVita consumption. Participants were asked to describe their experiences related to taste, touch, sight, and sound, to understand the multi- sensory aspects of product engagement.

Through this multi-faceted approach, the ZMET analysis sought to uncover the underlying moti- vations, emotions, and cultural associations linked to BournVita, providing a comprehensiveun- derstanding of consumer perceptions.

Creating a Consensus Map of Mental Structure

Once individual ZMET interviews were completed, the next step involved synthesizing these disparate perspectives into a cohesive understanding of consumer thinking. To achieve this, the collected data was input into Mapify which is a software tool to develop and relate the census then for better understanding and interpretation we used word cloud.

The bigger the size of words more the consumer relate to it. The optimal cutoff level is a balance between detail and interpretability. Researchers typically explore multiple maps with varying cutoff levels to identify the most informative representation. While a map with a cutoff equal to the number of participants might seem ideal, it often lacks practical value due to excessive com- plexity.

By iteratively adjusting the cutoff level and analysing the resulting maps, researchers can identi- fy the core themes and underlying structures of the consumer mental model. This process pro- vides a foundation for deeper insights into consumer behaviour and informs the developmentof effective marketing strategies.

4. FINDINGS

Consensus Map of Consumers' Mental Models

Look for Central Construct

First, look for the central, highly connected constructs (those constructs that are linked to several other constructs). The central construct, "Sweet & Tasty, " plays a pivotal role in the consensus map. It represents the sensory appeal of BournVita, which is likely the first experience consum- ers have with the product. The sweet taste creates a pleasurable and comforting experience, which anchors the consumer's perception of the product. This sensory appeal is central because it serves as the gateway to other attributes such as health, nutrition, and daily habits.

The associ- ation with taste is not merely about enjoyment but connects to broader themes like trust and reli- ability, since something that tastes good is also perceived as comforting and dependable. Im- portantly, the association between taste and trust is noteworthy. A product that isperceived as delicious is often linked to qualities like reliability and dependability. This sensory pleasure re- inforces the product's positioning as a comforting and dependable choice. participate in the sport, and how bourvita fits into their lives. Theoretically, as highly involved, highly

Expert consumers gain more knowledge and experience, they subdivide their knowledge intoman- ageable portions or chunks (cf. Mitchell & Dacin, 1996). How customers naturally self- organize meaning in this way is a fundamental step toward a useful and deeper consumer understanding.

Look for the Overall Goal/End State

The overarching goal among the orientations shown in Figure 1 showcases itself with the core objectives of Growth, Accomplishment, and Health & Nutrition, reflecting the aspirations of parents for their children as BournVita was present in each home mothers specially used it as tool to tell their children's before going to school and before evening games they have drink a glass of milk with bourvita. The brand also advertised itself as this only. By ensuring that children receive the essential nutrients needed for healthy physical development, BournVita supports Health & Nutrition. It also emphasizes Growth, focusing on both intellectual and

physical development, with a strong association with enhancing height, strength, and intelligence in children—outcomes highly valued by parents. Additionally, BournVita is perceived as a product that aids in children's Accomplishment, helping them achieve success in sports, academ- ics, and other areas of life. This sense of achievement fosters pride in both parents and children, creating a deep emotional connection that is crucial for building long-term brand loyalty. To elaborate the sense of

advertising bounvita they introduce a BournVita quiz contest to increase their reach.

Look for Missing Constructs

Another thing to look for when interpreting a consensus map is missing constructs. What ideas or concepts did you expect to be present but are not? *Environmental Impact and Ethi- cal Considerations* As consumer awareness of environmental and ethical issues grows brands are increasingly expected to address these concerns. The consensus map for BournVita, howev- er, does not include these aspects. For modern consumers, especially younger and more envi- ronmentally conscious parents, factors such as sustainable sourcing, eco-friendly packaging, and ethical production practices are becoming important. The absence of these constructs could be a gap that BournVita might need to address in the future to stay relevant. *Brand Competitiveness* Another missing element is how BournVita compares to its competitors. There is no mention of why consumers might choose BournVita over other health drinks. Including constructs that highlight BournVita's unique selling propositions (USPs) compared to competitors could strengthen the brand's position in the market. This could involve highlighting better taste, supe- rior nutritional content, or unique benefits that competitors do not offer.

5. BROAD MEANING THEMES:

Using Sensory Imagery

Sensory Imagery is used as a part of ZMET to elicit the subconscious perception of the con- sumers. Sensory experiences are deeply connected to our emotions and memories. By focusing on the sensory aspect, ZMET helps to uncover hidden thoughts and feelings. This technique provides a more nuanced and comprehensive understanding of consumer perceptions.The hid- den associations and meanings that the consumer may not be consciously aware about can be uncovered.

In this technique, the participants are encouraged to express their thoughts and feelings about a product or service with respect to colour, sight, taste, smell, touch sound and emotions. The selection of the images in Phase 1 of ZMET can be associated directly to these parameters. Hence, questioning the consumers specifically on these parameters will allow us to find the impact created by the brand on the minds of the consumers. This technique will help marketers in creating more compelling and resonant campaigns since they can now understand the aspects about the brand that have appealed the most and have been retained by the consumer and the gaps.

Asking questions as follows helps in uncovering such hidden images:

“Close your eyes and imagine the aroma of BournVita. What do you see?" “Image that you are preparing BournVita. What sounds do you hear?” “What is the first colour that you would associate BournVita with?”

“When you think back on BournVita, which emotions does it stir”

All the participants in the interview were asked similar questions and the following insights were obtained:

Sight

Words like “Brown”, “golden”, “frothy”, “steaming” were mainly used by the participants to describe the brand. The colours mentioned above are mainly associated with warmth and richness. Hot beverages, ideal for cold weather, are some insights that are obtained from thesevisual cues. The overall visual appearance is “inviting” and “indulgence”.

Taste

“Chocolaty”, “sweet”, “creamy” shows the core identity of BournVita. Showing the core flavour that is used by most consumers, these words also can be linked to the feeling of indulgence and richness. It also shows that the brand has perfected the amount of sweetness indicated using the “sweet” and not the word “over-sweet or sugary”.

Touch

Warm, smooth, velvety, grainy are the words used to describe BournVita – this shows that use case of the brand. Most consumers have it with warm milk when the powder easily dissolves in the milk giving it a smooth texture. It also describes the texture of the powder which is grainy with small rocky sugar cubes – showcasing how easily this has been imbibed in the minds of the consumer.

Smell

“Chocolate”, “milk”, “cocoa” are the aromas that are deeply ingrained in consumers’ minds. This again shows which flavour most consumers associate the brand with. When combined with the images, it can be easily seen that just the thought of the smell of BournVita evokes feelings of nostalgia, comfort and freshness.

Sound

“Foaming”, “pouring”, “stirring” are the sounds which are linked to the process of making a cup of BournVita. The frothing of the milk, the clinking of the spoon when the BournVita is mixed with a spoon into the milk, pouring the hot milk into a mug can be associated with feelings of anticipation and enjoyment, especially for children.

Colour

Most participants associated BournVita with “brown”, “orange and purple” which is the colour of the powder and the packaging of the product with the Cadbury logo in purple. However, some participants associated the colour “blue”. Upon further exploration, it was discovered that ‘Hor- licks’

the direct competitor of BournVita has its packaging and drink bottle in this colour.

Hence, there may be confusion amongst the consumers for the packaging colour.

Emotions/ Feelings

Most participants associated BournVita with the feeling of "nostalgia" as this was a product con- sumed by them during their childhood. They were able to associate many memories with the brand and showcase how the brand was a part of their day-to-day routine activities. Some partici- pants also associated emotions like "confidence", "success", "achievement" with the brandby as- sociating the brand with its advertisements which have a theme revolving around this concept.

This points out that the brand identity and personality is directly affected through its advertise- ments and consumers develop a brand image based on how it is portrayed through its communica- tions and media.

6. THEMES:

Comfort and Warmth

While the theme of escaping to nature isn't explicitly depicted, the map does convey a sense of warmth, comfort, and nostalgia, particularly through connections to childhood and motherly love. This can be seen as a metaphorical escape to the natural comfort and care that BournVita offers. The product is associated with nurturing and protective qualities, similar to how nature provides solace and safety. The brand doesn't only provide warmth comfort but with that it brings coziness and homily feeling. As interviews proceeded, we realized that BournVita is not justa brand but feeling a sense of strength, accomplishment that it brings with it.

Sense of Accomplishment

BournVita is positioned as a product that helps children meet challenges head-on, whether in academics or sports. The sense of accomplishment that comes with overcoming these challenges is a key theme. For instance, the idea of children growing stronger, smarter, and more capable is tied to the satisfaction and pride they and their parents feel. This theme resonates with the idea that BournVita is more than just a drink, it's a partner in achieving life's milestones.

Connections and Emotions

The connection between BournVita and an active lifestyle is evident in the map's association with sports, energy, and games. This theme suggests that BournVita is not just about physical nourishment but also about fueling the energy and enthusiasm needed to participate in fast-

paced, thrilling activities. This aligns with the modern parent's desire to see their children excel in various physical activities, contributing to their overall growth and development. The emo- tional bonds that BournVita fosters within families are another significant theme. The map high- lights how BournVita is integrated into daily family routines, symbolizing care, support, andto- getherness. This theme is important as it positions BournVita as more than just a product; it be- comes a ritual that brings family members together, reinforcing the brand's role in creating shared moments of joy and connection.

Transformation

The concept of transformation is depicted through the journey from childhood to maturity, facil-itatedby BournVita. The map suggests that BournVita plays a role in this transformation, help-ing children grow from being nurtured to becoming confident and capable individuals. This theme ispowerful as it taps into the parental desire to see their children develop into well- rounded individuals who can face the world with confidence.

Perception in the Digital Age:

In the digital age, BournVita's sensory and emotional appeal remains relevant but requires adapta- tion to digital consumer behaviours. Digital platforms provide opportunities to enhance brand sto-rytelling through engaging content that highlights sensory experiences, such as videos showcasing the creamy, chocolaty texture of BournVita or campaigns that evoke nostalgia. UGC can amplify trust and authenticity, as consumers share their memories, daily rituals, new recipes involving the brand.

Tools like AR can provide an immerse experience to the users in the product journey - enhancing sensory connections. Additionally, addressing missing constructs like sustainability and ethical practices can align BournVita with modern consumer values, ensuring relevance in an increasingly conscious market.

By integrating these findings with digital strategies, BournVita can sustain its legacy while evolv-ing to meet modern consumer demands. This approach ensures that the brand remains both a nos-talgia favourite and a forward-looking choice of new generations.

7. DISCUSSION

Thematic Substructures

- The consensus map illustrates how various themes like nutrition, growth, and emotional connection are interconnected, creating a comprehensive mental structure around BournVita. These substructures reinforce the brand's identity as a nutritious supplement that also plays a significant role in emotional well-being and family bonding. By inter- linking these themes, BournVita is able to appeal to a wide range of consumer needs, from basic nutritional requirements to higher-order emotional and aspirational goals.

Affect versus Cognition

- Affect: The emotional appeal of BournVita is strong and multi-faceted. It encompasses feelings of warmth, comfort, nostalgia, and family togetherness. These emotions are crucial for building brand loyalty as they create a deep, personal connection with the product. The association with pride and accomplishment further strengthens the emo- tional bond, making BournVita not just a drink but a symbol of parental love and care.
- Cognition: On the cognitive side, BournVita addresses practical needs such as health, nutrition, and daily habits. Parents are rationally invested in providing their children with the best possible nutrition to support their physical and intellectual growth. The emphasis on cognitive benefits like nutrition and growth complements the emotional appeal, mak- ing BournVita a well-rounded product that satisfies both emotional and rational consum- er needs.

Situational Specificity

- The consensus map reflects how BournVita is specifically integrated into daily routines and seasonal habits. For example, it is consumed as a warm drink in winters, symbolizing comfort and warmth. It's also seen as a source of motivation and energy, helping children start and end their day on a positive note. This situational specificity underscores the product's versatility and relevance across different contexts, enhancing its value in the eyes of consumers.

Dimensions of Involvement with BournVita

- Emotional Involvement: High, due to strong associations with family, care, and pride. The emotional connections foster long-term loyalty and make BournVita a part of the family's daily life.
- Behavioral Involvement: High, as BournVita is depicted as a daily habit, essential for starting and ending the day, and for providing energy and motivation throughout.
- Cognitive Involvement: High, with a focus on ensuring that the product delivers on its promises of health, nutrition, and growth. Parents are cognitively engaged in choosingBournVita as it aligns with their goals for their children's well-being.

8. LIMITATIONS

The limitations present in this paper are as follows:

Sample size: The study involves a small sample size (of 15 respondents) as is the ideal sample size range used in while collecting data through ZMET. However, compared to other data collection techniques this sample size is relatively smaller. Having said that, as we conducted more interviews the perspectives and inputs started to repeat. Thus, the decision was taken to limit the sample size to 15 respondents. Since the respondents were particularly those who were regular users of the brand in their young age or have tried using the brand at least once, this could introduce selection bias.

Focus on a single brand: The study centers exclusively around BournVita, limiting its application to similar brands and product categories. Boarder research could explore multiple brands to identify generalizable storytelling strategies.

Cultural Context: The research primarily focuses on the Indian context. While this is relevant for local brands, the finding may not be directly applicable in global markets.

9. IMPLICATIONS AND FUTURE DIRECTIONS

Brand Messaging

- Future Campaigns: Future campaigns should continue to emphasize the transformational journey that BournVita supports—from nurturing young children to helping them become confident and successful individuals. Additionally, incorporating messages that address environmental sustainability, and ethical practices could attract environmentally con- sciousconsumers, further enhancing brand loyalty.

Product Development

- Sustainability Focus: BournVita could explore developing new products or variants that cater to consumers' growing interest in sustainability. This might include offering organic options, using eco-friendly packaging, or sourcing ingredients through fair trade practic- es. These developments could differentiate BournVita from competitors and strengthen its market position. For example Boost ad their biggest competition gives reusable glass- es, BournVita can also make those to stay in people mind more.
- They can also make products with dark chocolate variant, in addition to cater to adults they can add plant-based protein powder with same formula and even BournVita chocolates protein bars.

Targeting Specific Situations

- Seasonal and Contextual Marketing: Marketing strategies could be refined to target spe- cific situational contexts, such as emphasizing warmth and comfort in winter campaigns or focusing on energy and performance in sports-centric promotions. This approach could enhance the relevance of BournVita in consumers' lives by aligning withtheir spe- cific needs and preferences in different situations.

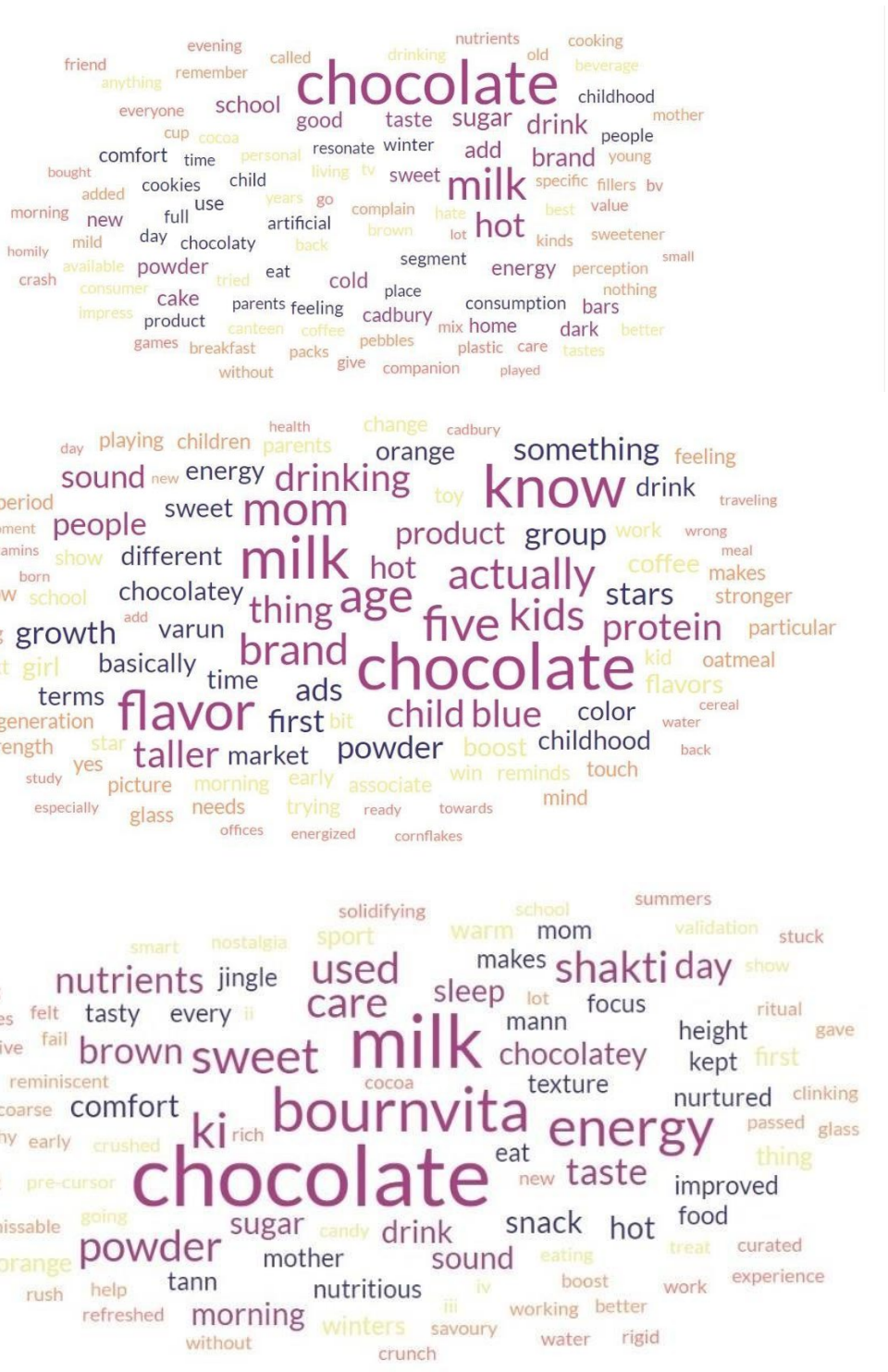
Consumer Education

- Highlighting Cognitive Benefits: Educating consumers about the long-term cognitive benefits of BournVita,

such as supporting brain development and intellectual growth, could reinforce its importance as a holistic growth supplement. This could be particularly appealing to parents who are focused on their children's academic and intellectual suc- cess, making BournVita an indispensable part of their daily routine.

ANNEXURES:

Word clouds from the interviews:



Common Images from all the interviews:

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2

Impact of Effective Digital Marketing Capabilities on the Firm's Performance: An Empirical Study

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ABSTRACT

In today's rapidly evolving business environment, digital marketing tools such as social media, SEO, email marketing, and content marketing are essential for firms to connect with a wider audience, engage customers, and drive business growth. By leveraging data analytics and performance metrics, firms can optimize their marketing efforts, ensuring higher return on investment and efficient resource allocation. The adaptability and scalability of digital marketing tools allow firms to respond swiftly to market dynamics, providing a competitive edge. The study focusses on how these capabilities enhance customer engagement, brand awareness, profitability, and competitive positioning. The study acknowledges certain limitations, such as the challenge of isolating the effects of digital marketing from other influencing factors, measuring long-term impact, and the variability of effectiveness across different industries and regions. To address these limitations, the study suggests a need for further research through longitudinal and cross-industry analysis. People from digital marketing department were surveyed to know the role and Impact of Effective digital marketing Capabilities on the firm's performance and concludes that there is significant impact of Effective digital marketing Capabilities on the firm's performance like increased Brand Awareness and Reach, Enhanced Customer Engagement and Experience, Data-Driven Decision Making, Targeted Marketing and Better ROI (Return On Investment), Competitive Advantage, Sales Growth and Lead Generation, Improved Brand Loyalty and Advocacy & Scalability and Cost-Effectiveness.

Keywords: Organizational Performance, Digital Marketing Capability, Marketing Strategies, Digital marketing innovation, Customer

1. INTRODUCTION

Digital marketing capabilities refer to the skills, tools, strategies, and technologies a company or individual possesses to effectively execute and manage digital marketing activities. These capabilities enable organizations to reach, engage, and convert their target audience through various online channels and methods. "Effective digital marketing capabilities" greatly influence a firm's performance by improving its capacity to engage with target audiences, increase brand awareness, and drive customer acquisition and retention. By leveraging "data analytics, social media, SEO, and content marketing", firms create personalized and relevant campaigns that resonate with customers. This enhances customer experience, builds loyalty, and drives conversions, ultimately leading to higher revenue and market share. Additionally, effective digital marketing allows firms to adapt quickly to market trends and customer behavior, ensuring they remain competitive and responsive in a dynamic environment. Marketing capabilities are intricate combinations of skills and knowledge at the firm level, embedded within organizational processes that execute marketing functions and enable the company to adapt to changes in the marketplace **(Morgan et al., 2018).** However, to adapt to the "profound transformations in practice brought about by the digitization of marketing activities," firms develop "new digital capabilities, particularly digital marketing capabilities". Digital marketing provides real-time feedback and performance metrics, enabling firms to make informed decisions, adjust strategies swiftly, and measure return on investment (ROI) accurately. An effective digital marketing strategy also builds a strong online presence and reputation, essential for gaining customer trust and loyalty in today's digital landscape. Therefore, firms that invest in and continuously innovate their digital marketing capabilities are more likely to see positive effects on their overall performance and long-term success. **Sridhar and Fang (2019)**, and others says that "Digital marketing capabilities" (DMCs) refer to a company's ability to leverage digital technology-driven processes to engage with consumers and suppliers in a targeted, measurable, and integrated manner, creating new forms of value irrespective of location or time. Although managers' growing interest in digital marketing has generated extensive literature that has greatly advanced the marketing field, research on DMCs, particularly in the apparel industry, remains limited. This gap is surprising given that practitioners and academics have frequently "called on scholars to explore these emerging capabilities." While the few empirical studies on digital marketing skills have provided valuable insights, they also face significant limitations.

As consumers become increasingly engaged with technology and media, traditional marketing strategies are losing their effectiveness. This shift is influencing consumer behaviour,

with 84% of consumers expressing dissatisfaction with conventional marketing approaches, according to a study. Understanding customer motivation and behaviour has become crucial. Social media marketing, with ads appearing almost every time a user scrolls, has emerged as a powerful tool **(Jimenez, Valdes et al. 2019).** Digital marketing significantly influences consumer behaviour by providing customers with access to a broader range of products, information, and distribution channels**.** Digital marketing has uniquely affected the fashion industry by making products accessible to everyone. Customer feedback plays a crucial role, and social media serves as the most cost-effective and efficient platform for businesses to engage with their clients. "Effective Digital Marketing Capabilities on the Firm's Performance" examines the essential role that digital marketing capabilities play in enhancing a company's overall performance. In an era where digital presence is critical, businesses must effectively engage their audiences through various online channels to drive growth and sustain competitive advantage. This research aims to explore how capabilities such as data analytics, social media marketing, search engine optimization, and content creation contribute to key performance metrics, including sales growth, customer satisfaction, and brand loyalty. By analyzing empirical data from multiple industries, the study seeks to uncover the relationship between the effectiveness of digital marketing strategies and improved firm performance. Ultimately, this research will provide valuable insights for organizations looking to optimize their digital marketing efforts and achieve their business goals in a rapidly evolving digital landscape.

Overall, performance reflects how efficiently an organization achieves its objectives, mission, and values **(Khalil et al., 2021)**. Firm performance, however, refers to the assessment of the effectiveness and efficiency of particular activities or processes. Firm performance refers to evaluating the effectiveness and efficiency of a company's activities or processes. It measures how well a firm achieves its objectives, including "profitability, growth, market share, and customer satisfaction". Performance assessments help identify strengths and areas for improvement, enabling companies to make informed decisions and optimize strategies for better outcomes. Marketing performance measurement evaluates "the connection between marketing initiatives and business outcomes." Financial indicators include "net profit, return on assets, inventory turnover, net income before tax, inventory management efficiency, productivity ratio, financial liquidity, market share, quality performance, and gross profit margin before tax" (**Gandhi et al., 2017)**. On the other hand, non-financial measures include "market share, competitive position, improvements in performance quality, and innovation outcomes".

An effective digital marketing strategy also enhances a company's online visibility, positioning it as a credible brand in the market. It provides real-time performance monitoring, enabling firms to evaluate the success of their campaigns and make data-driven adjustments to optimize return on investment (ROI). By continuously refining their digital marketing initiatives, firms can gain a sustainable competitive edge, boost profitability, and drive long-term growth. Therefore, investing in and developing strong digital marketing capabilities is essential for enhancing a firm's overall performance and success **(Kacker, 2018)**. An effective digital marketing strategy significantly boosts a company's online visibility, establishing it as a credible brand in the competitive marketplace. By utilizing a combination of "search engine optimization (SEO), content marketing, and social media engagement, " businesses can increase their presence across various digital platforms. This heightened visibility not only attracts more potential customers but also builds trust and authority in the eyes of consumers.

As a company consistently delivers valuable content and interacts meaningfully with its audience, it enhances its reputation, fosters customer loyalty, and ultimately positions itself as a leader in its industry. The marketing ability of a firm plays a crucial role in enhancing its growth by effectively connecting with target audiences and meeting their needs. A well-developed marketing strategy enables companies to identify market opportunities, understand consumer behaviour, and differentiate themselves from competitors. By leveraging various channels—such as digital marketing, social media, and traditional advertising—firms can increase brand awareness, generate leads, and foster customer loyalty. This, in turn, leads to higher sales, expanded market reach, and ultimately, sustainable growth. Additionally, continuous adaptation to market trends and customer feedback allows firms to refine their marketing efforts, ensuring long-term success in an ever-evolving business landscape.

Digital marketing innovation plays a crucial role in enhancing firm performance by improving customer engagement, brand visibility, and sales. Innovative strategies, such as personalized advertising, AI-powered customer insights, and interactive content, allow firms to target audiences more precisely. These methods not only enhance the customer experience but also increase conversion rates and foster loyalty. By leveraging data analytics and automation tools, firms can optimize their marketing efforts in real-time, achieving cost efficiency and higher returns on investment. A strong digital marketing capability provides a competitive advantage by allowing firms to quickly adapt to market changes, connect with customers more efficiently, and differentiate their brand. This agility and customer-centric approach help companies capture market share and achieve long-term success. Overall, digital marketing innovation enables firms to adapt swiftly to market trends, gain competitive advantages, and achieve sustainable growth. Agility and a customer-centric approach are vital for companies aiming to capture market share and achieve long-term success. Agility allows businesses to quickly adapt to

changing market conditions, customer preferences, and emerging trends, enabling them to respond effectively to new opportunities and challenges. By fostering a culture of flexibility and innovation, agile companies can streamline their operations and enhance decision-making processes. Simultaneously, a customer-centric approach ensures that businesses prioritize the needs and experiences of their customers. By understanding and addressing customer pain points, companies can create tailored solutions that resonate with their target audience. This dual focus on agility and customer-centricity not only strengthens customer loyalty and satisfaction but also positions companies to outperform competitors, seize market opportunities, and sustain growth in a dynamic marketplace.

Marketing capability—encompassing resources like human talent, financial investment, technology, and strategic planning—significantly impacts a firm's ability to effectively implement digital marketing innovations and improve performance. Marketing capability encompasses a firm's resources and competencies that enable it to effectively engage with customers and drive business growth. This includes human talent, where skilled marketers leverage their expertise to create and execute effective campaigns. Financial investment is crucial for funding marketing initiatives, ensuring that businesses can reach their target audiences through various channels. Technology plays a vital role in enhancing marketing efforts, allowing for data analytics, automation, and targeted outreach. Additionally, strategic planning helps organizations align their marketing objectives with overall business goals, facilitating coordinated and impactful efforts.

Together, these elements form a comprehensive marketing capability that empowers firms to navigate competitive landscapes and achieve sustainable success. "Effective digital marketing capabilities" significantly enhance the data-driven decision-making process by enabling businesses to "collect, analyze, and interpret vast amounts of data from various sources." This data-driven approach allows marketers to make informed decisions, optimize campaigns, and allocate resources more efficiently. By leveraging data, businesses can identify opportunities for growth, tailor their marketing strategies to meet customer needs, and improve overall performance, resulting in more effective and targeted marketing efforts. Marketing capabilities enable companies to sense and respond to market changes, including competitor actions and advancements in technology **(Wilden & Gudergan, 2015; Srivastava, S. et al., 2024)**.

Marketing capabilities are crucial for businesses to efficiently detect and respond to market changes. These capabilities include the skills, processes, and resources that empower an organization to collect and analyze market intelligence, comprehend customer needs, and recognize emerging trends. By utilizing data analytics, consumer insights, and competitive assessment, companies can rapidly adjust their strategies and offerings to align with shifting market demands. This, in turn, boosts customer satisfaction and enables businesses to capitalize on new opportunities, manage risks, and sustain a competitive advantage. Ultimately, strong marketing capabilities foster agility and innovation, enabling businesses to thrive in dynamic market environments. Technological capabilities empower organizations to enhance their competitive advantage by enabling innovation, efficiency, and agility. These capabilities also allow organizations to respond swiftly to market changes, customize offerings, and improve customer experiences.

2. REVIEW OF LITERATURE

Homburg and Wielgos (2022) examine the moderating impact of organizational and environmental contingencies on the interaction between "digital marketing capabilities (DMCs) and classic marketing capabilities (CMCs)." Environmental contingencies, including market dynamics, competition intensity, and technological advancements, also shape how these capabilities interact. In rapidly changing or highly competitive environments, the synergy between DMCs and CMCs becomes critical for adapting strategies quickly and effectively. Therefore, the effectiveness of combining DMCs and CMCs depends significantly on the organizational context and the external market environment. The results indicate that digital marketing capabilities significantly enhance firm profitability beyond the effects of classic marketing capabilities. This investigation highlights important trade-offs that lead to actionable managerial implications for maximizing the complementary potential and minimizing the substitutive potential of a firm's digital marketing capabilities and classic marketing capabilities.

Liu (2022) revealed a significant connection and direct relation between "digital marketing capabilities, customer-linking capabilities, market-sensing capabilities, and firm performance" which is in today's competitive landscape. Strong digital marketing capabilities enable firms to reach broader audiences, engage customers in real-time, and optimize marketing campaigns through data analytics. This leads to improved brand visibility and customer acquisition. Firms that excel in customer-linking can better understand customer needs and preferences, leading to enhanced "customer loyalty and retention". Strong market-sensing capabilities enable firms to identify opportunities and threats in the market quickly, facilitating timely strategic adjustments.

This agility can lead to a competitive advantage. Firms with robust digital marketing, customer-linking, and market-sensing capabilities can drive higher sales, improve customer satisfaction, and achieve greater market share. This is particularly evident in performance metrics like profitability, growth, and sustainability. integrating digital marketing, customer-linking, and market-sensing capabilities creates a synergistic effect that enhances a firm's performance.

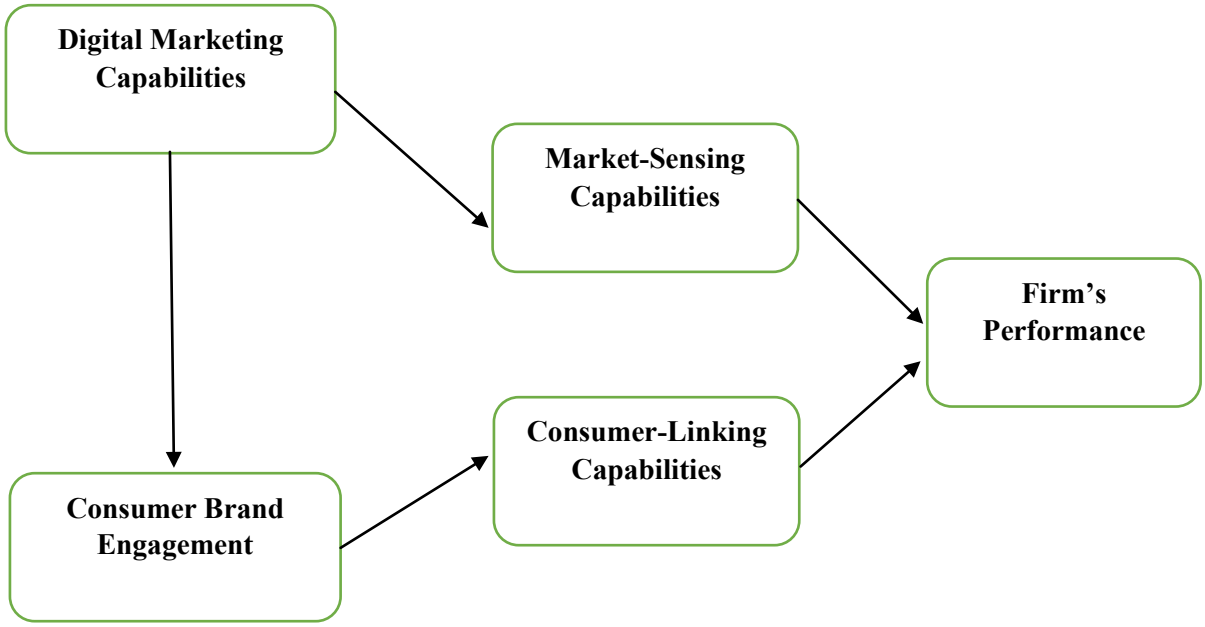

Figure 1 Relation between DMC, CLCs, MSCc and firm performance

Verma (2024) says that by utilizing digital tools and platforms, firms can target specific customer segments, personalize marketing efforts, and track campaign effectiveness in real-time. This allows for more cost-effective strategies, higher conversion rates, and improved customer retention. Digital marketing also provides valuable data insights that help firms make informed decisions, refine strategies, and anticipate market trends. As a result, firms that effectively adopt digital marketing practices often experience increased revenue, market share, and overall competitive advantage. Small and medium enterprises (SMEs) that adopt digital marketing have witnessed a rise in brand awareness and recognition within competitive markets. Firm size significantly influences marketing strategies and capabilities. Larger firms often have more resources, including bigger budgets, advanced technology, and specialized teams, allowing them to execute comprehensive and large-scale marketing campaigns. They can invest in market research, data analytics, and sophisticated digital tools to reach broader audiences and personalize their marketing efforts. In contrast, smaller firms may have limited budgets and resources, requiring them to focus on targeted and cost-effective marketing strategies. However, smaller firms can be more agile, enabling them to quickly adapt their marketing tactics to changing market conditions and customer needs.

Kudeshia & Mittal (2016) revealed that "Electronic word-of-mouth (eWOM)" significantly influences consumers' brand attitude and purchase intention. Positive eWOM, such as online reviews, testimonials, or social media recommendations, can enhance a brand's reputation, build trust, and shape favorable attitudes towards it. This, in turn, increases their intention to purchase. Conversely, negative eWOM can damage brand perception and reduce purchase likelihood, highlighting the importance of managing online feedback effectively. Digital marketing capabilities enhance brand awareness and extend a company's reach by leveraging online platforms, social media, SEO, and targeted advertising. These capabilities allow businesses to connect with a broader audience, create personalized and engaging content, and build a strong online presence. By using data-driven insights, firms can optimize their marketing strategies, ensuring they reach the right audience at the right time, which increases visibility, customer engagement, and brand recognition. Digital marketing enhances sales growth and lead generation by leveraging online platforms and data-driven strategies to reach a broader audience and engage potential customers. Through "targeted advertising, social media campaigns, email marketing, and SEO, " businesses can attract relevant leads and guide them through the sales funnel efficiently. By personalizing marketing messages and using analytics to optimize campaigns, companies can convert more leads into customers and drive sales growth. This scalable and cost-effective approach helps businesses maximize their reach, boost brand awareness, and achieve higher conversion rates.

Erhan et al., (2023) participated in the visions from "upper echelon (UE) theory" and the "attention-based view (ABV)" to discover how "digital marketing innovation" helps to improve organizational performance in the context of a pandemic by examining the comprehensiveness of "top management team (TMT) decision-making" and

"environmental dynamism." It is found that Digital marketing innovation has become essential for enhancing organizational performance, especially during the unpredictable environment created by the COVID-19 pandemic. The interaction between **top management team (TMT) decision-making** and **environmental dynamism** plays a pivotal role in this context The effectiveness of decision-making by the TMT is crucial for successfully implementing digital marketing innovations. A proactive TMT that embraces change, invests in new technologies, and encourages a culture of innovation can quickly adapt to the challenges posed by the pandemic. Strategic decisions, such as reallocating resources toward digital channels or enhancing online customer experiences, can significantly influence performance outcomes. During the pandemic, organizations faced heightened environmental dynamism, necessitating rapid responses to shifting consumer needs and market conditions. Companies that are agile and responsive to these changes through digital marketing innovations can maintain or even enhance their competitive edge. The integration of digital marketing innovation with effective TMT decision-making and a keen awareness of environmental dynamism can lead to improved organizational performance. Companies that innovate their marketing strategies can better engage with customers, increase sales, and strengthen brand loyalty. Additionally, organizations that adapt quickly to changing conditions are more likely to survive and thrive in uncertain environments. digital marketing innovation, when supported by effective TMT decision-making and responsiveness to environmental dynamism, significantly enhances organizational performance during a pandemic. This strategic alignment enables firms to navigate challenges, seize new opportunities, and maintain a competitive advantage in an ever-evolving marketplace.

Jung and Shegai (2023) addressed the mediating effect of "marketing capability" on relation between "marketing capability and firm performance" and investigated the impact of "digital marketing innovation on firm performance". The potential moderating influence of firm's size on this mediation is also been explored. It is then revealed that Firm size can significantly moderate the relationship between marketing capability and overall organizational performance. Larger firms typically possess more resources, including financial capital, human expertise, and technological tools, which can enhance their marketing capabilities. This allows them to invest in comprehensive marketing strategies, data analytics, and customer engagement initiatives that smaller firms might find challenging to implement due to resource constraints. Bigger firms often have established brand recognition and broader market reach, allowing their marketing capabilities to have a more pronounced impact on performance. They can leverage their size to conduct large-scale marketing campaigns, benefiting from economies of scale that enhance their competitive advantage. Conversely, smaller firms may demonstrate greater agility and adaptability in their marketing strategies due to less bureaucratic decision-making processes. They can quickly respond to market changes and innovate their marketing approaches more swiftly than larger firms. This flexibility can allow them to capitalize on niche markets or emerging trends that larger firms might overlook. firm size plays a crucial moderating role in marketing capability. While larger firms benefit from resource availability and established market presence, smaller firms can leverage agility and strong customer relationships. Understanding this dynamic helps organizations tailor their marketing strategies and capitalize on their unique strengths based on their size.

Nuseir and Refae (2022) says that in a competitive and digitally evolving market, insurance companies that leverage DMCs—such as personalized marketing, social media campaigns, and data-driven insights can effectively target diverse customer segments, tailor offerings, and create stronger relationships with clients. By using digital platforms and analytics, firms can also optimize their marketing spend, track customer behaviour, and adapt quickly to market trends. This digital transformation not only boosts sales and customer satisfaction but also positions UAE insurers as innovative and customer-centric, leading to higher profitability and market share. DMCs enable insurance companies to reach a wider audience through targeted digital campaigns. Utilizing data analytics and customer insights, firms can identify potential customers and tailor their marketing strategies accordingly. DMCs allow insurers to create personalized experiences by leveraging customer data to deliver relevant content and offers. DMCs help insurers build loyalty through consistent communication and value-added services. Additionally, personalized content and targeted marketing can encourage policy renewals and cross-selling opportunities, further enhancing customer retention. By analyzing data from various digital touchpoints, firms can identify trends, customer needs, and potential areas for improvement, leading to more effective marketing efforts and product offerings.

Paul, Mittal & Srivastav (2016) studied that enhanced customer engagement and experience involve creating meaningful interactions that connect customers with a brand across various touchpoints. By personalizing communications, responding promptly to feedback, and providing valuable content, businesses can foster deeper relationships and build loyalty. An engaging and seamless customer experience increases satisfaction, encourages repeat purchases, and turns customers into brand advocates. This holistic approach not only meets customer needs but also differentiates a brand, leading to sustained growth and competitive advantage.

Joensuu-Salo and Matalamäki (2023) investigates the effect of "digital capability on firm performance and growth". Findings show that smaller firms have lower digital capability compared to "larger small and medium enterprises (SMEs)" and struggle with performance metrics. Digital

capability is positively linked to both firm performance and growth. It also improves customer insights, enabling firms to customize products, services, and marketing strategies to align better with customer needs, resulting in increased sales and customer loyalty. Additionally, by adopting digital solutions such as e-commerce, automation, and data analytics, firms can expand their operations and enter new markets, fostering sustainable growth. Overall, digital capability offers a competitive edge, supporting both immediate performance improvements and long-term growth. It is also suggested that while multiple factors influence the growth trajectory of firms, digital capability enhances the opportunity creation process and aids survival in a competitive market. Digital capability is an essential asset for SMEs, helping them sustain their business model's viability.

Duah et al. (2024) relation between "marketing capabilities, resource orchestration capacity, and firm performance" in the context of modern business environments is investigated by the researchers, revealing that Marketing capabilities and resource orchestration capacity are closely linked and together they significantly impact firm performance. Marketing capabilities, such as brand management, customer relationship management, and market analysis, help firms effectively connect with their target audiences and build customer loyalty. However, the effectiveness of these capabilities is enhanced when firms have strong resource orchestration capacity—the ability to allocate, integrate, and deploy resources efficiently. By aligning marketing capabilities with the right resources, firms can implement marketing strategies more effectively, optimize their marketing mix, and respond quickly to market opportunities or challenges. This synergy leads to higher sales, improved customer satisfaction, and overall competitive advantage, thereby boosting firm performance.

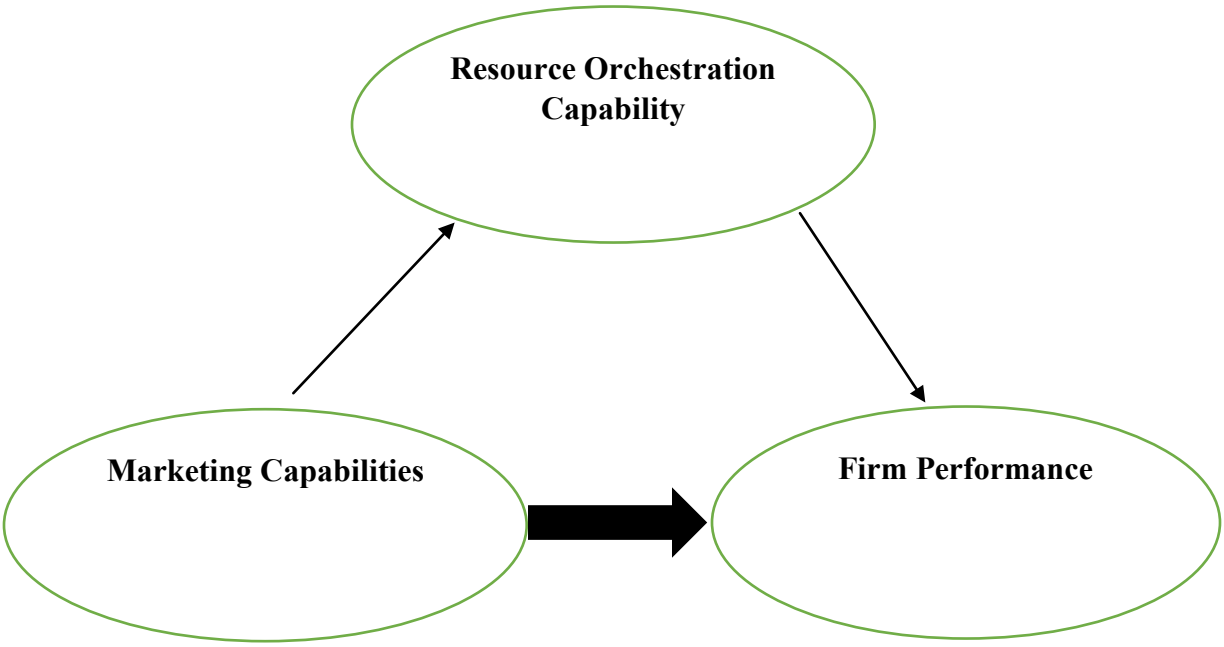

Figure 2 Relations between "marketing capabilities, resource orchestration capacity, and firm performance"

Tariq et al. (2022) says that digital marketing capabilities enable firms to explore new market opportunities through innovative campaigns, social media engagement, and data analytics, helping them identify customer needs and preferences. Digital marketing capabilities empower firms to tap into new market opportunities by leveraging innovative campaigns, engaging with audiences on social media, and utilizing data analytics. Through targeted strategies and creative content, businesses can effectively reach potential customers, enhance brand visibility, and drive conversions. The ability to analyze consumer behaviour and market trends allows companies to adapt quickly, ensuring they remain competitive and responsive to the ever-evolving digital landscape. At the same time, these capabilities facilitate the utilization of existing offerings by boosting customer engagement, optimizing marketing strategies, and strengthening brand loyalty. Based on the study results, the researcher urges decision-makers and managers to explicitly outline all tasks, roles, and operational procedures within organizations by leveraging digital marketing systems to enhance organizational ambidexterity and improve overall performance.

Salim and Issa (2024) investigated the impact of "digital marketing on customer behaviour and identified effective platforms for businesses". Digital marketing significantly influences customer behavior by shaping how consumers discover, engage with, and purchase products. The rise of online platforms has led to increased access to information, enabling customers to make more informed decisions. Personalized marketing strategies, such as targeted ads and tailored content, enhance user experience and foster brand loyalty. Digital marketing significantly influences customer behaviour by enhancing engagement, facilitating informed decision-making, and personalizing experiences. Through targeted advertising, social media interaction, and content marketing, businesses can reach customers more effectively, leading to increased awareness and interest in their products or services. Digital marketing fosters higher engagement levels through interactive content, social media, and personalized communication. Customers are more likely to respond to brands that actively engage with them online. Access to vast amounts of information allows customers to research products and services before making purchases. This transparency leads to more informed decision-making and can influence brand loyalty. This trend has accelerated, particularly in response to the COVID-19 pandemic. The study concluded that businesses that effectively harness digital marketing strategies and platforms experience enhanced customer engagement, increased sales, and improved brand loyalty. Companies that adapt to changing consumer behaviours and leverage data-driven insights are better positioned to succeed in the competitive digital landscape.

3. RESEARCH GAP IDENTIFICATION

Identifying research gaps in the study of effective digital marketing capabilities and their impact on firm performance is essential for advancing the field. It is observed that limited research has been conducted on the **integration of digital and traditional marketing strategies** and how this combination influences overall firm performance. This important as many firms still use traditional marketing methods alongside digital platforms. Understanding the synergistic effect of integrated marketing approaches can provide firms with more comprehensive strategies for improving performance. Much of the existing research focuses on general digital marketing practices, with **limited industry-specific analyses**. Sectors like manufacturing, healthcare, or B2B services are underrepresented in terms of how digital marketing affects firm performance. There is insufficient research comparing the **effectiveness of digital marketing capabilities in small firms versus large firms.** Most studies focus on large organizations with significant marketing budgets, overlooking the unique challenges faced by smaller firms. Small and medium-sized enterprises (SMEs) may have different capabilities, resource limitations, and market needs, and the impact of "digital marketing on performance" could vary significantly compared to larger firms. The **role of emerging technologies** such as "AI, machine learning, blockchain, and virtual/augmented reality" in enhancing digital marketing capabilities and their specific impact on firm performance is underexplored. There is a lack of comprehensive research on how **geographical and cultural factors** influence the success of digital marketing strategies across different markets. Firms operating in global markets need insights into how digital marketing performs in diverse regions. Factors such as consumer behaviour, regulatory environments, and digital infrastructure vary, influencing the effectiveness of digital marketing campaigns. Many studies tend to focus on metrics like ROI, conversion rates, or market share, but there is limited research on the **link between customer-centric metrics** (e.g., customer satisfaction, engagement, brand loyalty) and firm performance outcomes. Although studies exist on various digital channels, research comparing the **effectiveness of different channels in different contexts** is limited. While there is a growing interest in sustainability, there's limited research on how **digital marketing can promote sustainable practices** and drive growth without compromising ethical or environmental concerns. Most research emphasizes financial metrics, but there is a lack of focus on how digital marketing capabilities impact **non-financial performance metrics** (such as employee satisfaction, brand reputation, and corporate social responsibility) which is very important as non-financial metrics are increasingly becoming critical for long-term success, especially as firms look to enhance their brand's value and societal impact. Understanding this relationship can provide a more holistic view of firm performance. The integration of digital and traditional marketing strategies remains largely unexplored, as does the influence of external factors such as market dynamics and consumer behavior changes. Lastly, there is a need for more research focusing on small and medium-sized enterprises (SMEs) to understand how they leverage digital marketing capabilities compared to larger firms. Addressing these gaps could enhance strategic frameworks for effectively utilizing digital marketing to boost firm performance. These research gaps may help to understand the full scope of digital marketing's impact on firm performance, leading to more nuanced strategies and innovative solutions for businesses.

4. OBJECTIVE

1. To know the role and Impact of "Effective digital marketing Capabilities" on the "firm's performance".

5. METHODOLOGY

A sample of 221 individuals from the digital marketing department was surveyed to examine the role and impact of effective "digital marketing capabilities on firm performance". This study is based on a survey conducted using a structured questionnaire specifically designed for this research. The primary data was collected using a "random

sampling method, " and "multiple linear regression analysis" was employed to derive the results.

6. FINDINGS

The table below presents the general details of the respondents. Out of a total of 221 respondents, 57.0% are male and 43.0% are female. Additionally, 35.7% are below 36 years of age, 37.6% are between 36 and 42 years old, and the remaining 26.7% are above 42 years of age. In terms of job roles, 18.5% work as Search Engine Optimization specialists, 24.0% are social media specialists, 16.7% are Email marketing specialists, 31.2% are digital marketing specialists, and 9.5% hold other positions within the digital marketing department.

TABLE 1: Demographic details

"Variable"	"Respondents"	"Percentage"
Gender		
Male	126	57.0
Female	95	43.0
Total	**221**	**100**
Age		
Below 36 yrs	79	35.7
36-42 yrs	83	37.6
Above 42 yrs	59	26.7
Total	**221**	**100**
Designation		
Search Engine Optimization specialist	41	18.5
Social media specialist	53	24.0
Email marketing specialist	37	16.7
Digital marketing specialist	69	31.2
Others	21	9.5
Total	**221**	**100**

TABLE 2: Role of Effective digital marketing Capabilities on the firm's performance

S. No.	Role of Effective digital marketing Capabilities on the firm's performance	Mean values
1.	Digital marketing capabilities increase brand awareness and reach	3.67
2.	Enhance Customer Engagement and Experience	3.62
3.	Improves Data-Driven Decision-Making process	3.77
4.	Promote Targeted Marketing and Better ROI (Return On Investment)	3.91
5.	Enhance Competitive Advantage	3.80
6.	Improves Sales Growth and Lead Generation	3.88
7.	Improves Brand Loyalty and Advocacy	3.86
8.	Effective digital marketing Capabilities help firms in Scalability and Cost-Effectiveness	3.63
DV	Overall Impact of Effective digital marketing Capabilities on the firm's performance	3.80

Table 2 shows the mean values of the variables showing different Role of Effective digital marketing Capabilities on the firm's performance where highest mean value 3.91 is shown by Promote Targeted Marketing and Better ROI (Return On Investment) followed by Improves Sales Growth and Lead Generation with mean value 3.88, Improves Brand Loyalty and Advocacy (3.86), Enhance Competitive Advantage (3.80), Improves Data-Driven Decision-Making process (3.77), Digital marketing capabilities increase brand awareness and reach (3.67), Effective digital marketing Capabilities help firms in Scalability and Cost-Effectiveness (3.63) and Enhance Customer Engagement and Experience with mean value 3.62.

7. "MULTIPLE LINEAR REGRESSION"

TABLE 3: Model Summary

"Model"	"R"	"R Square"	"Adjusted R Square"	"Std. Error of the Estimate"
1	.805[a]	.648	.634	.50898
a. Predictors: (Constant), Increased Brand Awareness and Reach, Enhanced Customer Engagement and Experience, Data-Driven Decision Making, Targeted Marketing and Better ROI (Return On Investment), Competitive Advantage, Sales Growth and Lead, Generation Improved Brand Loyalty and Advocacy & Scalability and Cost-Effectiveness				

The value of the adjusted R-squared is 0.634, indicating that the model explains approximately 64% of the variation.

TABLE 4 ANOVA

"Model"		"Sum of Squares"	"df"	"Mean Square"	"F"	"Sig."
1	Regression	100.916	8	12.615	48.693	.000[b]
	Residual	54.921	212	.259		
	Total	155.837	220			

DV: Overall Impact of Effective "digital marketing Capabilities" on the "firm's performance"

b. Predictors: (Constant), Increased Brand Awareness and Reach, Enhanced Customer Engagement and Experience, Data-Driven Decision Making, Targeted Marketing and Better ROI (Return On Investment), Competitive Advantage, Sales Growth and Lead, Generation Improved Brand Loyalty and Advocacy & Scalability and Cost-Effectiveness

The impact of the independent variables on the dependent variable is detailed in the table above, and the significance value of 0.000 indicates that one or more of the variables have a significant effect on the dependent variable.

TABLE 5: Coefficients"

"Model"	"Un standardized Coefficients"		"Standardized Coefficients"	"t"	"Sig."
	"B"	"Std. Error"	"Beta"		
(Constant)	-.333	.247		-1.348	.179
Increased Brand Awareness and Reach	.104	.036	.127	2.900	.004
Enhanced Customer Engagement and Experience	.101	.047	.107	2.136	.034
Data-Driven Decision Making	.128	.047	.146	2.752	.006
Targeted Marketing and Better ROI (Return On Investment)	.037	.044	.037	.832	.406
Competitive Advantage	.187	.069	.189	2.720	.007
Sales Growth and Lead Generation	.179	.070	.177	2.567	.011
Improved Brand Loyalty and Advocacy	.255	.065	.258	3.914	.000
Scalability and Cost-Effectiveness	.102	.041	.109	2.520	.012

a. DV: Overall Impact of Effective "digital marketing Capabilities" on the "firm's performance"

Table 5 shows that in total 8 variables, 7 variables which are Increased Brand Awareness and Reach, Enhanced Customer Engagement and Experience, Data-Driven Decision Making, Competitive Advantage, Sales Growth and Lead, Generation Improved Brand Loyalty and Advocacy & Scalability and Cost-Effectiveness are showing significant impact of Effective digital marketing Capabilities on the firm's performance. Highest impact is shown by Improved Brand Loyalty and Advocacy with beta value .258 followed by Competitive Advantage (.189), Sales Growth and Lead Generation (.177), Data-Driven Decision Making (.146), Increased Brand Awareness and Reach (.127), Scalability and Cost-Effectiveness (.109) and Enhanced Customer Engagement and Experience with beta value .107.

8. CONCLUSION

The literature of different studies highlighted that effective digital marketing capabilities play a crucial role in enhancing a firm's performance across various dimensions, including customer engagement, brand awareness, revenue growth, and competitive positioning. Digital marketing capabilities enable firms to connect with a broader audience through diverse channels such as "social media, email marketing, SEO, and content marketing". By leveraging these tools, firms can engage more effectively with their target audiences, leading to higher customer acquisition and retention rates. Consistent and well-executed digital marketing strategies help firms build and maintain a strong brand identity, which enhances customer trust and loyalty. This, in turn, positively influences long-term customer relationships and brand equity. Digital marketing capabilities allow firms to deploy targeted and measurable campaigns that optimize marketing budgets and deliver higher ROI (Return on investment) compared to traditional marketing methods. The use of analytics tools and performance metrics

provides firms with valuable insights to refine strategies and enhance efficiency. Access to customer data and real-time analytics enables firms to make informed, data-driven decisions. By understanding customer behaviour, preferences, and trends, firms can personalize their offerings and marketing efforts, leading to more effective campaigns and improved business outcomes. The adaptability and scalability of digital marketing tools allow firms to quickly respond to "market changes, customer demands, and emerging trends." This flexibility helps businesses remain competitive in dynamic markets and expand their reach when necessary. Firms that effectively implement digital marketing strategies gain a competitive edge by setting industry standards and capturing larger market shares. This advantage is particularly evident for companies that continuously innovate and adapt their digital marketing practices to align with evolving market conditions. Overall, the study confirms that effective digital marketing capabilities are a critical driver of firm performance, providing measurable benefits that include increased customer engagement, improved brand loyalty, and higher profitability. The impact is amplified when digital marketing is aligned strategically with overarching business objectives and supported by the right technology, expertise, and data analytics capabilities. For companies to maintain these advantages, they must also remain agile and consistently adapt to the fast-evolving digital marketing environment.

The present study was conducted to know the Impact of "Effective digital marketing Capabilities" on the "firm's performance" and found that increased Brand Awareness and Reach, Enhanced Customer Engagement and Experience, Data-Driven Decision Making, Targeted Marketing and Better ROI (Return On Investment), Competitive Advantage, Sales Growth and Lead Generation, Improved Brand Loyalty and Advocacy & Scalability and Cost-Effectiveness are the factors showing significant impact of Effective digital marketing Capabilities on the firm's performance.

9. IMPLICATIONS

Effective digital marketing capabilities significantly impact a firm's performance, offering numerous benefits that can enhance competitiveness, customer engagement, and overall profitability. There are number of implications of the study such as the study recommends to invest in advanced digital marketing tools and strategies which help firms to establish stronger relationships with customers, gather valuable insights through data analytics, and tailor their offerings more precisely. The study also has several important implications for businesses and marketers. Firstly, it underscores the necessity of investing in and developing robust digital marketing capabilities, as these directly contribute to improved firm performance. Organizations that effectively harness digital tools and strategies are better positioned to enhance their online visibility, engage with customers, and ultimately drive sales growth. Additionally, the findings suggest that companies should prioritize continuous learning and adaptation to stay competitive in the rapidly evolving digital landscape. This may involve training employees in the latest digital marketing trends and technologies to ensure that the organization can respond swiftly to market changes. Moreover, the study highlights the importance of integrating digital marketing with traditional marketing strategies, as a cohesive approach can optimize overall marketing effectiveness. Finally, it encourages businesses, particularly small and medium-sized enterprises (SMEs), to leverage digital marketing capabilities to enhance their competitiveness, as effective digital strategies can level the playing field against larger competitors. Overall, the implications of this study can guide organizations in crafting more effective marketing strategies that contribute to sustained business success.

Firms must prioritize digital brand management and invest in technology that allows for real-time customer interaction and feedback to reinforce customer loyalty. It is also suggested to companies to focus on creating superior digital experiences to differentiate themselves in the market, leading to higher customer retention and positive word-of-mouth, further improving their competitive positioning. Firms should invest in data analytics capabilities and skills to make better marketing and business decisions, driving growth and profitability. The study suggests firms to integrate digital marketing efforts with performance measurement tools to continually optimize campaigns and maximize return on investment. Firms must be agile and responsive in their digital marketing approach, enabling them to leverage emerging trends and technology to maintain a competitive edge. The study also suggests firms to incorporate digital marketing into their strategic plans to capitalize on its potential for improving market performance and growth. There's a need for continuous learning and development in digital marketing skills, as technology and trends evolve rapidly. The study says that Investment in cutting-edge marketing technology and analytics tools is crucial for gaining actionable insights and optimizing campaigns. Firms should align digital marketing efforts with overall business objectives, ensuring that marketing campaigns drive business outcomes like increased revenue, market share, and customer satisfaction.

10. LIMITATIONS

While effective digital marketing capabilities can positively impact a firm's performance, there are limitations and challenges associated with studying this impact. It is a challenge to isolate the specific effects of digital marketing capabilities on a firm's performance, as performance outcomes may be influenced by various other factors like market conditions, competitive actions, product quality, and pricing strategies. Digital marketing activities can yield both short-term (e.g., an increase in website traffic or sales during a campaign) and long-term impacts (e.g., brand loyalty,

customer lifetime value). Measuring these effects accurately and consistently over time is difficult. Along with this, Access to high-quality data is essential for assessing digital marketing effectiveness. It is also observed that the impact of digital marketing capabilities varies significantly across different industries, business models, and geographic markets. The effectiveness of digital marketing capabilities depends heavily on the quality of execution, including how well strategies are implemented and adapted to changing market conditions.

Poor execution can lead to suboptimal outcomes, regardless of the potential of the capabilities. Demonstrating a causal relationship between “digital marketing capabilities and firm performance” can be challenging. Many studies may show a correlation but cannot definitively prove that improvements in digital marketing directly cause enhanced performance. Firm performance can be measured in various ways, such as revenue growth, market share, customer engagement, or brand perception. The selection of performance metrics can introduce subjectivity, as not all firms prioritize the same outcomes.

11. FURTHER RESEARCH AGENDA

To deepen understanding of the impact of “effective digital marketing capabilities” on “firm performance”, further research is needed to explore various dimensions and address existing limitations. The researcher may examine the long-term effects of digital marketing capabilities on firm performance, including customer loyalty, brand equity, and customer lifetime value. Studies may also focus on short-term outcomes; long-term studies can provide insights into the sustained benefits and challenges of digital marketing strategies.

The studies may be conducted to explore how digital marketing capabilities impact firms across various industries (e.g., retail, technology, manufacturing) and identify industry-specific strategies that drive success. Investigate the impact of emerging technologies like “artificial intelligence, augmented reality, and machine learning on digital marketing capabilities and firm performance”.

Study how the quality of digital marketing implementation influences the overall effectiveness of digital marketing capabilities. Develop comprehensive frameworks for measuring the impact of digital marketing on firm performance, taking into account both short-term and long-term metrics. In future studies, researcher may explore how digital marketing capabilities can be leveraged to promote a firm’s sustainability initiatives and how this impacts consumer perceptions and business performance. By addressing these areas, future research can provide deeper insights into how digital marketing capabilities influence firm performance and help firms optimize their strategies for maximum effectiveness in a rapidly changing digital landscape.

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3

Effectiveness of Codebasics and Dataprofessor: A Comparative Study of Chosen Edutech Companies

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ABSTRACT

In recent years, educational YouTube channels have grown rapidly, increasing by 300% to 400% from 2019 to the present. This paper examines two such channels—Codebasics and Data Professor—which began around the same time yet display vastly different growth patterns. Using YouTube API data from a sample of 958 Codebasics videos and 346 Data Professor videos, this study explores factors influencing their performance disparities, employing descriptive statistics, correlation, scatterplots, and trend analyses with Python.

Results show that Codebasics averages 109, 087 views and 2, 478 likes per video, with a top view count of 16.3 million, compared to Data Professor's 19, 665 average views and 468 likes, peaking at 438, 352 views. Codebasics achieves a 3.71% engagement rate by focusing on short, targeted content, with videos under 40 minutes attaining viral success, while Data Professor maintains steady, lower engagement. Correlation analysis reveals a strong positive correlation between views and likes for both channels (Codebasics: 0.99, Data Professor: 0.96), though Codebasics shows a weaker correlation with comments (0.34) than Data Professor (0.78).

These findings underscore Codebasics viewer-centric approach as a key driver of its success, suggesting a strategic model for other channels to increase engagement. Expanding this research with sentiment analysis could offer deeper insights into viewer feedback and emotional responses, potentially guiding content strategies for new educational channels.

Keywords: YouTube, Descriptive analytics, Correlation analysis.

1. INTRODUCTION

The digitalization in education has revamped how the knowledge is created, shared and consumed by the people, making YouTube a great platform for learning. In recent years, there is a significant increase in use of YouTube to gain knowledge and skills among students and professionals, which has become a key player in global knowledge economy where the knowledge is shared among countries without any barriers.

The present study focusses on two Educational YouTube channels – Codebasics and Data professor, which started around the same time, and both contribute to the same domain which is data science yet exhibiting noticeable differences in growth and popularity. With the help of Google cloud console, by using YouTube API data the current research analyses critical metrics like comments, views, likes, video duration to reveal the strategic approaches that make a channel successful. These findings aim to guide emerging YouTube educational channels on how to foster engagement rate, growth and popularity in the current increasing digitalized world.

2. REVIEW OF LITERATURE

You Tube serves as a pool of data source for research and analysis, allowing content creators, businesses and scholars to derive useful insights from channel metrics and audience interaction.The main objective of Raval's study is to extract the data automatically from YouTube and focus on key metrics like video likes, comments, posting time for real time data analysis to know the components for video's success. The Methodology used in this study is API-based Data Extraction. In this article google-auth, google-auth-oauthlib libraries are used for data extraction from YouTube and pandas is used for data analysis. The analysis concluded that the metrics mentioned above can provide insights into real time analysis allowing creators to take strategic decisions. The future scope of this study can include more advanced analytical tools and techniques to forecast video success . Using the same method as Raval but Aman's objective includes incorporation of correlation matrix and visualizations for better understanding of the results obtained in data analysis of you tube's video success. The Methodology used can be named as API-based Data Extraction with visualization and the libraries Matplotlib and seaborn were used for visualization, Pandas for data analysis. The Key findings of this study includes that the correlation plots and visualizations like bar chart, histogram, scatterplot, bar plot helped in effective understanding of how different metrics were affecting video's performance rather than simple data analysis. The future scope of this study can be extended by creating interactive dashboards by using visualization tools and the inclusion of machine learning algorithms to better forecasting .In contrast to above studies where they used Google cloud console APIs to extract the data from YouTube, Deepakshi's study included the Web

scraping methodology using selenium and BeautifulSoup libraries in python where selenium is used for automating web scraping activities and BeautifulSoup is to extract relevant data from youtube. The objective of this study is exploring alternate methods of data extraction when google cloud console access is limited to certain reasons. This method helped in extracting wider data from the youtube which wouldn't be possible with API for analysis. The future scope of this research includes incorporating machine learning algorithms for better analysis of the data..

Research done by, primarily focused on mining and preprocessing the unstructured data from the YouTube and analyzed the prediction of courier services from a dataset obtained from Kaggle. The methodology used in this article is Decision Tree Machine learning algorithm in R studio. The analysis of this article concluded that the used machine algorithm is efficient in predicting outcomes based on the metadata from the dataset. The future cope of this study can be extended by integrating more complex machine learning algorithms for the prediction improvements.

Sentimental analysis is a great way to understand perception of the business by the customers. The main objective of this study is exploring how Natural Language Processing (NLP) can be used to analyze the YouTube comments and to derive insights into audience sentiments. The Methodology used in this article is text blob for conducting sentimental analysis and word cloud for visualizing sentiments of audience in comments libraries in python and the data is derived through API collection of comments or can also be done through web scraping. The comments are classifying into positive, Negative and neutral based on which the analysis is done and are visualized through word clouds. This research provided how the audience received the videos and can help the creators align accordingly, likewise wordclouds provide a visual representation of themes used by the audience in the comments. The limitations of this study include involving more complex NLP techniques to identify mixed emotions or sarcasm. The above research by Yash is expanded by Ritika and Ayush by including Machine algorithms into the analysis for accurate insights. They used six different algorithms like naïve-Bayes (NB), Support Vector Machine (SVM), Logistic Regression (LR), Decision Tree (DT), K-Nearest Neighbor (KNN) and Random Forest (RF). These algorithms helped in classifying the you tube comments into broader categories rather than simple sentimental analysis. The key findings of this study proved that the machine learning algorithms improved the accuracy of analysis. Among all the algorithms used Random Forest and support Vector Machine algorithms performed well in providing accurate insights. Word clouds or tag clouds are used for the visual or graphical representation of the user sentiments. The future scope of this research involves usage of deep learning tools to further improve classification of sentiments.. The main objective of Bindhu Shravani & Ramalakshmi's research was to use machine learning algorithms to predict the growth and popularity of you tube channels based on their meta data like tags and titles. The methodology used in this article is machine learning algorithm Random Forest and Naïve Bayes that is applied to meta data that is extracted from the you tube. The article proved that Random Forest algorithm was able to predict the views from the metadata and the Naïve bayes was able to predict the category. The research also included word clouds, correlation plots and regression plots for better understanding of the analysis. They build an AI model using Random Forest Regressor based on the labels of the videos. The future work of this study can be done by integrating their model to create a website which can predict the views and is easily accessible to everyone. .

The main objective of Mohan's study is to integrate YouTube data with SQL and MongoDB for large-scale analysis and for the future use. The Methodology used in this study in YouTube API for data extraction and SQL, MongoDB for storage, analysis and for future use. The packages used in this article were pandas, streamlit, pymongo, mysql-connector-python, sqlalchemy, PyMySQL, isodate, google-api-python-client, plotly. The key findings of this research includes that integration of YouTube data with SQL and MongoDB was able to analyze large scale data which allowed for creation of interactive dashboards to monitor the channel's performance based on the extracted data. Here SQL is used for the storage of structured data and MongoDB is used for unstructured data. The future scope of this can include using other databases for the unstructured data and can involve creating real time visualization based on live data. The Research done by Johanes Fernandes Andry focused on how tableau can be used for analyzing YouTube datasets to know the insights about user engagement and content trends. The research used the dataset from Kaggle, which has all the trending videos from multiple countries. It included pie charts to represent the categorical proportions like video category distribution, Tree maps are used to represent hierarchical data structures, Area charts are used to show trends over time. The article covered metrics like views, likes, comments to analyses video performance across different regions. The key findings of this article are Tableau proved to be effective in visualizing youtube's data and delivered what type of content is preferred across various regions. As Tableau is interactive and we can get the specific data using filters in it, this article used drill down to get specific data based on regions which helped to make informed decisions based on user engagement metrics. The future scope of this study can be done by expanding the dataset to other video platforms and broader audience interaction .

3. RESEARCH GAP IDENTIFICATION:

MULTIPLE DIMENSIONAL ANALYSIS: While prior studies have primarily focused on individual metrics like views or likes (,), there is limited work on exploring combined impact of multiple metrics like engagement

metrics, video length, posting time, to understand the audience in a more comprehensive way.

COMPARITIVE STUDY: Although existing works have analyzed and worked on various metrics and machine learning algorithms, there is very rare analysis of studies that compare and analyze content from similar domains, such as educational YouTube channels

4. OBJECTIVES

The primary objective of this study is to compare the performance metrics of the two YouTube channels – Code basics and Data professor that focus on education in the same field of teaching data science.

- To compare the growth in terms of performance metrics like views, comments, likes, duration and upload time.
- To identify factors influencing audience engagement across two channels.
- To Provide insights for smaller channels to improve their content strategy and audience interaction.

5. METHODOLOGY:

5.1. Data Collection:

Data for both the channels Code Basics and Data Professor is derived using YouTube Data API from Google Cloud Console using below python code.

- The metrics collected include:
- No. of Likes for each video
- No. of Comments for each video
- No. of Views for each video
- Video Duration
- Upload time
- Tags associated with each video

The code to extract Codebasics channel metrics is as follows:

```
1. import requests
2. import re
3. from datetime import datetime
4. API_KEY = 'AIzaSyCOwGgCxs1bCzu5O6SB_zYkSuUVw53UpxU'
5. CHANNEL_ID = 'UCh9nVJoWXmFb7sLApWGcLPQ'

6. # Step 1: Get the uploads playlist ID
7. channel_url = f'https://www.googleapis.com/youtube/v3/channels?part=contentDetails, statistics&id={CHANNEL_ID}&key={API_KEY}'
8. channel  response = requests.get(channel_url)
9. channel_data = channel_response.json()

10. # Extract the uploads playlist ID and subscriber count
11. uploads_playlist_id = channel_data['items'][0]['contentDetails']['relatedPlaylists']['uploads']
12. subscriber_count = channel_data['items'][0]['statistics']['subscriberCount'] # Subscriber count
13. # Step 2: Fetch all video IDs from the uploads playlist
14. def get  video  ids_from_playlist(playlist_id, api_key):
15.  video_ids = []
16. base_url = 'https://www.googleapis.com/youtube/v3/playlistItems'
17.  params = {
18.   'part': 'contentDetails',
19.   'playlistId': playlist_id,
20.   'maxResults': 50,
21.   'key': api_key
22.  }
23.  while True:
24.   response = requests.get(base_url, params=params)
25.   data = response.json()
26.   for item in data['items']:
27.    video_ids.append(item['contentDetails']['videoId'])
28.   # Check if there's a next page
29.   if 'nextPageToken' in data:
30.    params['pageToken'] = data['nextPageToken']
31.   else:
32.    break
33.  return video_ids

34. # Get all video IDs from the playlist
35.  video  ids  =  get_video_ids_from_playlist(uploads_playlist_id, API_KEY)

36. # Function to convert ISO 8601 duration to minutes
37. def duration_to_minutes(duration):
38.  match = re.match(r"PT(\d+H)?(\d+M)?(\d+S)?", duration)
39.  # Extract hours, minutes, and seconds
40.  hours = int(match.group(1)[:-1]) if match.group(1) else 0
41.  minutes = int(match.group(2)[:-1]) if match.group(2) else 0
42.  seconds = int(match.group(3)[:-1]) if match.group(3) else 0

43.  # Convert total duration to minutes (including seconds fraction)
44.  total_minutes = hours * 60 + minutes + seconds / 60
45.  return round(total_minutes, 2)

46. # Function to convert ISO 8601 upload time to readable format
47. def convert_upload_time(upload_time):

48.  # Convert from ISO 8601 format to 'YYYY-MM-DD HH:MM:SS'
49.  dt_obj = datetime.strptime(upload_time, "%Y-%m-%dT%H:%M:%SZ")
50.  return dt_obj.strftime("%Y-%m-%d %H:%M:%S")

51. # Step 3: Fetch detailed statistics for all videos, including duration, description, and tags
52. def get_video_statistics(video_ids, api_key):
53.  video  stats = []
54.  base_url = 'https://www.googleapis.com/youtube/v3/videos'
55.  for i in range(0, len(video_ids), 50): # The API allows up to 50 IDs per request
56.   ids = ', '.join(video_ids[i:i + 50])
```

```
    params = {
     'part': 'snippet, statistics, contentDetails',
     'id': ids,
     'key': api_key
    }
    response = requests.get(base_url, params=params)
    data = response.json()
    for item in data['items']:
     video_info = {
      'videoId': item['id'],
      'title': item['snippet']['title'],
                                                    'upload_time':
convert_upload_time(item['snippet']['publishedAt']),
 # Convert upload time
                                                    'duration':
duration_to_minutes(item['contentDetails']['duration']),
# Convert duration to minutes
      'tags': item['snippet'].get('tags', []), # Video tags
      'views': item['statistics'].get('viewCount', 0),
      'likes': item['statistics'].get('likeCount', 0),
      'comments': item['statistics'].get('commentCount', 0)
     }
     video_stats.append(video_info)
    return video_stats

# Fetch video statistics, including detailed information like duration, description, and tags
video_statistics = get_video_statistics(video_ids, API_KEY)
# Print subscriber count
print(f'Subscriber count for the channel: {subscriber_count}')
# Print the statistics for each video
for video in video_statistics:
 print(video)
```

The code to extract Data professor channel metrics is as follows:

```
import requests
import re
from datetime import datetime
import pandas as pd # Import statement for pandas
                                    API_KEY                                    =
'AIzaSyDsPSANIqyhk79XWMhFs1VbQNItQmWhk6s'
CHANNEL_ID = 'UCV8e2g4IWQqK71bbzGDEI4Q'

# Function to convert ISO 8601 duration (PT5M35S) to minutes
def duration_to_minutes(duration):
 if pd.isna(duration) or not isinstance(duration, str):
  return None
 match = re.match(r'PT(\d+H)?(\d+M)?(\d+S)?', duration)
 if not match:
  return None # If duration doesn't match the expected pattern
 hours = int(match.group(1)[:-1] if match.group(1) else 0)
 minutes = int(match.group(2)[:-1] if match.group(2) else 0)
 seconds = int(match.group(3)[:-1] if match.group(3) else 0)
 total_minutes = hours * 60 + minutes + seconds / 60
 return round(total_minutes, 2)

# Function to convert upload time to readable format
def convert_upload_time(upload_time):
 if pd.isna(upload_time) or not isinstance(upload_time, str):
  return None
 try:
  return datetime.strptime(upload_time, '%Y-%m-%dT%H:%M:%SZ').strftime('%Y-%m-%d %H:%M:%S')
 except ValueError:
  return None # Handle incorrect format

# Step 1: Get the uploads playlist ID
                                    channel_url                                    =
f'https://www.googleapis.com/youtube/v3/channels?part=contentDetails, statistics&id={CHANNEL ID}&key={API_KEY}'
channel_response = requests.get(channel_url)
channel_data = channel_response.json()

# Extract the uploads playlist ID and subscriber count
                                    uploads playlist id                                    =
channel_data['items'][0]['contentDetails']['relatedPlaylists']['uploads']
                                    subscriber count                                    =
channel_data['items'][0]['statistics']['subscriberCount'] # Subscriber count

# Step 2: Fetch all video IDs from the uploads playlist
def get_video_ids_from_playlist(playlist_id, api_key):
 video_ids = []
                                    base_url                                    =
'https://www.googleapis.com/youtube/v3/playlistItems'
 params = {
  'part': 'contentDetails',
  'playlistId': playlist_id,
  'maxResults': 50,
  'key': api_key
 }
 while True:
  response = requests.get(base_url, params=params)
  data = response.json()
  for item in data['items']:
   video_ids.append(item['contentDetails']['videoId'])

  # Check if there's a next page
  if 'nextPageToken' in data:
   params['pageToken'] = data['nextPageToken']
  else:
   break
 return video_ids

# Get all video IDs from the playlist
video_ids = get_video_ids_from_playlist(uploads_playlist_id, API_KEY)

# Step 3: Fetch detailed statistics for all videos, including duration, description, and tags
def get video statistics(video_ids, api_key):
 video_stats = []
 base_url = 'https://www.googleapis.com/youtube/v3/videos'
 for i in range(0, len(video_ids), 50): # The API allows up to 50 IDs per request
  ids = ', '.join(video_ids[i:i + 50])
  params = {
   'part': 'snippet, statistics, contentDetails',
   'id': ids,
   'key': api_key
  }
  response = requests.get(base_url, params=params)
  data = response.json()
```

```
70.  for item in data['items']:
71.   video_info = {
72.    'videoId': item['id'],
73.    'title': item['snippet']['title'],
74.                                                    'upload_time':
convert_upload_time(item['snippet']['publishedAt']), # Converted
upload time
75.                                                    'duration':
duration_to_minutes(item['contentDetails']['duration']), # Converted
duration in minutes
76.    'tags': item['snippet'].get('tags', []), # Video tags
77.    'views': item['statistics'].get('viewCount', 0),
78.    'likes': item['statistics'].get('likeCount', 0),
79.    'comments': item['statistics'].get('commentCount', 0)
80.   }
81.   video_stats.append(video_info)
82.  return video_stats

83. # Fetch video statistics, including detailed information like
duration, description, and tags
84. video_statistics = get_video_statistics(video_ids, API_KEY)

85. # Print subscriber count
86. print(f'Subscriber count for the channel: {subscriber_count}')

87. # Print the statistics for each video with only the converted
duration and upload time
88. for video in video_statistics:
89.  print(video)
```

The data collected for both the channels are stored in two different data frames dfcb for code basics and dfdp for Data professor.

```
1. import pandas as pd
2. # Convert the video statistics into a DataFrame
3. dfdp = pd.DataFrame(video_statistics)
4. # Display the DataFrame
5. print(dfdp.head())

6. import pandas as pd
7. # Convert the video statistics into a DataFrame
8. dfcb = pd.DataFrame(video_statistics)
9. # Display the DataFrame
10. print(dfcb.head())
```

5.2. Data Cleaning:

The Extracted data was cleaned to remove missing values and NA values.
There was only one missing value in Data professor data in duration which was removed using drop.na ()

```
1. #Data_cleaning
2. dfcb.isnull().sum()
3. dfdp.isnull().sum()
1. dfdp.dropna(inplace=True)
2. dfcb.dropna(inplace=True)
```

5.3. Descriptive Analysis:

The basic statistics like mean, median, Standard Deviation and Percentiles were calculated for both the channels which gave an understanding of distribution of metrics between the channels.

```
1. #Descriptive Analysis
2. pd.set_option('display.float_format', '{:.2f}'.format)
3.  dfcb_stats=dfcb[['views', 'likes', 'comments', 'duration',
'upload_time']].describe()
4. print(dfcb_stats)
5.  dfdp_stats=dfdp[['views', 'likes', 'comments', 'duration',
'upload_time']].describe()
6. print(dfdp_stats)
```

5.4. Engagement Rate Calculation:

The Engagement rate was calculated for videos of both the channels to understand the participation of audience across the two channels using the below formula

Engagement rate= (Likes + Comments) / Views * 100

```
1. # Calculate the engagement rate
2.  dfcb['engagement_rate'] = (dfcb['likes'] + dfcb['comments']) /
dfcb['views'] * 100
3.  dfdp['engagement_rate'] = (dfdp['likes'] + dfdp['comments']) /
dfdp['views'] * 100
4.
5.  # Display the engagement rate for both Codebasics and Data
Professor
6.  print("Codebasics Engagement Rates:")
7.  print(dfcb[['title', 'engagement_rate']].head()) # Display first few
rows
9.  print("\nData Professor Engagement Rates:")
10. print(dfdp[['title', 'engagement_rate']].head()) # Display first few
rows
```

5.5. Correlation Analysis:

A Correlation matrix was generated for the metrics likes, comments, views and duration to understand the relationship between the variables of two channels.

```
1. import matplotlib.pyplot as plt
2. import seaborn as sns
3. # Compute the correlation matrix
4. dfcb_corr = dfcb[['views', 'likes', 'comments', 'duration']].corr()
5. dfdp_corr = dfdp[['views', 'likes', 'comments', 'duration']].corr()
6. # Plotting the correlation matrix for Codebasics
7. plt.figure(figsize=(12, 5))
8. plt.subplot(1, 2, 1)
9.  sns.heatmap(dfcb_corr, annot=True, cmap="coolwarm",
cbar=True, fmt=".2f")
10. plt.title('Codebasics Correlation Matrix')
11. # Plotting the correlation matrix for Data Professor
12. plt.subplot(1, 2, 2)
13.  sns.heatmap(dfdp_corr, annot=True, cmap="coolwarm",
cbar=True, fmt=".2f")
14. plt.title('Data Professor Correlation Matrix')
15. plt.tight_layout()
16. plt.show()
```

5.6. Scatterplot:

A scatterplot is visualized to understand the impact of video duration on views of the videos, allowing us to understand the difference in channel popularity.

```
1. sns.scatterplot(data=dfcb, x='duration', y='views', label='Codebasics')
2. sns.scatterplot(data=dfdp, x='duration', y='views', label='Data Professor')
3. plt.title('Video Duration vs Views')
4. plt.show()
```

5.7. Trend analysis:

The evolution of views overtime was plotted for both the channels in respect to upload time, to understand whether it makes any difference in audience retention over time.

```
1. dfcb.set_index('upload_time')['views'].plot(label='Codebasics', figsize=(12, 6))
2. dfdp.set_index('upload_time')['views'].plot(label='Data Professor')
3. plt.legend()
4. plt.title('Views Trend Over Time')
5. plt.show()
```

6. RESULTS

6.1. Descriptive Statistics:

The interpretation for descriptive statistics are as follows:
Output for codebasics descriptive statistics is as follows:

```
1.  views  likes comments duration
2. count  963.00 963.00 963.00 963.00
3. mean 109037.27 2476.35  91.24  13.38
4. std  556813.49 13810.74 183.29  19.95
5. min  1142.00  27.00  0.00  0.08
6. 25%  8071.50 335.00  10.00  0.83
7. 50%  26291.00 806.00  37.00  6.98
8. 75%  98169.50 2016.00  97.00  16.34
9. max 16420473.00 408882.00 2595.00 199.43
```

Output for Data professor descriptive statistics is as follows:

```
1.  views likes comments duration
2. count 348.00 348.00 348.00 347.00
3. mean 19627.12 467.11  41.68  15.48
4. std 37667.47 886.48  46.24  18.95
5. min  0.00  0.00  0.00  0.27
6. 25%  3970.50 107.00  14.00  5.74
7. 50%  9035.50 249.00  29.00  10.67
8. 75% 19319.25 481.75  55.00  18.40
9. max 440360.00 10695.00 373.00 151.53
```

The channel Code basics have higher mean of views, likes and comments compared to the channel Data Professor. The Standard deviation for all metrics in Code Basics is higher indicating that there is wide range of content performance compared to the other channel.

6.2. Engagement Rate:

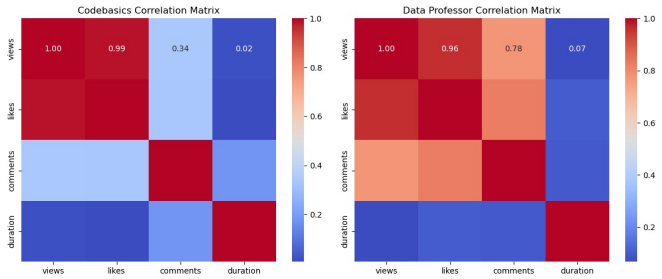
The interpretation for Engagement Rate is as follows:

```
1. Codebasics Engagement Rates:
2.  title engagement_rate
3. 0 Is Power BI the same as Excel? #powerbi #data ...  6.42
4. 1 SQL Query: Syntactical Order vs. Execution Ord...  9.24
5. 2  Is Statistical Machine Learning OUTDATED?  4.47
6. 3  How good is your memory? #shorts #codebasics  3.71
7. 4 100 Hoodies Giveaway! #shorts #codebasics #dat...  7.26
8.
9. Data Professor Engagement Rates:
10.  title engagement_rate
11. 0 Building a YouTube AI assistant for content cr...  5.99
12. 1  Data Science Podcast with Sebastian Flores  3.76
13. 2  How to level up in Gen AI  4.41
14. 3  Code your own YouTube AI assistant in Python  5.31
15. 4  Data Storytelling in Python  3.69
1. Average Engagement Rate for Codebasics: 3.710179493173169
2. Average Engagement Rate for Data Professor: 3.1748576840989475
```

The Engagement rate for code basics was consistently high compared to Data professor indicating that code basics might had more content relevance and better promotion strategies.

6.3. Correlation Analysis:

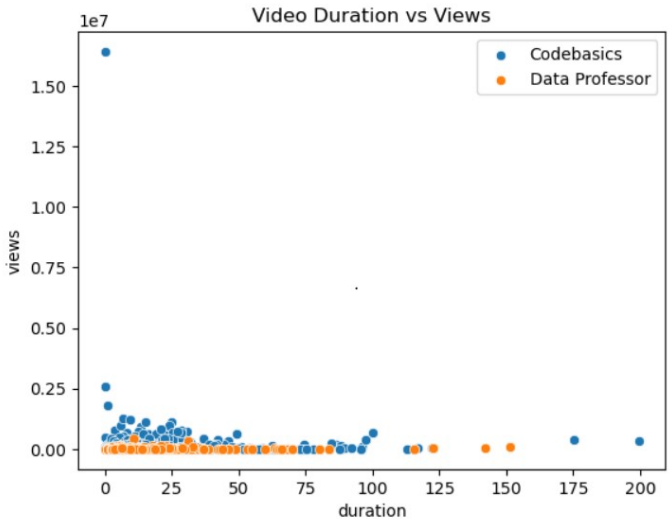
The interpretation for Correlation Analysis is as follows:



Both the channels had shown a strong positive correlation between likes, comments as well as between views and likes indicating that videos with more views tend to receive more likes and comments.

6.4. Scatterplot Analysis:

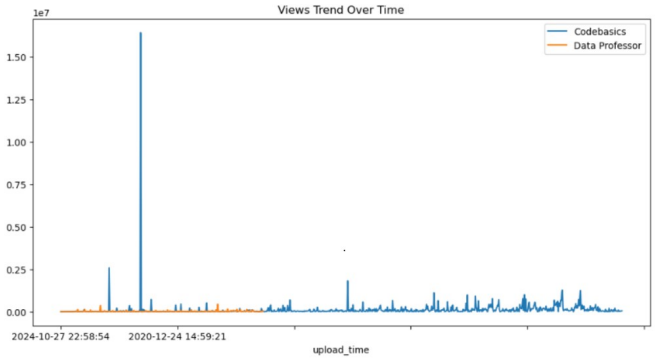
The interpretation for Scatterplot Analysis is as follows:



- The scatterplot of video duration against views shows that videos with less than 30 minutes duration had more views for both the channels.
- Code basics show highly viewed videos with shorter durations indicating that audience may prefer short videos with good content.
- Data professors view count was lower bit consistent across similar durations indicating that video length may not be enough to attract the audience to view the videos.

6.5. Trend Analysis:

The interpretation for Trend Analysis is as follows:



Code basics exhibited a few viewership spikes, with one video reaching 10 million views indicating that certain videos gone viral and reached more audience.

Data professor exhibited a consistent but lower view with no peaks as code basics indicating that there was a limited reach compared to code basics.

7. IMPLICATIONS

The study's conclusions have important ramifications for YouTubers who produce instructional content. According to the data, brief, targeted videos—like Codebasics' sub 40-minute productions—perform better in terms of views and engagement, indicating that viewers strongly favor shorter, more focused content. For smaller or up-and-coming channels looking to maximize their growth plans, this information is especially helpful. Additionally, Codebasics' greater engagement rates highlight how crucial it is to encourage audience interaction through likes, comments, and other engagement measures, as these can greatly increase visiblity.

In-depth performance analysis using YouTube API data offers researchers and artists a reproducible framework for data-driven decision-making, facilitating the discovery of expansion prospects and content improvement tactics. Adding sentiment analysis to this kind of analysis could improve comprehension of audience preferences and emotional reactions even more, assisting content producers in better matching their work to the expectations of their audience. Furthermore, Data Professor's consistent but constrained growth points to the necessity of creative content tactics to increase reach and engagement, such as integrating hot themes, partnerships, or a variety of multimedia features. All things considered, the study highlights the need of a viewer-centric strategy and provides a scalable analytical model for enhancing audience engagement and content production on digital platforms.

8. FUTURE SCOPE

Paper offers avenues for further research and practical applications. Expanding the analysis to include sentiment evaluation using Natural Language Processing (NLP) for the comments variable to get deeper insights into audience feedback and emotional responses, enabling content creators their strategies more effectively. Additionally, we can use advanced machine learning algorithms to improve the accuracy of performance predictions and robust the video success. Furtherly, there is scope for get new YouTube channels for educational videos to attract the people and gain some knowledge regarding to their subject contents this makes more efficient as comparative to educational platforms.

9. CONCLUSION

The comparative analysis between the two channels Code basics and Data professor revealed that engagement rate and audience interaction played a significant role in channel performance. Code basics higher engagement rate and strong correlation between all the metrics indicates good audience interaction while Data professor has a lower engagement rate.

Smaller channels like Data professor can increase their channel popularity and growth by boosting audience interaction and strategically tailoring the content for engagement of audience.

10. DECLARATION

I, Madineni Vineela, hereby confirm that the manuscript titled “EFFECTIVENESS OF CODEBASICS AND DATAPROFESSOR: A COMPARITIVE STUDY OF CHOSEN EDUTECH COMPANIES”. authored by Ms. Madineni Vineela, Mr. Rajagiri Jyothish Naga Vara prasad, Dr. Akondi Srikanth, has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to IIM Sambalpur Conference, 2025.

I/we declare that all necessary permissions have been obtained for any third-party materials included in the

manuscript, and appropriate citations and acknowledgments have been made where required.

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4

Ascendancy of Facebook Campaign on Young Voters in Haryana

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ABSTRACT

This study examines the influence of the Facebook campaign on young voters' political perceptions during the Haryana legislative elections in 2024. It also assesses the youth's ideological stance in Haryana, which influences their voting behavior. Politicians can now influence the public without regard to time or location by using an online campaign. This quantitative analysis is based on a poll of young voters in Haryana that was conducted by questionnaires. Results indicate that Facebook campaign has assumed the role of an initiator in influencing young people with education when it comes to voting. Facebook campaign was seen by respondents as biased when it came to expressing opinions and helping political organizations manipulate data to get more votes. However, since the majority of them haven't seen fake news, they either don't recognize it or take the material at face value. Additionally, respondents' cognitive capacities are not hindered by politicians' use of Facebook campaigns; rather, voters' decisions appear to be more influenced by their friends and family networks. The findings show that voters' decisions are significantly influenced by their ideological perspectives. Based on age and gender, there is no statistically significant variation in the respondents' voting behavior. The distinctiveness of this study lies in its emphasis on the communication channel between politicians and young people, rather than on the influence of socioeconomic divisions on voting behavior.

Keywords: Facebook campaign, political marketing, 2019 assembly election, social networking site, democracy and voting behavior

1. INTRODUCTION

A political election involves parties, political leaders, and voters in a multifaceted and intricate process. In the state of Haryana, several political parties run candidates in the elections. Among the significant political parties in Haryana are the Indian National Congress, Bhartiya Janta Party, Indian National Lokdal, and Jannayak Janta Party (Arora et. al., 2024). Several more powerful parties, such as the AAP, BSP, and others were also active in the Haryana elections to join the coalition. Elections in Haryana are overseen by the Chief Electoral Officer and are managed by the Election Commission of Haryana, just like in any other state. The Election Commission operates in conformity with the Constitution's Article 324. Haryana has elections at several levels, including the state (Vidhan Sabha or Assembly Elections), the federal level (Lok Sabha Elections), and the local municipal (urban) and Gram Panchayat (rural) levels. At present, Haryana has 90 Vidhan Sabha seats and 10 Lok Sabha seats (Atti and Mishra, 2024). The state's ten Lok Sabha constituencies are Ambala, Bhiwani-Mahendergarh, Faridabad, Gurgaon, Hisar, Karnal, Kurukshetra, Rohtak, Sirsa, and Sonipat. The fourth Lok Sabha elections, held in 1967 following Punjab's separation, were held. After then, there were elections in 1971, 1977, 1980, 1984, 1989, 1991, 1996, 1998, 1999, 2004, 2009, 2014, 2019 and the 18th Lok Sabha election was scheduled from 19th April to 1st June 2024 (). State assembly or Vidhan Sabha elections are regularly held in Haryana in a way similar to this within one or two months of Lok Sabha elections which was on 5th Oct 2024 (ECI, 2024). After the Haryana-Punjab partition, the Indian National Congress won the first assembly elections in 1966. However, the second assembly elections were held in 1967, just after the second assembly election. Afterwards, there were elections in 1968, 1970, 1977, 1982, 1987, 1991, 1996, 2000, 2005, 2009, 2014, and 2024. Seventeen seats are set aside for the SC in the fifteenth assembly elections, which recently held on 5th October 2024 over 90 constituencies. The 73rd and 74th constitutional amendments, which pertain to rural and urban municipalities, respectively, stipulate that local elections are conducted below the state level. The ninety-odd Haryana assembly constituencies are displayed in Figure 1 (ECI, 2024).

India witnessed a significant convergence of technological and political developments in the 2014 elections. Additionally, because of the nation's frequent election cycles, Facebook campaign saw an unprecedented level of citizen involvement with politicians. According to Statcounter's 2019 report, India has the highest number of Facebook users worldwide, with 3.07 billion people. Facebook users' political perceptions may be impacted by increased exposure to the social media platform, as seen by the increased usage observed in India. As stated by the Cambridge Dictionary, "A belief or opinion that is based on how something seems is called a perception." Facebook's constant and frequent interaction, free from State control, shapes people's political perceptions, particularly those of youth (Tsoumou, 2020). This is in contrast to China, where state institutions heavily regulate social media because of its state- centric focus (Hine and Floridi, 2022). Social media, especially Facebook,

provides consumers in India with a wide range of information that is unfiltered by government agencies.

Source: Government of Haryana.

Figure 1 Map showing the constituencies of Haryana

The purpose of this study to is to determine how Facebook campaign affects youth voting behaviour. How does the political campaign on Facebook affect young people's voting behaviours in Haryana? What are the ways in which the gender and age of educated youth are influenced by Facebook campaign to determine how they vote? (Barclay, 2015).

Facebook campaign, however, has grown in popularity in India as a venue for political advertising. Facebook ads from political parties can be highly effective in influencing a certain campaign by targeting particular demographics and geographic areas (Chou and Fu, 2017). Parties and politicians can interact with voters on Facebook by sharing their platforms, policies, and future goals. Facebook has the reputation of being able to spread content quickly, thus political parties and politicians can take advantage of this to generate interest in and support for their campaigns (Chan, 2016). With political leaders, parties, and their followers utilizing Twitter and Facebook to interact with the public, rally support, and sway public opinion, these social media sites have become indispensable in Indian politics (Sinha, 2021). Facebook is a social media platform that enables users to connect with others, share updates, images, and videos, and establish profiles. By creating an even playing field for political communication,

these platforms have made it possible for politicians to interact directly with their constituents and cut out traditional media outlets (Kaushik & Sharma, 2022). Social media has,

meanwhile, also been used to disseminate false information and fake news, which may have a detrimental effect on Indian politics. Researchers have examined the effects of social media use in Indian politics on voter attitude, political advertising, and engagement in a thorough analysis. The function of Facebook and Twitter in Indian politics will be discussed in this article, with particular emphasis on how they affected the country's general elections in 2014 and 2019 (Rao, 2019).

2. LITERATURE REVIEW

The connectivist approach explains how social media facilitates information sharing between users. Politicians use social media to engage with people and spread their message (Kaushik and Sharma, 2022). According to traditional agenda-setting models, the media shapes the public agenda by drawing attention to and elevating particular concerns in the eyes of the public. However, the traditional agenda-setting authority of the mass media is in danger due to growing selectivity and audience fragmentation in today's digital media environment. The increasing usage of social media for information and entertainment is a significant trend to take into account in light of this shift (Feezell, 2018). Social media makes it simple for people to support and distribute political content. By facilitating personal influence, these features may make partisan material more salient and increase the likelihood that users will read content that is endorsed (Ansapach, 2017). President Obama of the United States was the first politician to effectively use social media for election-related communication and campaigning. His strong use of social media helped him win the US presidential election. Once more, Obama's strong social media interaction with his supporters contributed to his win in the 2012 US election. During the Arab Spring in North Africa and West Asia, social media played a major role in organizing the populace against their monarchical governments. Social media has also helped a number of social and neo-social movements in other nations, like India, in addition to these (Kanungo, 2015).

In order to engage directly with individuals and encourage greater political dialogue and activity, political parties have also begun to use Facebook pages, groups, and events. Facebook is a platform for free speech and the unrestricted direct sharing of information amongst individuals of many nationalities, religions, and origins. As a result, during the election process, the younger generation has engaged in many forms of political communication (Sally and Wickramasinghe, 2020). The first-time social media was widely used in an Indian election was during the 2014 Lok Sabha elections. The Bhartiya Janata Party (BJP) recognized the importance of digital media and made an effort to incorporate it into their campaign strategies for the 2014 and 2019 Lok Sabha elections. Both mobile phones and social media platforms were heavily utilized by the BJP for its advertising. The 2014 Lok Sabha elections have been referred to as "India's first actual mediatized election" in comparison to previous elections (Alam, 2021)

To connect and interact with voters, political parties and candidates made heavy use of Facebook and Twitter during the general elections of 2014, 2019, and 2024 in India. Parties utilized a variety of strategies to influence voters' opinions, including political advertising, data analytics, and viral material. However, hate speech and fake news have also been disseminated via social media, which has had a detrimental effect on Indian politics (Siam and Islam, 2023). Political leaders can use Facebook as a platform to connect with voters on a personal level by showing them photos of their families enjoying local festivals, visiting regular people, having a cup of tea or dinner with them, and wishing them a happy holiday season complete with photos of their homes celebrating (Herkman, 2012). Politicians also highlight unimportant subjects on their pages, such as private matters, sentiments, and routine non- political activities (Jackson & Lilleker, 2011).

The Internet and Mobile Association of India (IAMAI, 2022) found that political parties extensively invested in social media advertising during the general elections of 2019. The analysis found that Facebook was the most popular medium for political advertising, accounting for around half of all advertising expenditures. Politics have become more casual, as described by Xenos et al. (2017), which refers to the in formalization of politics as a result of social media platforms like Facebook and terming them as a Modern connections with power. According to Ross and Burger (2014), voters like these unofficial structures' flexibility and immediacy. Politicians enable themselves to be portrayed as everyday people on social media in the hopes that by fusing political rhetoric with sentimental speech, voters would see them as a good fit and a representative of their community. Politicians are capable of having sincere conversations with the public and acting upon their opinions in addition to listening to them (Dean, 2014). These developments in digital technology suggest a change in the way the public and politicians interact, which may also signal a change in the distribution of political power. Facebook campaign has the potential to improve democracy by facilitating communication between the public and officials. According to ECI (2019), there were nearly 18 million voters in the state of Haryana. Political parties could use Facebook campaign to reach 6.9 million voters in Haryana, according to Facebook Ad Manager (Diwakar, 2017).

Model of the Study

Many theories attempt to forecast the conduct of voters, including the Michigan approach, the Downsian theory, the rational choice theory, and the Columbia School of Thought. This part will address the various aspects that these theories consider when forecasting voting behavior. Following that, we will examine our approach for the study model. According to the Columbia School of Thought, voters'

sociological traits will predominate over cognitive criteria, and their influence on voting behavior will rely on how attached they are to caste, race, religion, and ethnicity. A novel idea of cross-pressure on electoral conduct has been developed as a result of this strategy (Mahsud & Amin, 2020). When members of different social groups present contradicting information and persuade them to alter their voting behavior, this is known as cross-pressure. This theory focuses more on voters' social traits, which are the subject of in-depth research in the local setting. The theoretical game model of political engagement was also proposed by Downsian theory. In 1957, Downs presented the voter participation equation (Hansen et al., 1987). Down mentioned the following formula.

$$Rw = (Be)(Pe) — C + D$$

R_W = Reward gains after voting
B_e = Benefit
P_e = Perception of the probability (his or her vote will change the outcome)
C = Cost of individual voting (money, time)
D = Psychic stratification person gains from voting

The economics theory of Downsian (1957) is founded on precise calculus. It prioritizes cost reduction and elector benefit maximization. Since this model focuses more on maximizing public services, it is not necessary for our investigation. At the micro level, rational choice theory focuses on how people's cognitive abilities affect their decision-making. The focus of rational choice theory, according to Radner (1982), is on options, constraints, and strategic calculation as well as how these factors affect personal choices. At the individual level, rational choice theory formalizes the work of empirical researchers, but at the collective level, it generates counterintuitive notions.

According to Michigan's approach, voters are the main actors in the election process, and their social context indirectly influences their partisan and ideological affiliation. Voters have the final say over their choices, and social context serves as a funnel. Campbell and Kahn (1952) devised this method. They take into account three important factors that voters take into account when choosing a candidate. Party affiliation, issue orientation, and candidate orientation are these characteristics. Voters' loyalty to a political party, regardless of their formal participation in party events and membership, is known as party identification. The voter's social group, peer group, and family all influenced their party affiliation. Issue orientation is the tendency of young people to focus on topics that are more significant to them and that voters believe are critical to their advancement. Candidate orientation refers to the mannerisms, public statements, and gestures that candidates use to convey their style and tactics. The party identification that was formed early in life due to sociological causes provides the foundation for both issue orientation and candidate orientation (Sajid et al., 2024). The Michigan method is used in this study because it considers the social context of individuals, and in this study, we consider Facebook campaign to be a social setting of teenagers that affects their choices. This technique takes into account three variables that align with our study questions: party identity, issue orientation, and candidate orientation.

3. METHODOLOGY

This study is quantitative and is based on a survey. The study's primary goal is to evaluate Facebook's impact on educated youths' voting behavior. The pertinent scholarly literature was reviewed to create a semi-structured questionnaire. Strongly Disagree to Strongly Agree was the range of the five-point Likert-type scale used in the survey. The survey consists of three sections: demographic data, Facebook campaign are used during the 2024 parliamentary elections, and the impact of Facebook use on voting behavior. There are also two open-ended questions. A calculation of Cronbach's alpha has been made to confirm the reliability. Nine assertions about how users believe Facebook campaign affects their voting behavior have a Cronbach's alpha value of 0.79, indicating internal consistency par excellence. The population is divided into subgroups based on shared traits using proportional stratified random sampling. According to a probabilistic foundation, samples were selected from subgroups, meaning that every person had an equal chance of being chosen. In summary, this demographic will be useful in understanding Facebook's overall influence on voting behavior. The Taro Yamani formula was used to determine the sample size (Krejcie & Morgan, 1970).

$$n = \frac{N}{1 + N\,(e)^2}$$

n = sample size; N = population size; e = margin of error; n = 381.

In order to figure out if there was a problem with the questionnaire's comprehension that needed to be fixed, a test of the questionnaire was done beforehand. Furthermore, before filling out the questionnaire, each voter gave their informed consent. Respondents did not receive any honoraria or supplementary perks for their voluntary participation in this poll. Their names were kept private and they were free to leave at any point during the data collection process. Along with a questionnaire and cover letter, a consent form was created and signed by each respondent. The surveys were given out at random, and they were examined impartially. Responses from these people were excluded from the survey itself. Based on the input of a few students who were not included in the population, minor adjustments were made to the questionnaire. Students completed a questionnaire survey following pretesting. Questionnaires were completed and returned to the surveyor using a proportional stratified random sampling technique, which states that the size of each stratum is proportionate to the size of the stratum population as viewed from an overall population.

Participants also received assistance when required. The Statistical Package of Social Sciences was used to enter the gathered data (STATA version 17). Descriptive analyses, including Mean and SD, were carried out following database formation and are shown in Figure 1 as tabular and pie chart data.

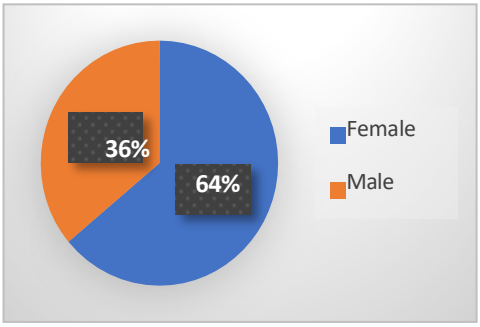
4. RESULTS AND DISCUSSION

In the context of Haryana, the research concerns center on how Facebook campaign affects young people's voting patterns and ideological perspectives, as was previously mentioned. There were four sections created in the questionnaire. The demographic questions in the first section—which asked about age, gender, and educational program—helped gauge Facebook's influence on these factors. Questions about Facebook usage, frequency, and purpose were asked in the second section. Youth perceptions of Facebook were the focus of the third portion. The respondents were asked to rate their opinions on nine items using a five-point Likert scale that ranged from strongly disagree to strongly agree (Sajid et al, 2024).

A descriptive test was used on the data set after it was generated using Stata software. Open- ended questions about the youths' political party identification and ideological inclinations were included in the fourth and final section. Demographic Information

The results of the research show that 399 participants participated in the study. Of the 399 responders, 255 (64 percent) were female and 144 (36 percent) were male, as shown in Table1. With 65 female respondents in the 25–32 age group, the great majority of the 255 female respondents (151 respondents) were between the ages of 18 and 24. Of the respondents who were female, only 39 were in the age range of 33 to 40. Of the 144 male respondents, 82 were 19–24 years old, and 44 were 25–32 years old. Between the ages of 18 and 24, 233 (58 percent) of the respondents were in this age range; 109 (27 percent) were in the 25–32 age range; and 57 (14 percent) were in the 33–40 age range. India's voting age is eighteen.

Figure 1: Number of Respondents (N=399) Table 1: Demographic Characteristics of the Respondents (N=399)



Source: Author's calculation

Age	Female	Male	Total
18-24	151	82	233
25-32	65	44	109
33-40	39	18	57
	255	144	399

Source: Author's calculation

The present study indicates that 87 percent of youth believe social media political campaigns affect their voting behavior. Because of the media's wide informational reach, people are more conscious of everything, including politics (Gill & Ritchie, 2020). Political information exposure increases public understanding, which may result in better voting decisions.

According to Table 2, of the 399 respondents, 53 (13 percent) use Facebook campaign for informational purposes, 79 (20 percent) use it solely for amusement, and 53 (3 percent) use it to find out what other people think of them. Additionally, 232 people (58 percent) use Facebook for all of the aforementioned reasons. According to the findings, the majority of young people use Facebook for all kinds of activities.

TABLE 2: Purpose of using social media (399)

Purpose	Frequency	Percentage
Entertainment	79	19.85
Information	53	13.32
Opinion awareness	13	3.27
Entertainment, Information	10	2.51
Information, Opinion awareness	2	0.50
Entertainment, Opinion awareness	9	2.26
All of the above	232	58.29

Source: Author's calculation

In Table 3, data showed how frequently people used Facebook. Of the respondents, 169 (42 percent) used Facebook multiple times a day, 103 (26 percent) used it once a day, and six (2 percent) were constantly signed in. Additionally, 68 (17 percent) of the respondents reported using Facebook one to two times per week, while 52 (13 percent) reported using Facebook infrequently. These days, young people are also drawn to other platforms like Twitter, Instagram, and Snapchat.

TABLE 3. Frequency of Facebook Use Among Youth

Use	Frequency	Percentage
Always logged in	6	1.51
Several times a day	169	42.46
Once a day	103	25.88
1–2 times a week	68	17.09
Rarely	52	13.07
Total	398	100

Source: Author's calculation

Early in the twenty-first century, social networking sites (SNS) like Myspace, Facebook, LinkedIn, and Twitter are readily available worldwide, and other SNSs like Spotify, Tumblr, Foursquare, and Pinterest have started to appear to fill niches in the social network. This is according to Hendricks (2013). According to the results, there is a disparity in the degree of Facebook usage between those who use it frequently (2 percent) and those who use it infrequently (13 percent). This result disproved Scott & Ravenscroft (2017) findings, which showed a sharp rise in Facebook usage in the US between 2012 and 2018. This paradox suggests that Facebook usage is less intense in developing nations than in developed nations. A study conducted by the Pew Research Center on teenagers, social media, and technology indicates that the social media landscape is less centered on a single platform than it was three years ago (Ooi et al, 2023).

The influence of Facebook campaign on voting behavior was demonstrated by data. A five- point Likert scale, ranging from strongly disagree to strongly agree, was used to gauge the respondents' opinions on nine statements in Table 5. The findings demonstrate that the majority of young people think Facebook affects how they vote. All nine assertions had mean values ranging from 2.55 to 2.79. The mean value of 2.70 is assigned to the statement, "Facebook displayed bias when expressing opinions." Kroll-Smith et al. (2002) found that people's consciousness is generated by media follow-up of information, which is consistent with this conclusion. The results show that exposure to unrestrained material on Facebook makes people more aware of the differences between objective and subjective opinions.

TABLE 4. Effect of Facebook campaign on Voting Behavior (*N* = 399)

I think during Haryana's 2024 Parliamentary election, Facebook campaign:	Mean	SD
spread rumors as authentic news	2.72	1.15
Motivated users to vote	2.66	1.01
Influenced political views through blogs and opinions	2.55	1.16
Provided different lenses to understand the political structure	2.77	1.09
Lacked ethical check of content posting	2.70	1.18
Assisted political entities to manipulate data to increase their vote bank	2.65	1.11
Impaired rational thinking of users	2.74	1.04
Codified rules for political advertisement improve information reliability.	2.79	1.06
Showed biasedness while expressing views	2.70	1.17

Source: Author's calculation

It is important to note that, on a five-point Likert scale, respondents' mean score for their perception of Facebook's assistance in helping political bodies alter data to boost their vote bank during the 2024 parliamentary election was 2.65. People are aware of the marketing strategies and tactics politicians employ, as this finding demonstrates. In addition to directly influencing its audience's cognitive thinking, political marketing reduces the gap between voters and politicians. By offering a platform to collect information on users' preferences, Facebook campaigns further improved these tactics. Academic researchers can also use a variety of tools to harvest information from people's profiles and groups. Numerous programs assist in obtaining information from Facebook campaign, such as "application program interface, netvizz, and direct database access to the company server." (Rieder, 2013). Though there isn't a strict system in place to guarantee that these programs are used exclusively for educational reasons.

It is noted that during the 2024 elections, respondents considered the ethical check of Facebook campaign content posting (M = 2.70), after which Facebook gave them a variety of lenses to comprehend the political structure (M = 2.77). They believed that Facebook campaign had an impact on their political views and opinion through blogs (M = 2.55). Additionally, it motivated people to cast votes in the 2024 parliamentary elections (M = 2.66). Facebook's campaign mean motivation score of 2.66 indicates that it motivates people to cast votes.

To encourage people who don't use their right to vote seriously, a practice of uploading inked thumb photos with voting-related messages was observed on Election Day of the 2024 Haryana parliamentary elections. With a mean score of 2.79, respondents thought that Facebook's campaign codified guidelines for political advertisements increased the credibility of the material.

The findings indicate that young people were content with the new guidelines Facebook campaign created to increase the accuracy of its information. Facebook campaign disseminated rumors as authentic news having a mean score of 2.72. This demonstrates that young people do not trust the news and information blindly that are shared on Facebook campaigns. Table 5 shows that Facebook campaign impact on male respondents' (N = 144) voting behavior has a mean value of 2.66 (SD = 0.79). Comparatively, impact of Facebook campaign on voting behavior was numerically

significant for female respondents (N = 255), with M = 2.72 (SD = 0.92).

TABLE 5: Gender-Based Disparities Regarding the Effect of Facebook campaign on Voting Behavior.

Factor	Male		Female				
	Mean	SD	Mean	SD	t-Value	df	P value
Effect of Facebook campaign on Voting Behaviour	2.66	0.79	2.72	0.92	0.62	397	0.52

Source: Author's calculation

An independent sample t-test was used to see whether the mean opinions of the male and female responder groups about Facebook campaign impact on voting behavior differed statistically substantially. As indicated in Table 5, the independent sample t-test was linked to a statistically significant effect (t (397) = 0.62, p =.52), with the p-value exceeding the alpha value of.05. Therefore, there was no statistically significant difference in their opinions about how Facebook campaign affects voting behavior based on gender.

Using a one-way ANOVA, respondents' opinions about impact of Facebook campaign on their voting behavior in the 2024 parliamentary election were analyzed for statistically significant differences in the mean by age group. We measured the F score, p-value, mean, and SD. The findings indicated that, according to age groups, the p-value, or value of significance, was 0.00, which was less than the alpha value (.05). This p-value demonstrated that the respondents' opinions on their age level differed statistically significantly. Table 6 illustrates the varying opinions of people of different ages on the impact of Facebook campaign on their voting behavior during the Haryana parliamentary election of 2024.

TABLE 6: Age-Based Difference Regarding the Effect of Facebook campaign on Voting Behavior.

Factor	18-24		25-32		33-40				
	Mean	SD	Mean	SD	Mean	SD	F	df	P value
Effect of Facebook campaign on Voting Behavior	2.86	0.97	2.37	0.63	2.68	0.67	12.01	396	0.00

Source: Author's calculation

Figure 2 shows the youth's party identification and ideological inclination. As per the data and figure, 49 percent of young people identified as right-wing, 22 percent as liberal, and 14 percent as left-wing. The findings show that young people's ideology has changed.

This ideological shift from liberal to rightist political ideology is seen in the top percentage share of 49. Notably, the BJP, a right-wing party, emerged victorious in the election and was able to form the government for the record third consecutive time with the full majority of 48 seats out of 90 with 39.94% of the total vote polled. The outcome of the 2024 assembly elections shows the dramatic shift in young people's ideological inclinations from liberal to conservative.

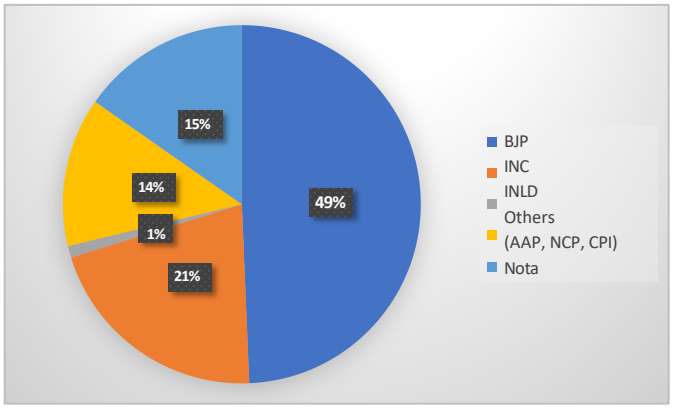


Figure 2: Political ideology of youth (*N* = 379).

Source: Author's calculation

5. CONCLUSION

Facebook campaign has significantly influenced young people's voting behavior by serving as a social milieu in which they presently reside. Our survey reveals that 42% of young people in Haryana use Facebook campaign many times a day, which indicates that Facebook campaign influences their voting decisions, the extent of its influence varies with the frequency of its use. Facebook campaign affected young people's partisanship in the 2024 Haryana parliamentary elections, as we witnessed a change from liberal to rightist political parties. Furthermore, Facebook campaign social context is made up of peer and family networks that shape opinions and define political issues for young people of all genders while taking age groups into account to help them concentrate on issues that the public finds most important. The role of identity politics in elections in Haryana cannot be ignored because the state is a pluralistic and ethnically diverse society, and young people who use Facebook are members of various ethnic groups that have an impact on them. However, in the 2024 Haryana parliamentary elections, young people made the historic choice to choose a different political party, demonstrating that Facebook campaign creates a virtual social reality that

has a greater impact on young people than the real one. One other noteworthy fact is that the BJP was the first to use Facebook campaign for political campaigns in the 2014 general elections. It reaps the benefits of its efforts in the 2019 and 2024 general elections at the country level along with bigger states. It's fair to claim that Facebook campaigns has made virtual reality more accessible.

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5

Neurobiology of Storytelling in Advertising: Impact on Audience

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ABSTRACT

Studying the relationship between neurobiology and storytelling has become very interesting. This explores the complex relationship between the narrative devices used in advertising campaigns and the responses of the human brain. This paper explores the neurobiology of storytelling in advertising with the help of hypothesis neural engagement and brand recall, emotional storytelling and consumer decision making, cross cultural variances in neural processing and long term effect on brain perception. Paper start with the storytelling perception of the Disney, Coca-Cola, Manchester United and Apple, further analyze these brand with the hypothesis. This paper also works on the data set with the parameters types of storytelling, neurotransmitter level, heart rate variability and purchase intent score and identify the descriptive statistics and regression based equations of all the parameters. At the end it is identified, a purchase based on an emotional connection formed through a storytelling advertisement.

Keywords: Emotional Storytelling, Brand Recall, Decision Making, Data Analysis, Neural Processing

1. INTRODUCTION

In the dynamic realm of advertising, the art of storytelling has transcended traditional narrative boundaries to become a potent tool in capturing the attention and emotions of consumers. At the intersection of neuroscience and marketing, the "Neurobiology of Storytelling in Advertising" emerges as a fascinating exploration into the intricate workings of the human brain and how it responds to narrative stimuli. As brands seek to forge deeper connections with their audiences, understanding the neurological underpinnings of storytelling becomes paramount [Dallimar 2012]. This interdisciplinary approach delves into the realms of cognitive science, psychology, and marketing, unraveling the mysteries of why certain stories resonate more profoundly, create lasting impressions, and ultimately drive consumer behavior. This exploration into the neurobiology of storytelling not only sheds light on the mechanisms that make advertisements memorable but also offers a unique lens through which marketers can craft narratives that leave an indelible imprint on the minds of their target audience. In this journey through the neural pathways of storytelling, uncover the science behind the art, deciphering how narratives wield the power to shape perceptions, influence decisions, and establish enduring brand-consumer relationships [Dietz 2005]. Neurobiology is the branch of biology that focuses on the structure and function of the nervous system, including the brain. It is an interdisciplinary field that combines principles from biology, psychology, physics, and computer science to understand the cellular and molecular processes that govern the development, structure, and function of the nervous system. The nervous system is a complex network of cells, including neurons and glial cells, that work together to process information and generate responses to stimuli [Edwards 2016]. Storytelling in advertising is a strategic approach that involves using narrative techniques to convey a brand's message or values in a compelling and memorable way. Instead of simply presenting information about a product or service, storytelling weaves a narrative that engages the audience emotionally and creates a connection between the brand and the consumer. This approach recognizes the power of stories to capture attention, evoke emotions, and leave a lasting impression [Everard 2016].

In the context of the neurobiology of storytelling in advertising, researchers explore how the brain responds to narrative stimuli, examining the neural processes involved in perceiving, processing, and interpreting stories. This involves investigating how storytelling activates different regions of the brain, influences emotions, and shapes cognitive responses [Fielding 2008a, Fielding 2008b]. There are lots of work already to be done in the field of storytelling in the advertisement. **Moin et al. [Moin 2020]** explain effect of storytelling in the destination brand. The analysis involves breaking down advertisements to evaluate elements such as their narrative structure, story category, archetype portrayal, and experiential results. The results reveal that a significant number of destination commercials do not incorporate cutting-edge storytelling practices, indicating a missed chance. Utilizing the Hero's Journey as a tool can assist destination marketers in crafting compelling promotional videos that effectively resonate with and captivate potential tourists. **Cetin et al. [Cetin 2021]** describe effect of digital storytelling in the education system. This study seeks to investigate the impact of the digital storytelling process on the digital literacy skills of pre-service teachers, delving into the creation process in detail. The research involved 36 pre-service teachers specializing in computer education. Data collection utilized the digital literacy assessment scale, digital storytelling assessment scale, and an opinion form assessing the digital story creation process. The results indicate significant variations in the digital literacy levels of

pre-service teachers following engagement in the digital story creation process. **Long et al. [Long 2022]** discuss the effect of storytelling to improve healthcare worker understanding, beliefs, and practices related to LGBTQ + patients. Post-event surveys, along with written reflections/notes during five biannual storytelling events in Baltimore, Maryland spanning from 2016 to 2018, were employed for evaluation. Additionally, a survey was conducted among healthcare workers (HCW) in a citywide care collaborative, focusing on HIV prevention and treatment for LGBTQ+ individuals, to assess the impact on those who attended the storytelling events compared to those who did not. The analysis involved measuring differences in understanding, beliefs, and practices through surveys, along with a thematic qualitative analysis of written reflections/notes from the storytelling events. Of the 416 attendees at storytelling events, 124 (30%) completed post-event surveys, and 449 written reflections/notes were gathered. Among the healthcare workers, 56 completed post-event surveys, with 49 (87.5%) strongly agreeing/agreeing that they had a better understanding of LGBTQ+ patients. **Table 1** shows the different research work related to the storytelling in advertisement.

TABLE 1: different research work related to the storytelling in advertisement

Science Direct Paper				
Years	2000-2005 (107)	2006-2010 (242)	2011-2015 (291)	2016-2023 ()
Article Types	Review articles (60)	Research articles (976)	Encyclopedia (53)	Book chapters (351)
	Conference abstracts (6)	Book reviews (16)	Case reports (1)	Conference info (3)
	Discussion (8)	Editorials (15)	Mini reviews (1)	News (2)
	Short communications (17)	Other (90)		
Publication Title	Journal of Business Research (115)	Public Relations Review (53)	Journal of Retailing and Consumer Services (32)	Business Horizons (29)
Publication Title	Computers in Human Behavior (28)	Industrial Marketing Management (25)	Tourism Management (25)	Journal of Pragmatics (22)
	Tourism Management Perspectives (20)	Technological Forecasting and Social Change (19)	Futures (19)	Annals of Tourism Research (18)
	Evaluation and Program Planning (18)	International Journal of Information Management (15)	Journal of Cleaner Production (15)	Journal of Destination Marketing & Management (13)
	Telematics and Informatics (12)	Journal of Interactive Marketing (12)	Procedia - Social and Behavioral Sciences (12)	International Journal of Hospitality Management (11)
	Computers and Composition (11)	Procedia Computer Science (11)	Poetics (10)	International Journal of Research in Marketing (9)
	Journal of Business Venturing (9)			
Subject Areas	Business, Management and Accounting (626)	Social Sciences (568)	Arts and Humanities (324)	Psychology (219)
	Computer Science (176)	Medicine and Dentistry (113)	Agricultural and Biological Sciences (71)	Decision Sciences (49)
	Environmental Science (46)	Engineering (45)		
Taylor and Francis				
Article	Research Article (6368)	Book Review (527)	Other (370)	Review Article (76)
	Editorial (51)	Introduction (40)	Abstract (28)	Article Commentary (19)
	Essay (15)			
Subject Areas	Humanities (3380)	Communication studies (1165)	Social Sciences (1119)	Economics, Business and Finance (957)
	Arts (943)	Area Studies (926)	Language and Literature (914)	Education (889)
	Politics and international relations (515)	Behavioral Sciences (435)		

The primary objective of the study on the Neurobiology of Storytelling in Advertising is to comprehensively investigate and understand the neurobiological mechanisms underlying audience responses to different storytelling styles in advertising campaigns. The goal of this study is to clarify the complex interactions that exist between neurobiological elements such as neurotransmitter levels and heart rate variability and the storylines used in advertising. The ultimate objective is to give advertisers useful information on

how different narrative techniques affect brain responses and, in turn, affect customer behaviour, especially with regard to Purchase Intent Scores.

2. APPLICABLE HYPOTHESIS:

This assessment is work on the basis of following hypothesis:

- **H 1: Neural Engagement and Brand Recall:**

Statement: Increased neural engagement during storytelling in advertising will positively correlate with higher brand recall among consumers.

Rationale: This hypothesis provides the sense of customer and how customer remember the particular brand. It also shows the effect of neurons to and how neuron work towards the storytelling of the advertisement. Anticipate that greater levels of involvement in particular brain regions will be linked to improved brand memory by monitoring neural activity during exposure to advertising stories [Davydiuk 2023].

Justification: The term "neuronal engagement" describes the degree of involvement and activity of the brain during information processing. Narrative frameworks that can arouse feelings, conjure up memorable scenes, and activate different brain regions linked to attention and memory are frequently used in commercial storytelling [De Angelis 2012]. Viewers may have more brain engagement during this storytelling advertisement as they become emotionally invested in the characters and plot.

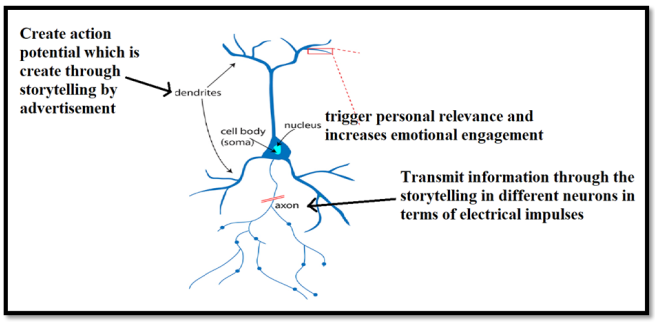

Figure 1: Analogy between neurons and storytelling based advertisement

Figure 1 shows the analogy between neurons and storytelling based advertisement. The advertisement's story framework may stimulate the brain's emotional, empathic, and memory centers. Because of this increased brain activation, there is a greater chance that the brand and the car that goes along with it will stick in the mind of the spectator. Because of the deep neural impression left by the captivating story, buyers are more likely to remember the brand mentioned in the storytelling advertisement when they decide to buy a car in the future. Studies in neuroscience and advertising corroborate this association between better neural engagement and higher brand recall, showing that emotionally charged and narratively driven content tends to have a longer-lasting effect on memory [Dessart 2018]. As a result, marketers frequently work to develop narrative campaigns that not only grab viewers' attention right away but also have a lasting effect on them, thus increasing brand recall [Domingo 2020].

- **H2: Emotional Storytelling and Consumer Decision-Making:**

Statement: The use of emotionally charged storytelling in advertising will correlate with a higher likelihood of positive consumer decision-making.

Rationale: Strong emotional reactions can be elicited via emotional storytelling, which can impact consumers' attitudes and decision-making. Anticipate that emotionally compelling advertisements will influence consumers to make better choices [Eberhardt 2021].

Justification: The goal of emotional storytelling is to present stories that cause the audience to feel something. These feelings might be anything from inspiration and nostalgia to happiness and empathy. Consumer decision-making is a multifaceted process that is impacted by feelings, perceptions, and ties to specific brands [Eisend 2006, Erdogan 1999, Escalas 2007]. **Figure 2** shows the psychological mechanism with storytelling based advertisement.

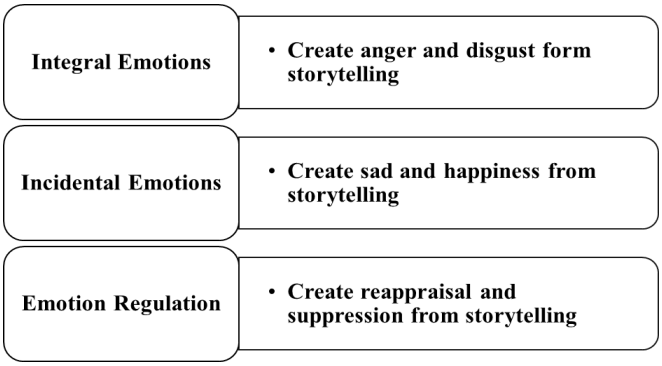

Figure 2: Psychological Mechanism with Storytelling based Advertisement

- **H3: Cross-Cultural Variances in Neural Processing:**

Statement: Neurobiological responses to storytelling in advertising will exhibit cross-cultural variations.

Rationale: Cultural variations can affect how stories are interpreted. Anticipate that the neurological reactions to advertising narrative may alter depending on the cultural setting, which could impact the message's efficacy [Fisch 2019].

Justification: The physiological and neurological reactions that take place in the brain in response to stimuli in this case,

narrative in advertising are referred to as neurological responses. Cross-cultural variances suggest that people's perceptions, emotions, and cognitive processes may be shaped differently by their cultural background. People perceive emotional and narrative inputs differently in different cultures, neurobiological reactions may change as well [Fisch 2020, Fisch 2021, Green berg 2019].

- **H4: Long-Term Effects on Brand Perception:**

Statement: Consistent exposure to narrative-based advertising will have a measurable impact on long-term brand perception.

Rationale: There should be noticeable shifts in consumer views over time if narrative in advertising is shown to have a long-lasting impact on brain patterns linked to brand perception.

Justification: The general opinion and associations people build about a brand over time are referred to as long-term brand perception. Recurring exposure to narrative-based advertising content is implied by consistent exposure, highlighting the regularity and consistency of exposure. Think about a shoe company that has been using storytelling in its ads for years. The stories might focus on topics like pursuing one's passions, growing personally, and conquering obstacles. The brand uses a variety of advertisements to present a consistent narrative about people using its products to help them achieve their goals [Halder 2021]

3. CREATIVE STORYTELLING IN ADVERTISING:

Marketing through storytelling involves conveying a message through a narrative. This approach is applicable to a wide spectrum of businesses, ranging from small startups to larger corporations. The objective is to evoke emotions in the audience, compelling them to take action and fostering increased loyalty to the brand. By incorporating storytelling into marketing strategies, consumers gain an understanding of the reasons they should be invested in a product or service, contributing to the humanization of the brand [He 2008]. **Figure 3** shows the brand and their perception. The world's biggest brands understand the power of storytelling in marketing and here's a roundup of some of the best storytelling marketing examples:

Figure 3: Brand and their perception

Disney: Disney, which is well-versed in storytelling, uses this Disneyland Paris advertisement to highlight its storytelling abilities. The touching tale is on a little duckling who falls in love with his newfound idol after finding a comic book about Donald Duck. But bad weather compels the duckling and its family to take off, taking the beloved comic book with them.

Coca- Cola: As Coca-Cola's creative augmented reality (AR) campaign demonstrates, marketing through narrative can take many forms. During this promotion, consumers may access one of 12 animated stories by scanning a Coke can with their phone's camera. A small dilemma was depicted in each story, with lively characters having a lighthearted conversation and coming to a satisfying conclusion centered on sharing a Coke.

Manchester United: Manchester United wanted to be the first football team in China to launch a culturally relevant marketing campaign. They worked with Qumin to create a storytelling experience that was mobile-focused and effectively captured the essence of the Red Devil. The story, called "Wake Up the Devil Inside You, " was told in a sequence of videos that skillfully combined gaming, manga, and football in an effort to uplift Chinese football fans.

Apple: 'Detour' tells the story of a child's tricycle that becomes misplaced and sets out on an exciting quest to find its little owner. The Oscar-winning filmmaker and screenwriter Michael Gondry, who is best known for "Eternal Sunshine of the Spotless Mind, " is the brains behind this Apple-produced short film, which was shot exclusively on an iPhone 7 Plus.

4. ASSESSMENT OF BRAND WITH HYPOTHESIS:

4.1 Disney with Hypothesis:

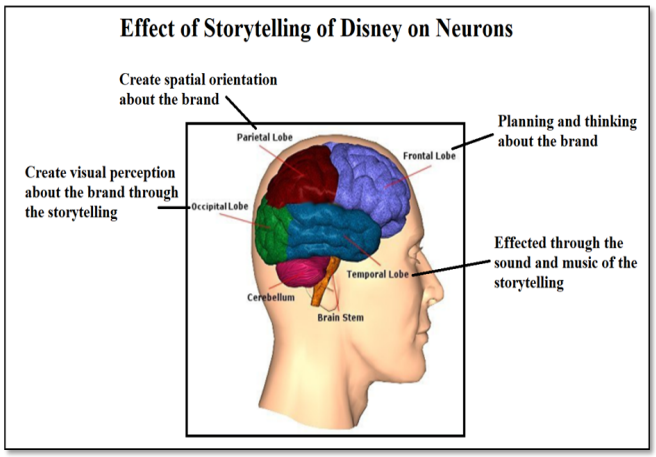

Figure 4: Effect of storytelling of Disney on neurons

Disney with H1: Analyzing Disney's storytelling from the perspective of neural engagement and brand recall entails determining how well the company's stories hold viewers' attention on a neurological level and help them form enduring brand memories. Disney is a master at developing

stories that are both emotionally and visually captivating. Several brain regions linked to emotion, attention, and memory are probably activated by the use of vivid colours, endearing characters, and gripping stories [Hofstetter 2022].

Figure 4 shows the effect of storytelling of Disney on neurons. Disney's use of music and sound effects in their storytelling increases brain engagement even more because auditory stimuli can have a significant effect on how memories are formed and how emotions respond [Howell 2020]. There may be times when the audience and the particular content determine how engaged the audience is. Evaluating personal preferences and modifying narrative strategies accordingly may improve neuronal involvement overall. Disney's narratives are frequently enhanced by powerful branding components, such as recognizable logos, characters, and theme tunes. Effective brand recall is facilitated by these dependable brand signals [Kahneman 1979, Kahneman 2003].

Disney with H2: Disney is renowned for its exceptional ability to weave emotionally compelling narratives. The incorporation of relatable characters, powerful themes, and heartwarming moments evokes a broad range of emotions in audiences. Emotional storytelling in Disney productions often transcends age barriers, creating universal appeal.

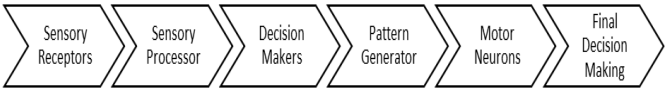

Figure 5: Path of Emotional storytelling and decision making

Figure 5 shows the path of emotional storytelling and decision making. However, a conceptual representation to capture the essence of this relationship. Let's denote Emotional Storytelling as ES and Consumer Decision Making as CDM. The relationship between emotional storytelling and consumer decision-making can be represented as follows:

CDM = g (ES, Others Factor)

g is a function that considers emotional storytelling (ES) and other relevant factors influencing consumer decision-making. Emotional storytelling may involve elements such as narrative structure, emotional engagement, relatability, and authenticity. Other factors could encompass product attributes, brand reputation, pricing, and external influences [Kang 2206].

Experimenting with nuanced emotions and addressing more complex themes could further enrich Disney's storytelling repertoire. Disney's emotionally charged narratives play a significant role in influencing consumer decision-making. The emotional connection formed during storytelling can translate into increased brand loyalty and a higher likelihood of consumers choosing Disney products and experiences. The immersive storytelling in Disney theme parks, movies, and merchandise creates a holistic brand experience, impacting consumer decisions across various touchpoints [Keller 2002].

Disney with H3: Disney has demonstrated an ability to create stories with universal themes that resonate across different cultures. The fundamental emotions and moral lessons embedded in Disney narratives often transcend cultural boundaries. The use of diverse characters and settings in Disney films showcases an awareness of cultural representation, contributing to a more inclusive and globally resonant storytelling approach. While Disney has made strides in inclusivity, there may still be opportunities to deepen cultural authenticity by involving diverse creators and consultants in the storytelling process. Tailoring certain storytelling elements to specific cultural nuances could further enhance the emotional impact on audiences from different regions [Kaufman 2003, Janssen 2012]. Disney's storytelling is designed to engage neural processes associated with emotions, empathy, and memory. The use of vivid visuals, music, and compelling narratives contributes to a robust neural response, creating memorable experiences. The consistent quality of animation and storytelling techniques ensures a reliable and positive neural processing experience for audiences worldwide. Considering cultural variations in neural processing preferences, Disney could explore ways to adapt storytelling styles to better align with the neural sensitivities of diverse audiences. Collaborating with neuroscientists or conducting cross-cultural studies could provide insights into optimizing storytelling for different neural responses.

Disney with H4: Disney has maintained a consistent and recognizable brand image over the years, aligning its storytelling with core values such as magic, imagination, and family-friendly entertainment. The timeless and iconic nature of Disney characters contributes to a lasting and positive brand perception that transcends generations. Disney can explore ways to evolve its storytelling to stay relevant to changing societal values and expectations while preserving its core identity [Lombard 2002, Love 2008].

4.2 Coca-Cola with Hypothesis:

Coca Cola with H1: Coca-Cola's storytelling often incorporates visually appealing and emotionally resonant narratives, contributing to strong neural engagement. Iconic branding elements, such as the red color and distinctive logo, are consistently integrated into storytelling, aiding in brand recall. Coca-Cola could explore interactive and immersive storytelling experiences to enhance neural engagement, leveraging emerging technologies. Continuous monitoring of neurological responses to storytelling could provide insights for refining content for optimal engagement [Lundqvist 2013]. **Figure 6** shows the storytelling of coca-cola with neural engagement and brand recall.

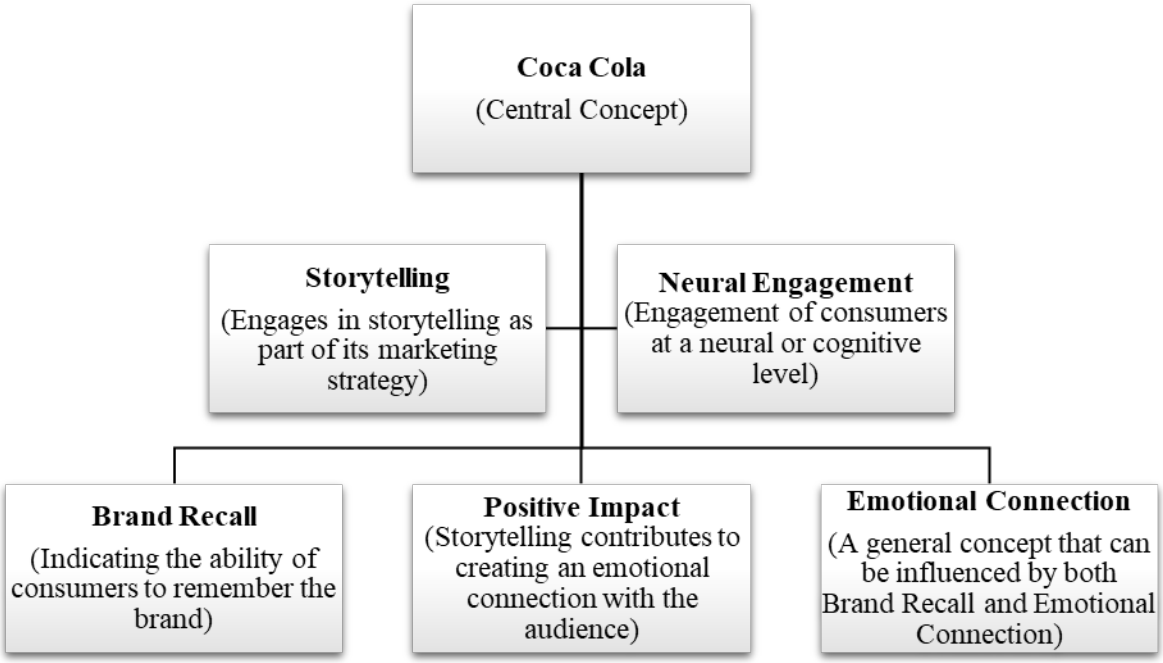

Figure 6: Storytelling of Coca-Cola with neural engagement and brand recall

Coca Cola with H2: Coca-Cola excels in emotional storytelling, creating campaigns that evoke joy, happiness, and a sense of togetherness. **Figure 7** shows the semantic network of emotional storytelling and consumer decision making.

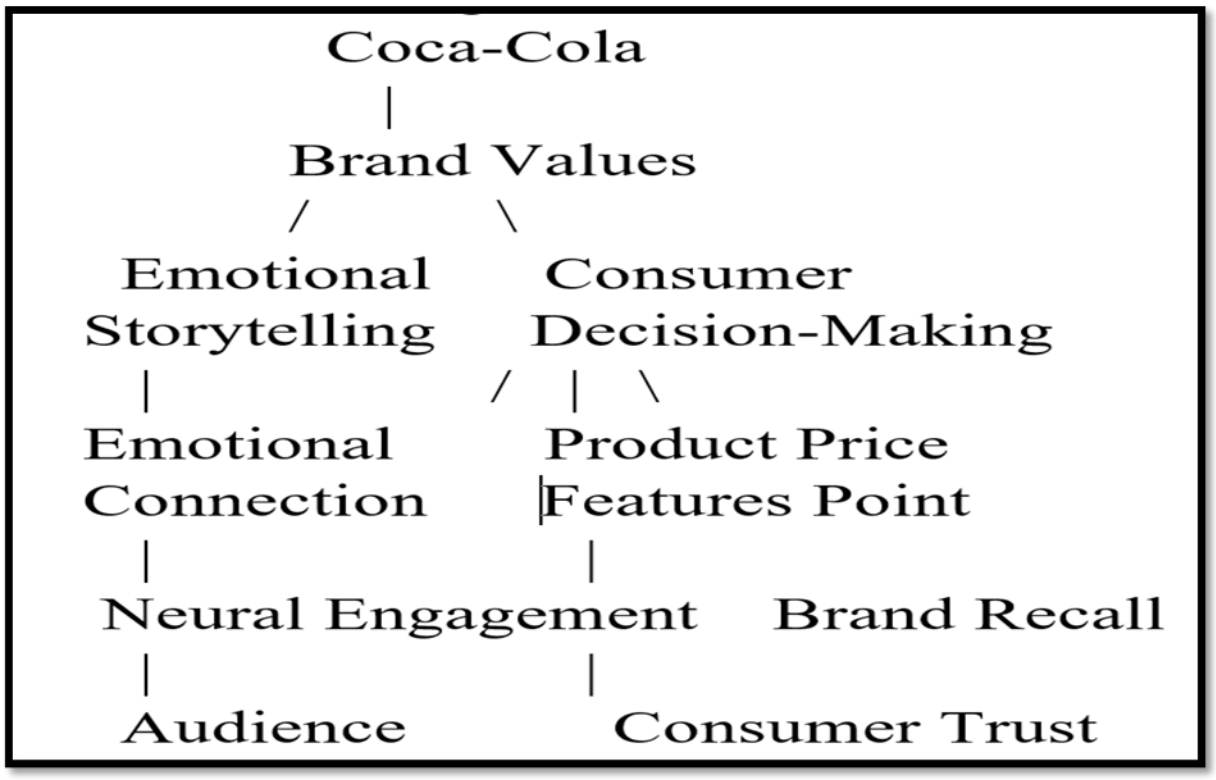

Figure 7: Semantic network of emotional storytelling and consumer decision making

The emotional connection established through storytelling contributes positively to consumer decision-making, fostering brand loyalty and preference [Mazzocco 2010]. Exploring a broader range of emotions in storytelling could deepen the emotional impact on consumers. Personalization of emotional storytelling experiences, such as user-generated content campaigns, can enhance consumer engagement and decision-making.

Coca Cola with H3: Coca-Cola's global presence is reflected in its culturally diverse storytelling, incorporating themes and characters that resonate across different regions. The brand demonstrates an awareness of cross-cultural nuances, ensuring that narratives are inclusive and adaptable to diverse neural processing preferences. Coca-Cola could further tailor storytelling elements to specific cultural sensitivities, ensuring an even more nuanced and targeted engagement [Megehee 2010]. Collaborative research with neuroscientists from different cultural backgrounds may provide insights into optimizing neural processing across diverse audiences.

Coca Cola with H4: Coca-Cola's storytelling has contributed to a timeless and positive brand perception, with campaigns that often focus on universal themes of joy and celebration. The consistent incorporation of brand elements, such as the contour bottle and signature jingle, aids in sustaining a positive and enduring brand image. Innovating storytelling to align with changing societal values and trends will be essential for maintaining a relevant and forward-looking brand perception [Moore 2012]. Implementing storytelling strategies that highlight Coca-Cola's commitment to sustainability and social responsibility can further enhance long-term brand perception. Coca-Cola's storytelling demonstrates notable strengths in engaging neural processes, creating emotional connections, addressing cross-cultural variances, and contributing to a positive long-term brand perception [Morgan 1997]. Opportunities for improvement lie in exploring interactive experiences, expanding emotional storytelling range, fine-tuning cross-cultural adaptations, and aligning with emerging societal values. Coca-Cola should continue leveraging its global storytelling approach while considering cultural nuances for deeper engagement. Exploring innovative technologies and personalized storytelling experiences can enhance neural engagement and consumer decision-making. Proactive adaptation to societal changes and emphasizing sustainability in storytelling will contribute to a resilient and evolving brand perception [Mossberg 2008].

4.3 Manchester United with Hypothesis:

Manchester United with H1: Manchester United's storytelling often incorporates visually compelling narratives, fostering strong neural engagement among fans. Iconic symbols such as the team logo, colors, and historic moments are consistently integrated, contributing to a high level of brand recall. Exploring innovative multimedia approaches and interactive content could further enhance neural engagement and fan connection [Muniz 2207]. Regular analysis of fan responses and adapting storytelling strategies accordingly may optimize brand recall.

Manchester United with H2: Manchester United excels in emotional storytelling, often focusing on themes of dedication, passion, and team spirit. The emotional connection built through storytelling contributes positively to fan loyalty and decision-making, fostering a strong affinity for the brand. Incorporating more personalized storytelling elements, such as fan stories and behind-the-scenes content, could deepen emotional connections. Exploring interactive fan engagement platforms can enhance the emotional impact and influence fan decision-making [Nacar 2011].

Manchester United with H3: Manchester United's global fan base is reflected in its efforts to create culturally inclusive storytelling, incorporating diverse themes and narratives. The use of multiple languages, cultural references, and player diversity demonstrates an awareness of cross-cultural nuances in neural processing preferences. Manchester United could further tailor storytelling to specific cultural contexts, ensuring narratives resonate even more deeply with diverse fan bases [Nudd 2012]. Collaborating with fans and cultural experts from different regions can provide insights into optimizing neural engagement across various audiences.

Manchester United with H4: Manchester United's storytelling has contributed to a enduring and positive brand perception, emphasizing the club's legacy, achievements, and community engagement. Consistent use of brand elements, such as the team crest and historical footage, helps maintain a strong and timeless brand image. Innovating storytelling to align with changing trends and fan expectations will be crucial for sustaining a relevant and evolving brand perception. Emphasizing the club's commitment to social responsibility and community impact through storytelling can further enhance long-term brand perception [Okazaki 2004]. Manchester United's storytelling demonstrates significant strengths in neural engagement, emotional connection, cross-cultural inclusivity, and contributing to a positive long-term brand perception. Opportunities for improvement lie in exploring innovative multimedia approaches, enhancing personalization, refining cross-cultural adaptations, and aligning with emerging societal values. Manchester United should continue leveraging its global fan base through culturally inclusive storytelling.

Exploring interactive and immersive storytelling experiences can deepen fan engagement and enhance neural processing. Proactively adapting storytelling strategies to changing trends and societal expectations will contribute to a resilient and evolving brand perception [Parson 2013].

4.4 Apple with Hypothesis:

Apple with H1: Apple's storytelling consistently incorporates visually stunning narratives, fostering strong neural engagement among users. The iconic Apple logo and design elements are seamlessly integrated, contributing to a high level of brand recall. Exploring interactive and immersive storytelling experiences could further enhance neural engagement and user connection [Reinstein 1997]. Regular analysis of user responses and adapting storytelling strategies based on user feedback may optimize brand recall.

Apple with H2: Apple excels in emotional storytelling, often focusing on themes of innovation, creativity, and the impact of technology on people's lives. The emotional connection built through storytelling contributes positively to user loyalty and decision-making, fostering a strong affinity for the brand. Incorporating more user-generated content and personal stories into the narrative could deepen emotional connections. Exploring interactive experiences and virtual reality to allow users to engage emotionally with products can further enhance storytelling impact.

Apple with H3: Apple's global presence is reflected in its efforts to create culturally inclusive storytelling, with diverse themes and narratives that resonate across different regions. The minimalistic design and universal appeal of Apple products contribute to a seamless cross-cultural experience in neural processing [Roper 2012]. Apple could tailor certain storytelling elements to specific cultural contexts, ensuring an even more nuanced and targeted engagement. Collaborating with local artists and cultural experts can provide insights into optimizing neural engagement across diverse audiences.

Apple with H4: Apple's storytelling has contributed to a positive and enduring brand perception, emphasizing innovation, quality, and user experience. The consistent use of brand elements, such as the sleek design and iconic Apple commercials, helps maintain a strong and timeless brand image. Innovating storytelling to align with changing technological trends and user expectations will be crucial for sustaining a relevant and evolving brand perception. Emphasizing Apple's commitment to sustainability and ethical practices through storytelling can further enhance long-term brand perception [Roznowski 2003]. **Table 2** shows the parameter of linear, interactive and episodic storytelling of different brand.

TABLE 2: Parameter of linear, interactive and episodic storytelling of different brand

Brand	Linear	Interactive	Episodic
Disney	Early Enchantment	Choose Your Adventure	Enchanted Tales Series
	Friendship and Adventure	Virtual Theme Parks	Princess Chronicles
	Circle of Life	AR Storytelling	Pixar Shorts Universe
	Legacy and Impact		
Coca-Cola	Refreshing Beginnings	Share a Coke Experience	The Summer Chronicles
		Virtual Tastings	Global Happiness Stories
Manchester united	Founding Legacy	Virtual Stadium Experience	The Title Chase Chronicles
		Managerial Decision Game	Legends Unleashed
Apple	Innovation Odyssey	Augmented Reality Experiences	Behind the Scenes Series
			Evolution of iOS Chronicles

5. DATA COLLECTION AND ANALYSIS WITH STORYTELLING BASED ADVERTISEMENT:

In order to obtain valuable insights from data collecting and analysis for storytelling-based marketing, information must be systematically gathered and then examined. data collection and analysis with storytelling-based advertisements involve gathering information about audience interactions with narrative-driven content and using that data to refine and optimize advertising strategies. This iterative process helps advertisers tailor their storytelling approach to better connect with their audience and achieve marketing objectives. **Figure 8** shows the level of data collection and assessment.

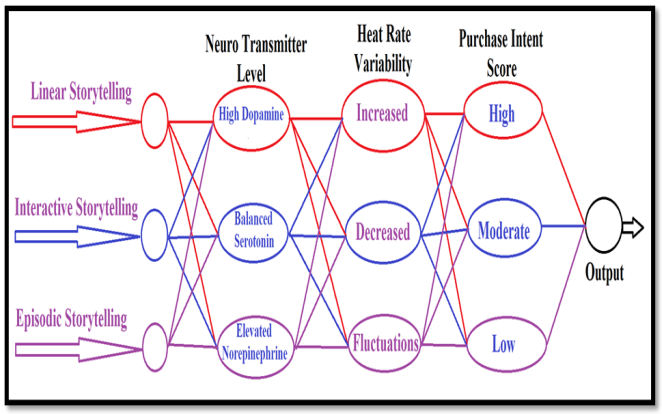

Figure 8: Level of data collection and assessment

- **Data Set Creation:**

Research to be done on the 500 persons (Male and Female) **(Table 3)** from the age of 15 to 56 from different cultural background.

Storytelling Format: The format of storytelling used in the advertisement (e.g., linear narrative, interactive storytelling, episodic storytelling).

Neurotransmitter Levels (NTL): Levels of key neurotransmitters (e.g., dopamine, serotonin) measured during the viewing of the advertisement.

- High Dopamine Levels: Associated with feelings of pleasure, reward, and motivation. An increase in dopamine levels may suggest that the advertising content is engaging and enjoyable [Schank 1999].
- Balanced Serotonin Levels: Serotonin is linked to mood regulation and a sense of well-being. Balanced serotonin levels may indicate a positive emotional response to the advertisement.
- Elevated Norepinephrine Levels: Norepinephrine is associated with arousal and attention.

Heart Rate Variability (HRV): Changes in heart rate variability as an indicator of physiological arousal during the advertisement in terms of increased, decreased and fluctuation.

Purchase Intent Score (PIS): A score indicating the likelihood of viewers to consider purchasing the product or service after watching the advertisement in terms of the high, moderate and low [Schmitt 2009].

TABLE 3: Dataset of 500 persons (Sample 9 persons) related to the neurobiology of storytelling in advertisement

Type of Storytelling	Neuro Transmitter Level (0 to 1)	Heart Rate Variability (Beats Per Minute)	Purchase Intent Score (1 to 5)
Linear	0.75	60	4.2
Interactive	0.82	65	4.5
Episodic	0.68	50	4.0
Linear	0.72	62	4.3
Interactive	0.80	67	4.6
Episodic	0.70	60	4.1
Linear	0.78	63	4.4
Interactive	0.85	68	4.7
Episodic	0.75	61	4.2

TABLE 4: Descriptive Statistics of the dataset

	Count	Mean	Median	Min.	Max.
NTL Linear	500	0.7394789	0.744	0.693	0.769
HRV Linear	500	62.89579	63	59	66
PIS Linear	500	4.107831	4.2	3.5	4.4
NTL Interactive	500	0.8261964	0.825	0.791	0.858
HRV Interactive	500	67.83968	68	62	71
PIS Interactive	500	4.52024	4.5	4.2	4.7
NTL	500	0.713942	0.71	0.682	0.749
Episodic					
NTL Episodic	500	57.884	58	12	61
PIS Episodic	500	4.1628	4.2	3.9	4.3

Based on the above data set following are the relationship according to the multiregression analysis:

PIS Linear = *4.14839725164309 + 0.503045115524917 × NTL Linear -0.00656019537845198 × HRV Linear*

PIS Interactive = *4.33929179588974 - 0.0229048554033644 × NTL Interactive + 0.00294624909600252 × HRV Interactive*

PIS Episodic = *3.97474328058965 + 0.187659493837026 × NTL Episodic + 0.00093426033206684 × HRV Episodic*

These formulas appear to describe the relationship between three distinct storytelling styles—linear, interactive, and episodic—and the perceived effect or performance scores (PIS) derived from neurobiological measures (NTL and HRV) in the context of advertising. The constants show the baseline impact in the absence of neurobiological measures, while the coefficients show the direction and strength of the influence of neurobiological measures on the perceived impact of each storytelling style [Singh 2012]. **Figure 9, 10, 11** shows the PIS linear, PIS interactive and PIS episodic respectively.

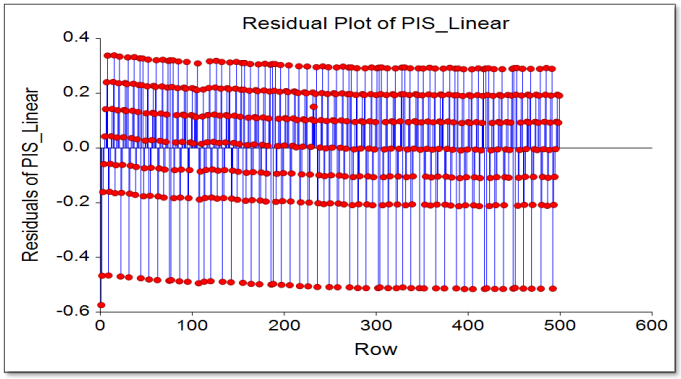

Figure 9: Residual plot of PIS Linear

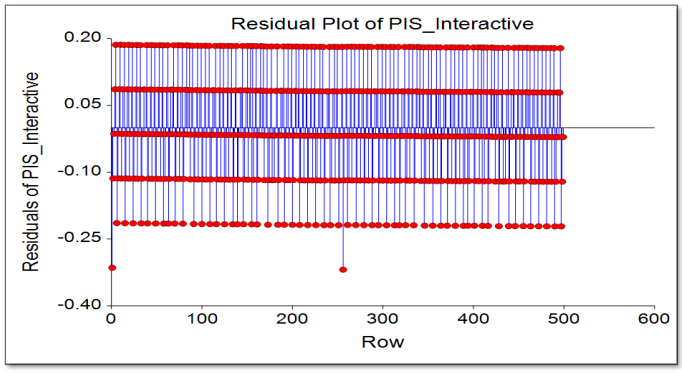

Figure 10: Residual Plot of PIS Interactive

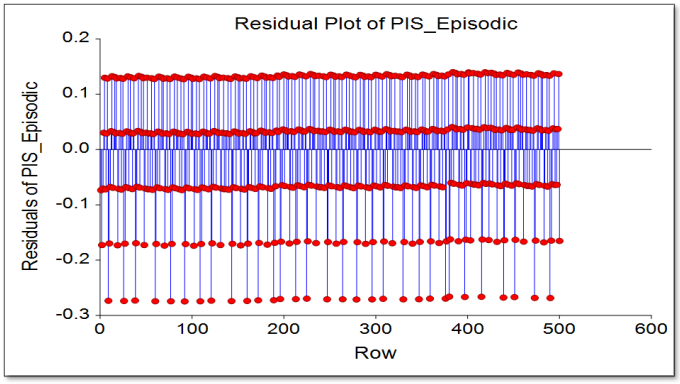

Figure 11: Residual Plot of PIS Episodic

The impact of storytelling on purchase intent depends on various factors, including the nature of the narrative structure and the emotional engagement it fosters. Interactive storytelling tends to offer a personalized and engaging experience, potentially leading to higher purchase intent. Episodic storytelling, by creating a prolonged and evolving relationship, can also positively influence purchase intent [Smith 2011]. **Table 4** shows the descriptive statistics of the dataset of Table 3. Linear storytelling, while straightforward, may need to rely on strong emotional connections to have a similar impact on purchase intent. Ultimately, the effectiveness of each storytelling approach in driving purchase intent may vary based on the specific context, audience preferences, and the quality of execution. According to the table, when storytelling is linear, neurotransmitter level is 0.739, heart rate variability is 62.89 and purchase intent score of customer is 4.10. Linear storytelling is a traditional narrative structure where events unfold in a chronological order. This approach is often straightforward and easy to follow, providing a clear and cohesive narrative. While linear storytelling can be effective, it may lack the element of surprise or nonlinear complexity found in other narrative structures. The neurotransmitter level of 0.739 could represent a balance or typical level, suggesting that the audience is likely engaged and receptive to the storytelling content. A heart rate variability of 62.89 suggests a moderate level of physiological arousal. This could mean the storytelling is eliciting some emotional response but may not be overly intense or calming. A purchase intent score of 4.10 indicates a moderate willingness of the customer to make a purchase, which could be influenced by the storytelling's impact on their perception of the product or brand.

Interactive storytelling involves audience participation and engagement, providing a personalized and dynamic experience. This approach can enhance immersion and connection with the narrative. A neurotransmitter level of 0.826 indicates a potentially heightened state of engagement and receptivity. This suggests that the interactive storytelling is likely eliciting a positive response from the audience. A heart rate variability of 67.83 suggests a moderate to high level of physiological arousal, indicating that the interactive storytelling is likely generating emotional responses among the audience [Spear 2013]. A purchase intent score of 4.52 is relatively high and suggests that the interactive storytelling is positively influencing customers' willingness to make a purchase. Episodic storytelling involves presenting a narrative in distinct episodes or segments. This approach allows for the exploration of various plotlines and character developments over time, creating anticipation and interest. Episodic storytelling is a recognized narrative technique employed in various forms of media. Its effectiveness depends on the quality of individual episodes and the overall coherence of the narrative arc [Stern 1994a, Stern 1994b].

Assessment through H1: Linear storytelling provides a structured and chronological narrative, which can be easier for the brain to follow. It helps create a cohesive and memorable experience. The brain tends to respond well to well-structured stories with a clear beginning, middle, and end. A linear narrative can enhance brand recall as it allows for a logical progression of information. If the story is well-crafted and aligns with the brand message, it can leave a lasting impression on the audience. Interactive elements, such as choices or branching narratives, can increase neural engagement by involving the audience more directly. Decision-making activates different areas of the brain, making the experience more immersive and memorable [Stern 1998, Taylor 2002].

Assessment through H2: Linear storytelling can provide a structured narrative that unfolds in a chronological order, allowing for the gradual build-up of emotions. This structure enables storytellers to carefully craft emotional arcs, leading to a more immersive and emotionally resonant experience for the audience. A well-executed linear story has the potential to guide the audience through a carefully curated emotional journey. Emotions play a significant role in decision-making, and a linear narrative can influence consumers by evoking specific feelings or responses at key points in the story. Interactivity adds a layer of personalization to the storytelling experience. When consumers actively participate by making choices, it can deepen their emotional connection to the narrative [Thompson 2006]. The emotional impact is heightened when individuals feel a sense of agency and control over the story's direction. Interactive elements allow consumers to feel more engaged and invested in the brand story. This engagement can positively influence decision-making by fostering a sense of ownership and connection. Choices made during interactive storytelling can also tailor the narrative to individual preferences, creating a more personalized and emotionally resonant experience. Episodic storytelling provides opportunities to develop characters, themes, and emotional arcs over time. Viewers may become emotionally invested in the characters' journeys, leading to a deeper connection with the narrative. The anticipation of each episode can also heighten emotional engagement. Over a series of episodes, consumers may form a lasting emotional

bond with the brand. This emotional connection can influence decision-making by creating brand loyalty and a positive association between the consumer and the brand's values. the integration of linear, interactive, and episodic storytelling can create a dynamic and emotionally compelling narrative. By leveraging these elements, brands can establish a stronger connection with consumers, elicit specific emotional responses, and positively influence decision-making processes. The key is to align the storytelling strategy with the brand's objectives and values while keeping the audience's emotional experience at the forefront [Van Laer 2014].

Assessment through H3: Linear storytelling often follows a structured narrative that may be influenced by cultural norms, storytelling traditions, and expectations. Certain cultures may have a preference for linear narratives with clear beginnings, middles, and ends, while others may appreciate more non-linear or circular storytelling structures. The degree of interactivity that resonates with audiences can vary across cultures. Some cultures may value active participation and choices in storytelling, while others may prefer a more passive or observer-oriented experience. Cultural attitudes toward agency, autonomy, and group dynamics can influence the effectiveness of interactive elements. Episodic storytelling can be influenced by cultural storytelling traditions, where some cultures may have a strong tradition of episodic narratives with recurring themes, characters, or motifs. The cultural significance attached to episodic storytelling can impact how individuals from different cultures engage with and process the content. It's crucial for storytellers to be culturally sensitive and aware of the diverse preferences and expectations of their target audience. This includes understanding cultural storytelling conventions, themes, and narrative structures. Neural processing is closely tied to emotional responses, and different cultures may have unique emotional expressions and sensitivities. Storytellers should be mindful of cultural nuances in portraying emotions to ensure resonance with diverse audiences. Incorporating culturally relevant symbols, contexts, and references in the storytelling can enhance cross-cultural appeal. However, it's important to avoid stereotypes and misinterpretations that may alienate or offend specific cultural groups. the impact of linear, interactive, and episodic storytelling on cross-cultural neural processing depends on the careful consideration of cultural nuances, preferences, and storytelling traditions. A culturally informed approach to storytelling can foster neural engagement and resonance with diverse audiences, contributing to a more inclusive and effective narrative strategy.

Assessment through H4: Linear storytelling provides a structured and coherent narrative that can contribute to a consistent brand image. Over time, this consistency can help build trust and reliability in the minds of consumers, positively influencing long-term brand perception. The linear format allows brands to convey their values and key messages in a sequential manner, reinforcing core brand attributes over time. When consumers consistently encounter a brand narrative that aligns with their values, it contributes to a positive and enduring perception. Interactive elements create opportunities for active engagement, fostering a deeper connection between the audience and the brand. This heightened engagement can lead to a more memorable and enduring brand perception as consumers feel a sense of participation and involvement in the brand story. Interactive storytelling allows for personalized experiences based on user choices. Over time, this personalization can contribute to a stronger emotional bond with the brand as consumers feel a sense of agency and individual connection to the narrative. Episodic storytelling, with its recurring episodes and evolving narrative, encourages long-term engagement with the brand. Audiences may become invested in the ongoing story, contributing to sustained interest and positive brand perception over time. A well-executed episodic storytelling strategy can foster brand loyalty. Viewers who anticipate and follow each episode may develop a strong attachment to the brand, associating positive emotions and experiences with the ongoing narrative. a strategic blend of linear, interactive, and episodic storytelling can have a lasting impact on brand perception by creating a cohesive, engaging, and memorable narrative. Over time, these storytelling elements contribute to shaping the way consumers perceive, connect with, and remain loyal to a brand.

6. CONCLUSION

Based on the above assessment of the brand with different hypothesis following points are identified:

- It is easy to remembering advertisements with a compelling story.
- When storytelling is linear, neurotransmitter level is 0.739, heart rate variability is 62.89 and purchase intent score of customer is 4.10.
- In a episodic storytelling a neurotransmitter level of 0.713 may suggest a moderate level of engagement and receptivity.
- A specific advertisement that used storytelling effectively to capture attention of audiences.
- It is also identified, advertisements with a narrative or story are more engaging than those without.
- Storytelling in advertisements influence perception of a brand or product.
- It is also identified, a purchase based on an emotional connection formed through a storytelling advertisement.

- Storytelling in advertisements has the power to evoke certain emotions of audiences.
- Characters in advertising narratives affect audience engagement with the brand or product being promoted.
- It is identified, advertisements that have changed your opinion or attitude towards a social or cultural issue through effective storytelling.
- Storytelling in advertisements has the potential to create a sense of authenticity for a brand.
- Human brain processes information differently when it is presented in a narrative form as opposed to straightforward facts and figures.
- Storytelling in advertisements is more influential in creating brand loyalty than other marketing techniques.

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6

Evaluating the Strategic Opportunities of Premium Vehicles as a Medium for Transit Advertising

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ABSTRACT

This research paper aims to explore the scope and opportunities of Marketing on Social Media platforms using Exotic vehicles as a medium. The advertising environment has changed as a result of digital transformation, outdoor advertising has taken a major hit. The research paper aims to explore a different perspective of this subset and look at advertising on private Exotic Cars. The research paper employs a mixed-methods approach, combining both primary and secondary research methods. For Primary research, a questionnaire was floated. The targeted sample size was 200 respondents. 157 respondents filled the questionnaire. The questionnaire had questions based on the respondents' preference and perception of Exotic cars as a suitable medium for advertising. For Secondary research, existing literature was reviewed, that presented the effectiveness of different means or types of transit advertising, particularly focusing on Public transport and how brands and companies have pushed their creative boundaries to capture the consumer's attention. The research paper also explores advertising in motorsports, specifically highlighting brand logos on competing vehicles from special liveries designed to promote a brand or a product. The concept or practice of using exotic cars or premium vehicles is not new, however, it is an unexploited opportunity. Due to the exponential popularity of social media platforms, pictures and videos featuring exotic cars and premium vehicles go viral. There are numerous pages (verified and unverified) that share photos of these premium vehicles to cater to their audience or subscribers. These social media pages tend to market/promote the vehicle or any brand/entity associated with it for no additional cost. The research paper concludes that there is a positive reception from a consumer's point of view when they view or see a company's branding on an exotic vehicle.

Keywords: Out-of-home Advertising, Transit Advertising Supercars, Exotic Cars, Social Media, Word of mouth, Liveries, Branding, Motorsports, Brand Image, Psychological Influence, Consumer Perception.

1. INTRODUCTION

Transit advertising is any printed or digital message that is displayed within or outside of a public transportation vehicle, such as a bus, train, taxi, or airline. It also includes ads that are displayed in subways, bus shelters, train stations, platforms, and terminals, among other places. It is a crucial tool for connecting with people of all ages, socioeconomic origins, and financial levels. With a steady daily audience and strong visibility, transit advertising is a fantastic deal. It is cost-effective, works fast, and doesn't waste circulation.

Transit advertising is effective since it may reach a wide range of people. Public transportation networks are a great medium for brand exposure since they naturally draw a mix of visitors, everyday commuters, and pedestrians. Strong brand recall is facilitated by its repetition, such as seeing the same advertisement at a popular subway stop or on a daily bus route. It's also reasonably priced, providing excellent visibility without going over budget. These advertisements create a big impression with big, striking forms like station takeovers or bus wraps. Transit ads are particularly beneficial for companies aiming to target particular communities or busy regions. However, there are certain issues with transportation advertising. For companies with narrow markets, its wide reach may make it difficult to focus on a particular target. Weather can also affect outdoor formats; snow or rain can make it difficult to see, and if advertisements aren't illuminated at night, their impact may be weakened.

Improvements in the city's mass transport vehicles' technology have also been observed in their linked components, such as the road system, lighting, safety and security equipment, etc. In addition to them, we see the next, but certainly not the least, significant and striking buildings, surfaces known as the advertising spaces, which give life to these otherwise empty city areas.

Before the traffic signal changed, a lot of the people had their phones out and were snapping selfies and photos with the car. Many of these photos undoubtedly ended up on social media, giving the vehicle a second life in the digital realm and emphasizing its emotional value as well as how simple it is for people to record and share content using devices like phones, the Internet, and social media. Many people will gather around the car in its virtual second life by leaving comments and "liking" it, which will translate real-world experiences into the virtual world. Social media has facilitated the exponential expansion of interpersonal connections in society by connecting people with similar interests. Despite being a relatively "young" creation, social media had to undergo multiple incarnations or forms before it could be acknowledged as what it is today. The progress

made in communication has had a significant impact on human society and sociality as a whole.

But more significantly, social media can bring users together around common interests by allowing them to look for "hashtags" (#) associated with their interests. These interests could include popular culture, cuisine, movies, or—more precisely—cars, which is the subject of my research.

My research investigates how companies and brands can use digital platforms such as Facebook, Instagram, X (formerly Twitter), and YouTube as a medium for cultural expression and communication to target consumers, belonging to the various automotive subcultures or just regular passersby, to attract their attention using premium and exotic vehicles and engaging with them and spreading brand awareness using social media as platform to reach out to car enthusiasts and other social media users.

2. LITERATURE REVIEW

The Internet and its various elements, including social media, are among the main forces influencing and redefining democratic practice. To put it another way, social media can serve as an example of the free speech rights that democratic principles grant to society. On the other hand, some social media platforms can be used to promote negativity, interpersonal conflict, and anti-democratic viewpoints, according to, who offer a techno-pessimistic perspective on social media and cast doubt on its potential as a useful instrument for improving human communication.

Although cars play a key role in transportation, their importance in social life is becoming more widely recognized in academic literature. Cars and the emotional bond that people can form with them, frequently explain how those who are part of the car culture community rise in social and economic standing by purchasing and/or selling cars . I expand on that in this thesis by examining the ways in which social media may unite auto enthusiasts and translate their real-world experiences into virtual reality, and vice versa.

Since the automobile subculture is a very tactile, sensory, and visceral culture, one of the main ways people experience it is through their senses, including sight, smell, hearing, and bodily sensations like touch. In an effort to recreate the "sensory" aspect of this subculture, these sensory experiences are now being shared digitally on sites like Facebook and YouTube, among others, using sound samples, videos, and other such formats.

Social Media's Impact on Brand Awareness

Marketing communications can provide information about the product's producer as well as the goals of a business or brand. Through marketing communications, a business can link a brand to people, locations, events, emotions, and more. By infusing the brand in people's memories, they help increase brand recognition for the company's goods. Brand awareness is the capacity of a prospective customer to identify and remember a brand as belonging to a specific product category. Brand awareness involves a range of emotions, from a sense of doubt that a specific brand has previously been recognized to the consumer's perception that the product is the sole brand in a given group. Social media has a major impact on how widespread a company's product brand is in the community. The improvement of product attraction to the product marketing that circulates on online platforms is greatly influenced by social media. Social media is a great way for businesses to market their products when they want to launch a new product because it has a big impact on public awareness. Social media's quick development has allowed numerous businesses to showcase their goods to the general audience. Thus, in order to draw in social media users, the business should have an excellent marketing plan, particularly for the corporate marketing communication division. .

With the rise of social media platforms, online word-of-mouth, including user-generated content (UGC) and professional-generated content (PGC), has become a common strategy to spread reliable information and boost product sales, even as firm-generated content (FGC) has become a common tool that allows brands to show consumers informative, interchangeable messages. Marketers ought to evaluate cross-media strategy by examining how it interacts with various social media platforms and keeping an eye on word-of-mouth about cars in a range of prices and popularity . Social media platforms are great tools for building relationships with clients. Establishing brand fan pages on social media platforms is one particular method to achieve this. On these brand fan pages, businesses can publish brand content, such as messages, videos, quizzes, information, and more. Consumers can show that they enjoy the brand post or leave a comment on it by becoming fans of these brand fan sites. The popularity of brand posts is reflected in the likes and comments on those posts .

Social Media's Impact of Transforming Consumer Behaviour

The introduction of new technology and improvements in old technology create the conditions for social transformation, a phenomenon in which consumer behavior is significantly changed at an exponential rate. Additionally, this has facilitated more effective and extensive communication and is altering consumer thought patterns that have an effect on nations, civilizations, and society. With time and money so limited, consumers have been forced to reconsider their buying patterns as a result of the global economy's decline. As a result, they have begun to consider perceived value in relation to cost and customer experience. As a result, there has been a significant shift in consumer expectations, knowledge, and interaction with goods and services. .

Customer engagement is regarded as a useful indicator of future business performance as well as a strategic necessity

for creating and maintaining a competitive advantage. Evidence of the growing use of the term "engagement" in regard to business relationships and branding may also be found in recent business practice discourse, which includes reporting on conferences, seminars, roundtables, blogs, and organizational reports. . In today's marketing exchange process, consumers are more than just passive recipients. They are now actively participating in the co-creation of everything from advertising messaging to product design. .

The Emergence of Social Commerce

In 2005, as social networking sites and many other social media websites began to be used for business purposes, the idea of social commerce was born. It introduces e-commerce, a new type of electronic trade. Social commerce includes online communities that facilitate user interactions and user-generated content, in contrast to traditional e-commerce, where customers often engage with online shopping sites independently. . One powerful marketing strategy is social media marketing. The impacts of message transmission and popular integration can be enhanced by like or sharing content on social media. Networks become effective marketing channels when more people utilize the internet and spend more time browsing. Only compelling and emotional messaging has the power to alter people' perspectives and spark passionate exchanges. Social media is a potent instrument for communication because of the collaborative benefits it provides. Marketing managers must therefore encourage internet users to share communications with friends, family, or coworkers on the spur of the moment. As a result, successful social media marketing depends on the efficient distribution of information, and current marketing study has shown that convincing internet users to support promotions is crucial. . For people who get their news, entertainment, and information via the internet, suggestions from friends are key sources. Viral marketing is a new type of marketing communication that thrives in this new internet environment. Since the decision to transfer online content is entirely voluntary i.e., marketers do not compensate Internet users for forwarding electronic content is imperative to understand why Internet users do so. .

Motorsport as Marketing Communication?

Live television, media events, and numerous televised sporting events are all considered spectacle. However, despite the fact that researchers frequently link sport to spectacle, the term is ambiguous and not often defined in publications as clearly as case studies on media events and live television examples. The way the Formula One event is now marketed for its viewers on television has been significantly influenced by television. Therefore, the phrase "mediated event" refers to the physical phenomenon under analysis and includes the complicated processes behind the ongoing production of modern televised sports. Recent Formula One events have also demonstrated how contemporary sports can serve as symbols for political movements, which is another instance of a worldwide media event. In addition to generating income, media events—particularly athletic ones—also confer prestige and importance on a worldwide level. Approximately every two weeks during the season, a different global location hosts a live Formula One event. Each race has a global television audience that watches the broadcasts in their homes either alone or in small groups. Television is not the only technical medium, though, that provides a point of crossing across different fields. Formula One has a closely linked connection with media firms that purchase the rights to broadcast the sport as well as business entities who invest as sponsors. Sports are today recognized as significant socio-economic activity and commercialized spectacles. Due to its dependence on broadcast revenue and associated sponsorship funds, Formula One motor racing is the quintessential modern sport. Additionally, governments and related governmental organizations, the numerous corporations that have made multi-level investments in the sport, and the media outlets that broadcast Formula One globally may all have an impact on the sport and its representation at some point. Sponsors can showcase their trademarks and logos on televised Formula One, notably during the podium and press conference when exposure is at its highest. A company's brand can reach a global audience through global telecasts, and it has been noted that sports like Formula One have the ability to draw significant numbers of young men, who are typically a challenging market to approach.

It has been proposed that the sponsors, teams, and organizers of Formula One favor the more contemporary racing circuits because they improve television coverage. Shorter, slower tracks that are safer and better suited for TV coverage have been the trend in circuit design. It is said that slow circuits are preferred because they enable the cameras to capture the names and logos of advertising more clearly and continuously. The idea of "virtual billboards, " in which a television might digitally overlay an advertisement on a television picture "while the athlete performs on and around it, " has been studied. There is a chance that different advertising message to be tailored to specific audiences, ethnicities, and nationalities.

When motor racing first began, affluent competitors could afford these fees, but more and more sponsorship is now needed to offset costs.

The human interest component of competitors has also been emphasized by television. Drivers like Ayrton Senna, Michael Schumacher, Sebastian Vettel and Lewis Hamilton, who were first shown on television, are also seen as aspirational figures in addition to being winners—aspects of a brand that appeal greatly to marketing strategists. As a result, other sports have introduced the idea of celebrity endorsement.

Sponsorship is defined as a promotional element that aims to influence a consumer's decision to buy a product in a positive

way. Promotion is a communication activity that informs, educates, and reminds potential customers of the advantages that a business, its goods, or services have to offer. Sponsorship is now the cornerstone of a marketing plan rather than an auxiliary one. One may argue that both cars and sparkling wine are examples of product placement in highly televisual sports. "The inclusion of consumer products or services in motion pictures for promotional purposes" or "the placement of a brand or a firm in a movie or in a television program by different means for promotional purposes" are two definitions of product placement. (Nebenzhal & Secunda, 1993). Touring car racing and the World Rally Championship are common platforms for pseudo product placements. Despite being significantly altered mechanically and for safety, the automobiles involved in this case appear to be typical road vehicles. One may claim that these competitive automobiles are exhibiting explicit and integrated product placement.

Through the use of corporate hospitality, sponsorship seeks to establish a favorable experience associated with a sponsor's name and product. This means paying for events that are held for customers or prospective customers. It goes beyond relationship marketing to increase trust, influence how people view the company, and promote goodwill. Corporate hospitality also aids in attracting new clients, retaining current ones, increasing sales from current ones, and regaining lost ones. A brand's inclusion in the team's name is the result of their decision to become a title sponsor. For example, Oracle has agreed to sponsor the current constructors' champions Red Bull Racing for five years, and effective of this season, the team will be known as Oracle Red Bull Racing. Brands can choose to sponsor a team for less money and have their name shown on the vehicle, even though title sponsorships might be costly. This category includes a number of sponsors; teams may have up to 20 sponsors who drive their vehicles. Although tobacco advertising produced iconic F1 liveries, this time period was bound for extinction. Regulations enforced by European governments in the late 1990s and early 2000s resulted in the total ban of tobacco advertisements following the 2006 Formula One season. After the demise of tobacco advertising, other businesses from a variety of industries, including banking and telecommunications, joined Formula One. The energy drink giant Red Bull gained the most from this sector. In the 1990s, it was a small sponsor of Sauber, but in late 2004, it bought the struggling Jaguar Formula One team. As of right now, this team has won 11 world championships. Petrochemical and petroleum companies also signed significant sponsorship deals with Formula One teams.

The Car Community and its presence on Social media

The concept of an a car community is based on finding fundamental points of agreement. When two car enthusiasts pose more general, simple demands regarding their cars, a dialogue unfolds. The sense of a car community emerges when the discussion gets more in-depth. The car itself is the physical manifestation of that affection. Whether in a club or when interacting with a car alone, the series of links continues into participation. The concept of the car community is not new. Since the first vehicle of its kind was produced, it has existed. Following the conclusion of World War II, the story picks up as soldiers acquire homes, establish suburban communities, and forge new identities. In order to find recreational activities away from the daily grind, a stronger nation was creating a culture focused on cheap petroleum and disposable income. Out of the generation that only learned of World War II, it also fostered a young culture. The emergence of social media and the Internet into the automotive industry is what sets aside the current status of the automotive community. Around the world, information, pictures, and ideas are constantly shared. Hundreds or thousands of people worldwide may have viewed and reposted the car you photographed this morning. Everyone, from the CEO of a large corporation to the child without a driver's license, reads what is posted on social media. Social media as a whole broadens the dynamics of the automotive community across national boundaries. The concept of finding commonalities for talks, debates, and idea sharing regarding anything and everything in the automobile industry is fostered by digital platforms .

These days, whenever I go on social media, I notice that people tend to characterize a car enthusiast as someone who exclusively likes Japanese vehicles, such as the Supra or the Mazda RX-7. Nowadays, this is the most widespread online stereotype of a car enthusiast. Internet influencers, fanboys, children, and everyone else with a growing interest in automobiles all seem to believe that you can only be accepted into the car world if you are a huge lover of these Japanese vehicles . A car person, in my opinion, is someone who considers his vehicle to be a buddy and feels that it is an extension of himself. It doesn't matter if it's a Lamborghini, a Supra, or any regular car.

Case- Shilajit Energy

Shilajit Energy Drinks are a relatively small startup, that sells energy drinks that claim to contain ‘shilajit’ or Asphaltum (a herbomineral- contains minerals and metals, a gluey tar-like resin, sourced from the rocks present in the Himalayas at an altitude of 1000 to 5000 metres above sea level.), Zam Zam water and Saffron, rounding up its main ingredients. *Exhibit 1a* shows a visual representation of the brands product.

Majority of my social media feed consists of posts and videos of premium vehicles, exotic cars, supercars, and motorsports. One day I was browsing through social media and I came across a bizarre yet interesting post. It showcased a specific supercar adorned in a striking yellow and red livery, which definitely caught my attention, that had logos and branding of the aforementioned “Shilajit Energy Drinks” branding (Logo, symbols, and Tagline) as seen in *Exhibit 1b*.

The post was uploaded by an account I follow that reposts photos, stories and videos (short-form) of random exotic and premium cars. This compelled me to search this particular brand's name and visit their social media page to know more about the product. Though this product was not available in India (at the time of this research) it ended up in my browsing feed and induced me to visit their social media page to gain awareness about their product. This post ended up in my feed through the social media algorithm. By the use of embedded hashtags and engagement metrics of my (user's) account or preferences, the algorithm predicts and updates my social media feed with such posts. As mentioned, my social media feed is flooded with posts and videos of vibrant, fast, and exotic supercars and other vehicles as well as news, posts or stories about anything in the world of motorsports (namely Formula One). Based on these preferences, the algorithm analyses the core subjects (premium vehicles, exotic cars, supercars, and motorsports) of these posts or accounts that post such content, predicts the content I prefer interacting with, and accordingly shows it on my feed, thus providing me a personalized experience, so I spend more time on the social media platform. And that is how I ended up interacting with the aforementioned "Shilajit Energy Drinks" social media account, growing my awareness about the existence of the product. This is one of the methods of Social Media Marketing. The car or transit in question (supercar with branded livery) was a form of promotion, the reposting of the car on another account, without having to sponsor the social media page or constitute any form of monetary exchange, makes this a form of Earned Media. Earned media is one of the most genuine and effective kind of promotion because it is not directly under the brand's control, in contrast to owned media (such as a business's website or social media accounts) or paid advertising. Following are Benefits of Earned Media:

- Consumer Trust: Consumers place greater faith in recommendations from third parties than in direct advertising. Earned media is perceived as objective and reliable.
- Graeter Reach: A positive review or viral post has the potential to spread swiftly, reaching audiences that the brand might not otherwise feed.
- Influences Purchase Decisions: People are more inclined to buy something after hearing recommendations from others (Word of Mouth).

To understand the benefit that companies like Shilajit Energy Drinks can reap from Earned Media, we should take a look at the 'Hierarchy of Effects' model. The hierarchy-of-effects theory is a comprehensive advertising strategy that uses effective, convincing advertising messages to gradually increase brand recognition in order to advertise a product. Cognitive, Affectionate, and Conative behaviors are the three primary categories of behaviors linked to the hierarchy-of-effects theory. When a customer is told about a product or service, they go through the awareness and knowledge (or cognitive) stages, depending on how they interpret the information. When consumers develop sentiments about a brand, they are in the liking and preference (or affectionate) stages. Actions (or conative) are the main focus of the phases of conviction and purchase .

The following table shows the implications of "Shilajit Energy Drinks" using the exotic car as a medium of transit advertising, spreading awareness on Social Media through their posts, reaching targeted consumers through social media platforms.

TABLE 1: The Implications of Transit Advertising

Stages	Implications
Awareness	An individual user becomes aware of the existence of the energy drink through social media reposts and acquires some limited knowledge through its social media page.
Interest	By visiting the social media page, the user learns about benefits of the product and in further detail by visiting links or website mentioned. It develops a positive outlook or sparks interest and desire for the product in the mind of the user.
Desire	The benefits of the energy drink are evaluated by surfing the company website and external links to other market places where the drink is sold and reviewed. There is a desire or intent to buy if it is believed to meet the user's requirements more effectively than alternatives currently selling in the market.
Action	This would include the user acting on the intent of buying the energy drink from the website or any other channels where the beverage would be available.

Exhibit 1a:

(Source: https://shilajitenergydrinks.com/pages/products)

Exhibit 1b:

(Source: Instagram-@shilajitenergydrinks)

Before- Regular McLaren720s

(Source: Instagram-@shilajitenergydrinks)

(Source: Instagram-@shilajitenergydrinks)

After- McLaren 720s wrapped in custom livery with "Shilajit Energy Drinks" branding (Logo, Symbols, and Tagline).

As seen in the post the supercar is wrapped in a special livery with prominent branding of the "Shilajit Energy Drinks" as well as a QR code given which redirects the user to company's website for more information.

Objectives/ Research Hypothesis

The Objective of the Research Paper is to study the correlation between the market efficacy of using Premium and High-performance vehicles as a medium for market communication, and how it results in positive brand value for the company.

3. HYPOTHESIS

Hypothesis *1*: Target Customers can positively recall the brand elements when they notice branding or logos on exotic vehicles or high-performance vehicles, proving the use of premium or high performance vehicle as a medium for transit advertising is effective in context for Brand Salience.

Hypothesis *2*: The Brand Image or Perception of the brand is positive in the minds of the customer when they observe market communication or branding, done on a premium or high performance vehicle, proving the use of premium or high performance vehicle as a medium for transit advertising is valuable in developing Brand Value.

4. RESEARCH METHODOLOGY

This research aims to explore the effectiveness of nostalgia marketing in contemporary brand strategies. A mixed-methods approach is employed, utilizing both primary and secondary research to provide a comprehensive understanding of how nostalgia marketing impacts consumer behaviour and brand performance.

Secondary Research:

Review of Literature:

An extensive review of academic journals, industry reports, and marketing

publications has been conducted to support the idea of implementing the use of premium and high-performance vehicles as mediums for a transit advertising as marketing communication strategy. After extensive study of concepts relating to Social Media, Social Commerce and altering Marketing communication to make it more Social Media friendly, one can infer that due to changing consumer behaviour and the rapid adoption of digital platforms, the marketplace is a coliseum, where brands compete vigorously with each other to stand out. It is crucial for brands to cement themselves in the minds of the consumer, aiming to improve

their brand perception and fostering brand loyalty. The challenge lies in differentiating your brand from numerous other brands. In a period, where digital platforms are growing in popularity and the number of users, brands can create unique campaigns, that can be cost-effective, as well as go viral if it ends up resonating with the target customer. Supercars and Exotic vehicles are of beautiful and exciting examples of man-made machinery. They draw a lot of attention and even if you are not an automotive aficionado, you always turns your head to get a glimpse. Car culture has only thrived since the advent of social media. Car enthusiasts share photos and videos of vehicles from all around the globe. Society has created an impression of these vehicles as a sign of wealth. Brands associated with this machinery are considered premium. The study proposes the idea of companies renting these premium cars and adorning them with a unique livery, showcasing the brand elements, that are prominent and eye-catching, so when the car is on the road, they are able to draw the attention of their target customer (thereby exploring the aspect of Transit Advertising). The other idea that was put forward was the sponsorship of teams participating in motorsport. While this is a large-scale and potentially pocket-draining proposal, the races or events the brand would be showcased at, garners enormous amount of viewership and has an immense and loyal fandom. It provides global exposure to the brand. This magnitude of publicity can attract some (if not many) potential targets to browse information about the brand just out of curiosity, increasing brand engagement and proving a chance for the brand to interact with its target customer.

Taking in consideration the case of "Shilajit Energy Drinks", it can be seen that the brand's founders have had a supercar (McLaren 720s) wrapped in a livery that contains the brands logos, taglines as well as a QR code that directs the user to their website. This is a notable example of using a high-performance car as as a medium in the context for transit promotion. While it would definitely turn heads on the road, it can also create buzz on Social Media (that's how I discovered it), by being reposted by fan-made pages that upload posts of miscellaneous exotic and high-performance cars, thereby gaining more online engagement, leading to wider brand awareness.

Primary Research:

Survey-Based Data Collection:

A Google Form survey was developed and distributed to consumers from diverse demographics, with an emphasis on Millennials and Generation Z—demographics particularly responsive to premium vehicles used as mediums for transit media. The survey gathered insights into consumer reactions to sponsorship advertisements in motorsports and measured their perceived brand image, brand value, and consumer awareness in response to these campaigns. The data collected from the survey provides firsthand insights into consumer preferences and behavioral tendencies in response to social media marketing as earned media and motorsport campaigns.

Reliability Analysis

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.845	0.864	16

This is primary research where we have collected data through a questionnaire by circulating a questionnaire among known people. The survey received 157 responses. After data collection, a reliability analysis was conducted using Cronbach's Alpha to assess the internal consistency of the survey instrument used for this study. The analysis revealed a Cronbach's Alpha value of 0.845 for the 16-item scale. This indicates a high level of reliability, suggesting that the survey items consistently measure the underlying construct. According to Nunnally's (1978) criteria, a Cronbach's Alpha value above 0.7 is considered reliable. Therefore, the scale used in this study demonstrates strong internal consistency, ensuring the dependability of the collected data for further analysis.

5. DATA ANALYSIS AND INTERPRETATION

1. Premium or High-performance vehicles improve Brand Salience

- **H0 (Null):** There is no significant correlation between the frequency of noticing branding or logos on sports or high-performance cars and the ability to recall the associated brand, logo, or symbol.
- **H1(Alternative):** There is a positive correlation between the frequency of noticing branding or logos on sports or high-performance cars and the ability to recall the associated brand, logo, or symbol.

Q. On a scale of 1 to 5 how often do you notice any branding or logos on a sports car on the road or high performance car during a race (Formula 1, Nascar, WEC etc.) * On a scale of 1 to 5 how often can you recall a brand, logo, or symbol, that you notice on a sports car on the road or high-performance car? (1=Not much 5=Very Much)

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	186.270[a]	16	0.000
Likelihood Ratio	105.549	16	0.000
Linear-by-Linear Association	68.601	1	0.000

N of Valid Cases	157		
a. 16 cells (64.0%) have expected count less than 5. The minimum expected count is .01.			

- **Since the p-value < 0.05 we will reject H0(null).**

  The high Pearson Chi-Square value (186.270) and the very low p-value ($p < 0.001$) indicate that there is a statistically significant relationship between the frequency of noticing branding or logos on sports or high-performance cars and the ability to recall the associated brand, logo, or symbol. Thus we reject the null hypothesis.

2. Premium or High-performance vehicles develop positive Brand Value

- **H0 (Null):** There is no significant relationship between the perception of a company based on its vehicle branding of premium vehicles for promotional purposes.
- **H1(Alternative):** There is a positive relationship between the perception of a company based on its vehicle branding of premium vehicles for promotional purposes.

Q. On a scale of 1 to 5, how would you perceive this company just based on its branding on the vehicle? * On a scale of 1 to 5, as a business owner or marketing manager, how likely would you rent out a premium vehicle and apply your company's branding elements to promote your brand?

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	191.335[a]	16	0.000
Likelihood Ratio	105.579	16	0.000
Linear-by-Linear Association	67.903	1	0.000
N of Valid Cases	157		
17 cells (68.0%) have expected count less than 5. The minimum expected count is .01.			

Since the p-value < 0.05 we will reject H0(null).

The high Pearson Chi-Square value (191.335) and the very low p-value ($p < 0.001$) indicate that there is a statistically significant relationship between the frequency of noticing branding or logos on sports or high-performance cars and the ability to recall the associated brand, logo, or symbol. Thus we reject the null hypothesis.

6. FINDINGS

- The p-values for all three hypotheses were below 0.001, indicating a strong level of significance for the relationships analyzed.
- The robust sample size of 157 responses (acquired from the Primary data collection tool) and the high Chi-Square values further validate the findings, showcasing there is a optimistic response to premium vehicles used as mediums for transit media.
- This study confirms that premium vehicles used as mediums for transit media, connect with the audience on an innate level, thereby enhancing engagement with the target customer and potentially contributing to long-term brand value.

Interpretation

- **Premium or High-performance vehicles improve Brand Salience-** The survey included a visual representing a Formula One car with a vibrant livery and numerous sponsors' branding all over the car. With an appropriate metric given, respondents were asked to rate mention the count of the number of brands (whose branding was on the car) they have noticed before and/or could remember, out of five (Likert scale- 1 being no brand, 5 being more than 10 brands). As per the results of the survey, 72% of the respondents were able to recall atleast four to ten brands, with 9% of the respondents being able to recall more than ten brands. This suggests that high-performance cars' branding visibility can enhance viewers' retention and recall. Because they are associated with speed and performance logos put on race cars can be distinguished and may leave a stronger impact on potential target customers.
- **Brands can escalate their Brand Value by using Premium or High-performance vehicles as medium-** The survey included a visual representing a supercar with the livery comprising of the branding of a well know food delivery brand. Respondents were asked to rate the image of the car out of five (Likert scale- 1 being the lowest, 5 being the highest). As per the results of the survey, the respondents have positively reacted to the image.

  The following question asked them about their perception of the vehicle. As per the results of the survey, the respondents have shown interest in potentially employing this type of marketing communication strategy, in the future. This implies that, premium or high-performance cars are often linked to attributes like exclusivity, speed, and luxury, therefore when a business uses these mediums for marketing, it produces a halo effect that contributes to the company's perceived brand value.

7. FUTURE RESEARCH DIRECTIONS

While this study provides valuable insights into the potential opportunities for using premium vehicles as a medium for transit advertising, several avenues for future research remain

unexplored. Brands can create highly engaging and impactful marketing strategies that resonate with consumers on multiple levels.

Potential Research Questions:

- Is advertising using Exotic vehicles as a medium for marketing communication, a viable option for companies? Premium vehicles may have limited reach compared to traditional transit advertising, as they operate in specific areas, targeting specific customers.
- Can transit advertising using premium transit a sustainable option for the long-term? The enthusiasm and attention received by supercars and high-performance vehicles is a short-term trend, therefore can this approach to transit advertising provide brands gains in the long-term.
- Which brands or industries benefit the most from advertising on premium vehicles? The study discusses prospects presented using premium vehicles for transit advertising, however is this a strategy may not applicable to all brands across all industries.
- How can premium car advertising incorporate cutting-edge technologies like artificial intelligence (AI) and augmented reality (AR) to increase engagement?

By exploring these areas, future research can contribute to a deeper understanding of the potential and limitations for using premium vehicles as a medium for transit advertising, providing valuable insights for marketers and researchers alike.

8. MANAGERIAL IMPLICATIONS

The research study highlights the opportunities presented for potentially using Premium and High-Performance vehicles as a medium to promote brands or simply spread awareness about a brand or their latest offerings. While this marketing strategy may have been proved to be effective in theory, the practical implementations and implications may make or break a brand.

- Maintaining the magnificence of the transit: The vehicles in question are not only expensive and fast, but also eye-catchingly beautiful, making them prodigious head turners and attention magnets. Any branding done will catch the eye of the targeted customer (on road or through forms of media), however the crucial consideration is to not disrupt the look of the vehicle. This means that companies should prefer using subtle branding or liveries that are not to cluttered, thereby avoid becoming an eye-sore. If the branding or choice of livery is too ostentatious, it can possibly displease the target customer, thereby painting the wrong picture in the customers' minds.
- Augmenting Brand Value: Promoting the brand using high-performance vehicles as a means transit advertising or sponsoring motorsports teams (like in Formula One) can help differentiate a brand from competitors. By highlighting its unique features or characteristics brands can develop positive perceptions and emotions associated with the brand's value. This can lead to improved visibility, generating curiosity and eventually word of mouth and long-term customer relationships. This can be especially effective in crowded markets where brands struggle to stand out. (Example the Fast Moving Consumer Goods Market).
- Developing Brand Image: Advertisements on high-end cars inherently relate the brand to exclusivity and superiority. This platform allows managers to market their products as premium or high-value. For instance, promoting a brand on a fleet of Mercedes-Benz or luxury vehicles with chauffeur services can enhance the brand's perception among target customers.
- Better ROI: Premium cars provide more targeted, niche advertising compared to conventional mass transit advertisements. This concentrated targeting can result in better engagement and conversion rates, particularly for firms that target high-income consumers. A thorough cost-benefit analysis is necessary because premium placements may have greater costs per impression.

9. LIMITATIONS

A small sample could not be representative of the whole population, which would restrict how broadly our results can be applied. The study's conclusions are constrained by its urban concentration and small sample size, which limit the range of responses and limit its generalizability to larger groups.

There may be other explanations for the findings that were overlooked throughout the investigation. Limitations of statistical testing include the likelihood for Type I and Type II mistakes. The analysis's breadth was constrained by the lack of access to pertinent data. Further research with larger and more diverse samples is needed to validate the findings.

10. ACKNOWLEDGEMENT

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11. DECLARATION

I, Tanmay Aggarwal, hereby confirm that the manuscript titled "Evaluating the Strategic Opportunities of Premium Vehicles as a Medium for Transit Advertising" authored by Tanmay Aggarwal, has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to International Management Perspective Conference 2025.

I/we declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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7

Navigating Filter Bubble in Social Media using Bibliometric Study

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ABSTRACT

AI-based personalized advertisements play an important role in enhancing the sales funnel and improving the consumer experience. This study explored how personalized algorithms —enhance engagement, but also create a filter bubble, leading to intellectual isolation and limited exploration of alternatives. Employing bibliometric study and bibliographic coupling, this study reviewed filter-bubble research. The approach identified key authors, countries, and institutions and revealed trends. Bibliographic coupling brought insights into triple filter bubble and misinformation. It further delved into platform-specific dynamics, ideological polarization, and automated serendipity to enable tailored marketing strategies. The study recommended integrating diverse content strategies and enhancing multi-disciplinary collaborations to mitigate filter bubble effects, thereby bridging the gap between academia and industry and improving consumer satisfaction and market dynamics.

Keywords: Personalisation Social Media Bibliographic coupling, Filter bubble

1. INTRODUCTION

Social media platforms extract and analyze enriched metadata to devise personalized marketing strategies. They penetrate consumers' everyday lives by developing social networks, online markets, and sharing personal experiences (Gottfried & Elisa, 2016). According to a recent Forbes Advisor report, the CAGR of social media users will explode at 26.2% from 2023-2030. The power of social media has brought about a shift in consumer behavior toward developing personalized relationships. However, it encapsulates consumer minds in an environment created by a marketer.

In the book filter bubble: What the Internet is hiding from you? Eli Pariser, states that personalized algorithmic filtering leads to intellectual isolation (Pariser, 2011).

Filter bubble has its roots from political marketing is equally relevant in consumer marketing. Facebook and Twitter provided tailored environment to voters which affected information diversity and reinforced the existing beliefs. Similarly, AI–based algorithms personalise the social media advertisements to shape unique consumer experiences. It creates information cocoons as it presents users with personalized shopping experiences. These experiences present users with a narrow selection of products, largely determined by their past behaviors, preferences, or demographic characteristics. Though personalisation leads to informative and relevant advertisements, too much of it can lead to intrusion and privacy control. Hyper personalisation is a common issue in both areas where it inhibits the user from being fully aware of the information to make objective decisions (Bozdag & Hoven, 2015

The paper adapts bibliographic coupling to discuss comprehensive themes on hyperpersonalisation due to filter bubble. One of the themes bring attention to 'automated serendipity', and 'ideological polarization' which help to devise sophisticated marketing strategies. Ideological polarization gained attention during the 2016 US presidential election. US conservatives preferred Fox News while Liberals stood strongly on the news shared by CNN and NPR (Iyengar & Hahn, 2009). The news readers were shown personalised information as per their ideals that resonated with their beliefs. It had a much greater influence as media channels influenced users based on their beliefs. The dynamics of ideological polarization can be leveraged in marketing, especially for products tied to specific consumer beliefs. Ideological polarisation can help to target trendsetters, who value their fashion identity by focusing on style, exclusivity, and individual identity. Automated serendipity allows subtle exposure of ads to engage people with limited fashion taste. A marketer can cater to same product to a person with no fashion interest and a trendsetter using the ideological polarization and automated serendipity

The preliminary investigation revealed that the topic is multi-disciplinary and its findings can be adopted to personalized marketing.

However, there has not been any significant study to understand the research structure from a bird's - eye view.

To overcome these shortcomings, we performed a comprehensive bibliometric analysis of the filter bubbles. In doing so, we strive to enrich the extant literature and contribute to a better understanding of the filter bubble and its implications for social media platforms.

We address the following questions-:

2. RESEARCH OBJECTIVES

1. Which are the prominent institutions, nations and authors across the globe?
2. What are the publication networks and collaborations over time?
3. What research frontiers, trends, and core topics are associated with the research domain?

3. LITERATURE REVIEW

Filter bubble is a state of intellectual isolation arising from personalized messages. The term was formulated after unexpected poll results during the 2016 US Presidential Elections. Upon investigation, it was found that Facebook was used as a medium to influence voter political ideology. Users continuously received curated posts before elections, which influenced their decisions and led to unexpected results (Burbach et al., 2019; Strauß et al., 2020). In a democracy, social media is considered a powerful platform for exchanging the viewpoints and opinions of voters. The sole agenda of personalized content is to isolate the minds of users from the real world and influence their decision making by creating a narrower world.

Consumers are unlikely to access information on other products available in the market, which is a form of an information barrier. Such user-centric recommendations activate consumer consciousness, leading to resistance in purchase intention. A study on pop-up windows during online shopping showed reduced levels of acceptance of personalized recommendations (Liu & Cong, 2023). The filter bubble phenomenon faces a "polarization problem, which means that the business tends to lose potential consumers at the cost of gaining users' attention. Highly accurate algorithms surely posit relevant product suggestions, but they limit users' ability to explore other brands.

AI tracks footprints of consumer behavior in various digital spaces to generate the relevant content on a real-time basis. The recommender system employs personalized algorithms to influence consumers' purchase intentions. It tracks consumers' online data, web search behavior, search history, and click behavior to create personalized advertisements. Consumers perceive advertisements as self-related, which aligns with their values, goals, and needs (Zhu & Chang, 2016). The self-referencing theory explains how relevant information, videos, and images lead to a positive cognitive response. Advertisements of baby care products shown to expecting mothers are more likely to induce a positive response than teenagers. Previous studies have shown that relevant advertisements lead to better recall rates, effectiveness, and purchase intention (Jung, 2017). A personalized recommender system is an indispensable marketing strategy; however, excessive personalization has its own risks. Highly accurate advertisements can lead to information cocoons or filter bubbles. This alienates consumers from other products available in the market, which limits their decision-making skills.

Presenting a highly accurate product recommendation is an ineffective strategy. Highly accurate online recommendations are invariable as consumers are most likely to purchase the product (Herlocker et al., 2004). Rather marketers should focus on diverse mix recommendation. For instance, a curly-haired female receives personalized advertisements for the XY shampoo. The advertisement discusses how the shampoo treats curly hair and renders it frizz-free. She will continue to buy XY products because of increased satisfaction. Any related product such as hair oil, gel, or hair mask for curly hair will also be purchased by the female as it is personalized. This is an example of a hybrid recommender system.

Although personalized algorithms enhance customer satisfaction, they also create filter bubbles that restrict access to diverse information. This phenomenon influences decision making, making it crucial to balance the benefits of personalized algorithms to mitigate the drawbacks of over-personalization.

4. METHODOLOGY

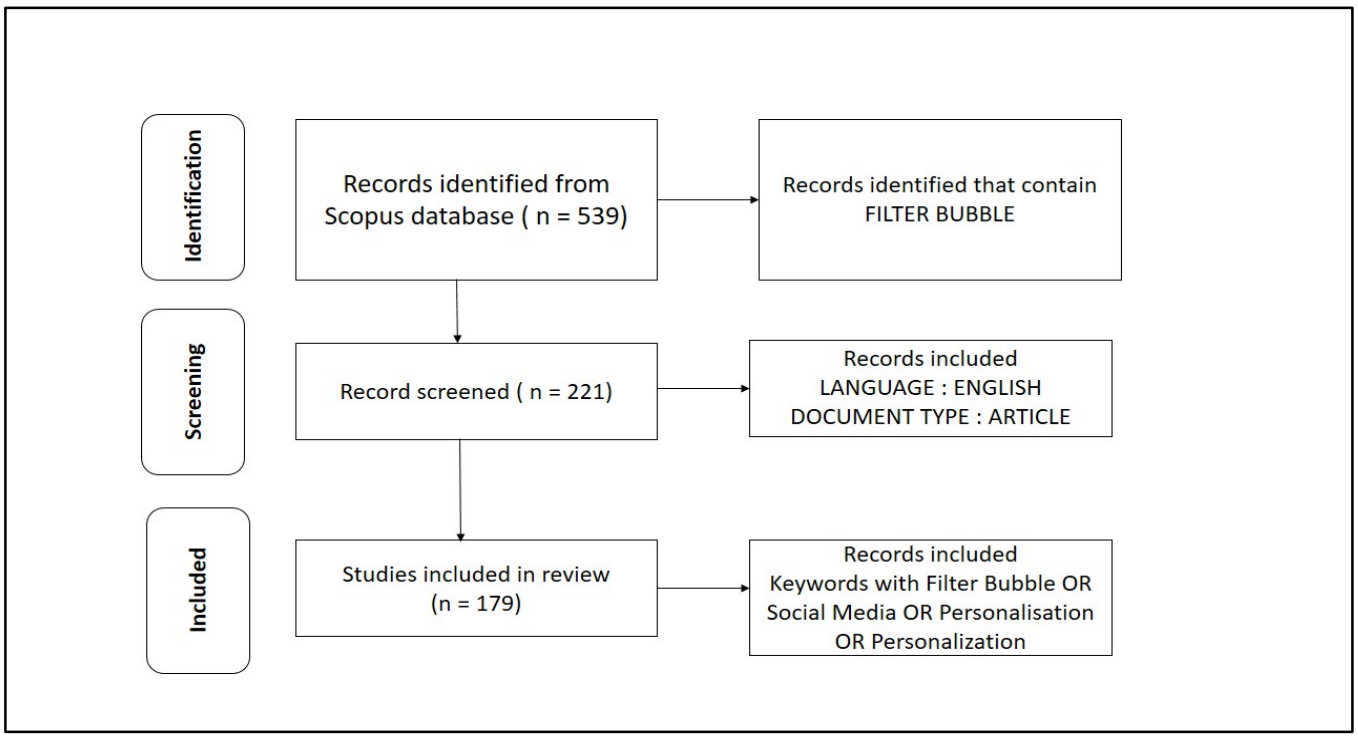
Bibliometric analysis aims to identify the research hotspots and trends in published works on filter bubbles. Unlike traditional systematic review methods, it provides comprehensive, detailed, and accurate results. Various software packages, such as R Studio and VosViewer are employed to produce systematic, quality, and unbiased results. These software programs are based on knowledge domain visualization (KDV) to provide a comprehensive and graphical representation of the existing literature. The maps present the interactions and linkages between authors, keywords, and institutions. It converts large sets of data into graphical illustrations that facilitate easy interpretation and interactive visualization (Rejeb et al., 2022). Bibliometric analysis revealed leading author, country, and institutional collaborations using statistics and KDV in the given research area. The findings lay the foundation for future research and reveal issues that are yet to be resolved by global academics. Cluster analysis results in the emergence of themes and identification of research gaps (Zhao & Li, 2023).

The study employed the VOS Viewer software package and R Studio – Biblioshiny package. The VOS Viewer compiles and refines the literature to generate networks, density

visualization, and overlay visualization maps (Nobanee et al., 2021). Performance mapping is descriptive in nature, and measures the publication, citation and author metrics. Science mapping helps understand the relationship between research constituents (Donthu et al., 2021).It involves citation, co-citation, bibliographic coupling, co-authorship, and co-word analyses.

Data collection was guided by a search process with a defined protocol. The data file was extracted from Elsevier Scopus, which has reputed journals in the fields of communication, information technology, management, psychology, and media. A multi- disciplinary database has a comprehensive pool of studies with a structured search function. It has more than 20, 000 peer-reviewed journals with advanced search filters for extensive data analyses.

Figure 1: PRISMA flow chart



Source: Authors elaboration

The data extraction guide involved a TITLE – KEYWORD – ABSTRACT search in the Scopus database. No time restrictions were imposed at the beginning of the publication year. The dataset was downloaded from. csv format, which includes metadata for articles, conference papers, erratum, book chapters, editorials, and conference reviews. Author's full name, title, source title, abstract, publication year, keywords, affiliations, publication year, and funding data.

The PRISMA protocol directed the systematic review process (Page et al., 2021). The results identified 539 records with filter bubbles. As per the screening process, only English articles were included, resulting in 221 records. Other publications were excluded because they were less significant in the research industry. The inclusion criteria were articles that had keywords such as filter bubbles, SOCIAL MEDIA, PERSONALISATION, or PERSONALIZATION. The descriptive statistics (Table 1) of the final file has 179 records present data about sources, citation, authors and keywords.

TABLE 1: Descriptive Statistics of Articles

Description	Results
Timespan	2006:2023
Sources (Journals, Books, etc)	142
Documents (Articles only)	179
Annual Growth Rate %	9.93
Document Average Age	3.32
Average citations per doc	19.78
References	244
DOCUMENT CONTENTS	
Keywords Plus (ID)	437
Author's Keywords (DE)	632
AUTHORS	
Authors	419
Authors of single-authored docs	53
AUTHORS COLLABORATION	
Single-authored docs	55

Co-Authors per Doc	2.54
International co-authorships %	7.821

Source: R- Studio

5. FINDINGS

Author Based

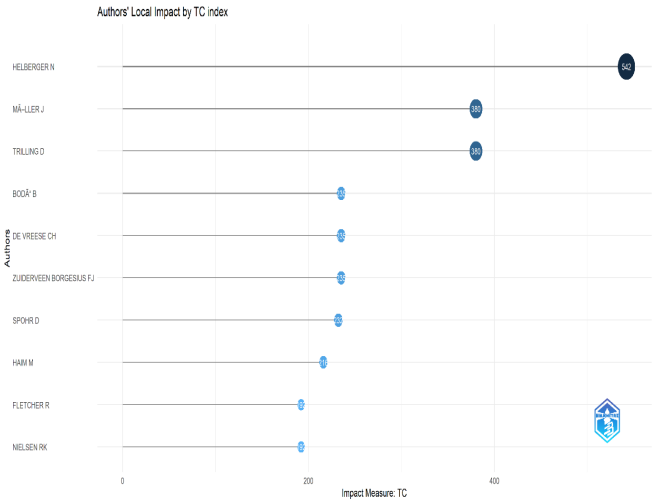
Natali Helberger, a professor at the University of Amsterdam, is the most influential author in research on personalized communication, AI and Data Analytics (Table 2). She has the maximum number of publications (n =4), with a maximum citation of 543. Bodâ-B, De Vresse, and Zuiderveen Borgesius have a citation ratio (235), primarily due to the significant impact of one paper, "Should we worry about filter bubble? This study explores the impact of personalized communication that leads to information cocoons (Figure 2).

TABLE 2: Top 10 Authors by the Number of Publications

Authors	Articles	Total Citation
Helberger N	4	542
Fletcher R	3	192
Liu Y	3	2
Min Y	3	8
Nielsen RK	3	192
Arfini S	2	3
Bharadwaj S	2	44
Castellano C	2	12
Choudhury Tr	2	44
De Marzo G	2	12

Source: R Studio

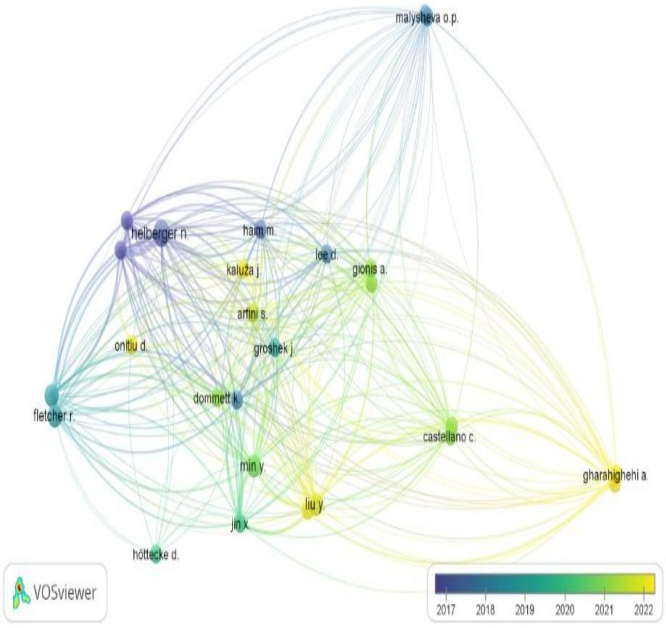
Figure 2: Authors' local impact by total citation index



Source: R Studio using Bibliometrix package

The recent author collaboration network (Figure 3) shown in the yellow-colour node discusses identity loss due to algorithmic personalization. The authors worked on real-world datasets to continuously improve recommender systems to mitigate such effects. There is a need for Malysheva to conduct collaborative research on socio-political life post elections as it has the weakest collaboration network.

Figure 3: Author Collaboration Network Overtime



Source: Vos-Viewer software

Country Wise Analysis

The USA is the leading publisher, followed by the United Kingdom and Germany (Table 3). However, the highest citation-to-publication ratio is by the Netherlands. Overall European countries are the highest contributors in the research field owing to advanced research infrastructure.

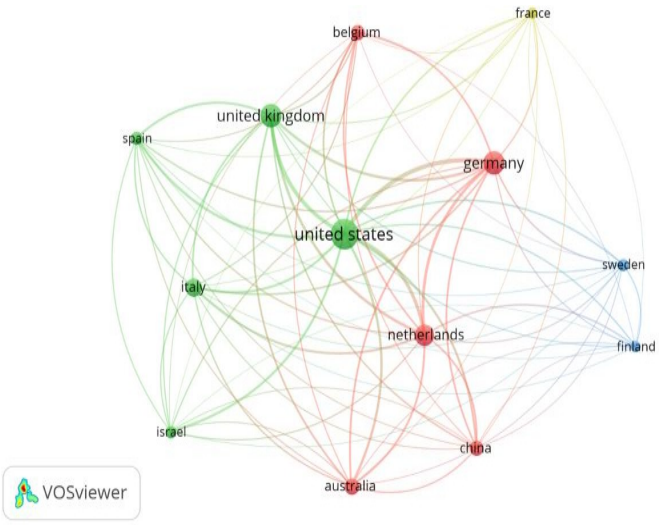
TABLE 3: Country Wise Publication Metrics

Country	No. Of Publications	Total Citation	Citation Per Publication
USA	49	594	12.12244898
GERMANY	25	553	22.12
NETHERLANDS	17	551	32.41176471
UNITED KINGDOM	28	251	8.964285714
AUSTRALIA	11	166	15.09090909
BELGIUM	12	86	7.166666667
NORWAY	3	58	19.33333333
ITALY	13	47	3.615384615
INDIA	3	44	14.66666667
CANADA	2	37	18.5

Source: R Studio

The country cooperation network (Figure 4) shows that green cluster is the largest formed by five prominent countries. The USA being the leader (TLS – 4839) has a strong country cooperation network with the Europe and Asia despite the geographic boundaries.

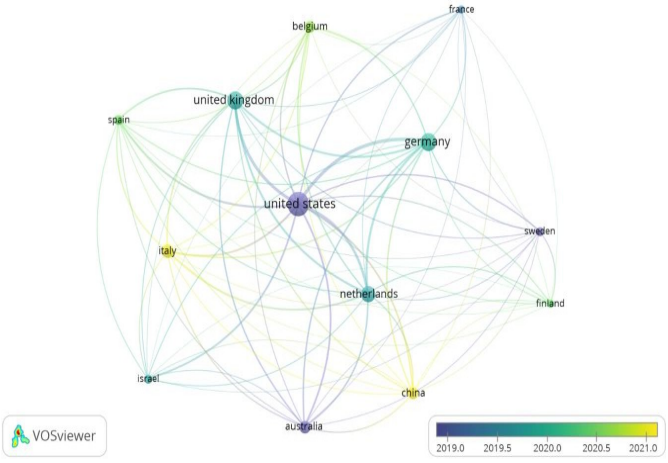
Figure 4: Country Cooperation Network



Source: Vos-Viewer software

The United States of America is pioneer in country collaborations since 2019. China is the only Asian country that has gained recent attention for collaborative research(Figure 5).It suggests that collaborations in Asia are at nascent stage. Hence, research collaboration between countries is suggested for better insights.

Figure 5: Country Overlay Visualisation Network



Source: Vos-Viewer software

6. AFFILIATION ANALYSIS

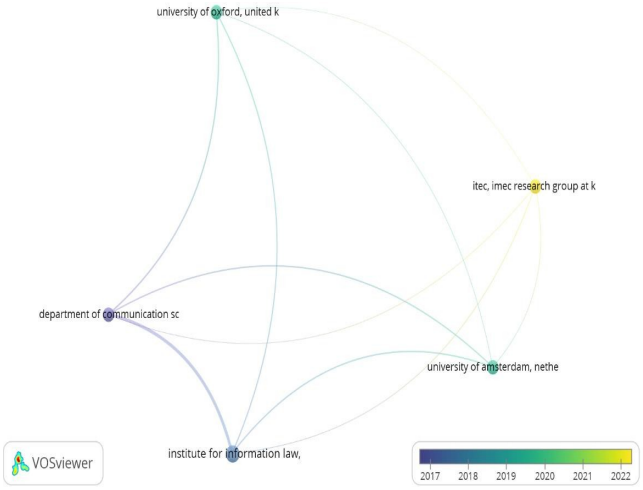
60% of the universities are affiliated with Europe which marks their expertise in the field (Table 4). The node size explains the number of publications by each institution, and the links correspond to the collaborative relationship in the overlay institutional collaboration network (Figure 6). The University of Amsterdam has the highest publications being the part of oldest and largest institutional collaboration.

TABLE 4: Publication Metrics of Institutions

Affiliation	*Articles*
UNIVERSITY OF AMSTERDAM - Netherlands	18
UNIVERSITY OF OXFORD - United Kingdom	7
ZHEJIANG UNIVERSITY OF TECHNOLOGY - China	7
AALTO UNIVERSITY – Finland	6
UNIVERSITY OF PAVIA – Italy	6
TAMPERE UNIVERSITY – Finland	5
UNIVERSITY OF TORINO – Italy	5
BOSTON UNIVERSITY - USA	4
CENTRE FOR THEORETICAL STUDIES – India	4
GHENT UNIVERSITY- Belgium	4

Source: R Studio

Figure 6 – Overlay Institutional Collaboration Network



Source: Vos-Viewer software

7. BIBLIOGRAPHIC COUPLING

Bibliographic coupling reflects the similarity between the two documents. It identifies when two documents cite a third document directly. Since bibliographic coupling uses common references to establish similar concepts, it helps to understand the evolution and growth of a research area. Nine central themes were identified in this study. The first seven clusters discuss 95 % of the articles presents the central themes (Table 5).

Cluster 1: *The impact of Algorithmic Filtering on Information Diversity* is the largest cluster, with 27% of the publications and the third highest citation count. Traditional recommender systems are designed as per users' interests which can lead to a feeling of boredness to the user due to

the monothematic and repetitive nature of content (Zhang & Hurley, 2008) Marketers always do not understand the 'real interests' of the consumers (Bucher, 2017). The algorithmic filters can be sometimes imposing. The individual autonomy perspective believes that a self-seeking individual maximizes utility by knowing and choosing products as per his interests (Dahlberg, 2011).

Hyper- personalization limits consumers' exposure to other alternatives, which can be regarded as a 'market failure' that limits an individual's autonomy and prevents them from seeing what they want outside the filter bubble. A resistance leads to consumer behavior to break the filter bubble. Designing diversity-based recommendations promotes consumer awareness and offers more choices to correct the 'market failure'. Diverse- recommendation system is based on individual choices and offers them more opportunities to realize their interests.

Cluster 2 – *Triple filter bubble in personalized algorithms* has 17 % of the publications and 12 % of the total citation count. Google News offers personalized news recommendations by syncing online activity across other Google applications such as mail, search engines, maps, and calendars.

Albert recently searched about Paris on Google with his friends. After that, he saw repetitive advertisements in Google News sharing news about Paris and also saw an advertisement on Instagram on Paris travel packages. This is a relevant example to iterate the difference between personalisation and hyper-personalisation. Hyper-personalisation are viewed as intrusive, hinders privacy and consumer reactance. It reinforces existing beliefs and opinions creating an echo chamber and filter bubble (Sunstein, 2009).

TABLE 5: Filter Bubble Cluster Overview

Cluster	Number of papers	Central Focus	Major topics explored	Starting Year	Ending Year	Top 3 cited papers		
						Author	Year	Citations
Cluster 1	42	The impact of Algorithmic Filtering on Information Diversity	Information diversity, filter bubble, democracy, recommender systems, social media, elections	2014	2022	(Bozdag & Hoven, 2015) (Helberger et al., 2018) (Groshek & Koc- Michalska, 2017)	2015 2018 2017	156 128 122
Cluster 2	25	Triple Filter Bubble in personalized algorithms	Triple filter bubble, agent- based modelling, echo chamber, news, Google News, journalism, personalised algorithms	2018	2023	(Möller et al., 2018) (Nechushtai & Lewis, 2019) (Geschke et al., 2019)	2018 2019 2019	145 85 81
Cluster 3	22	Audience fragmentation v/s audience duplication	Audience segmentation, fragmentation, algorithmic bias, critiques of filter bubble, selective exposure, comparative research	2016	2022	(Borgesius et al., 2016) (Haim et al., 2018) (Fletcher & Nielsen, 2017)	2016 2018 2017	235 174 145
Cluster 4	17	Misinformatio n Challenges	Misinformation, fake news, auditing partisan bias, information systems, web search engines, empirical studies, science communication, YouTube	2018	2021	(Robertson et al., 2018) (Hussein et al., 2020) (West & Bergstrom, 2021)	2018 2020 2021	66 61 53
Cluster 5	17	Understanding Filter bubble structure	Opinion dynamics, controlled experiment, social network, filter bubble structure, echo chamber, polarisation methodological insights	2015	2022	(Min et al., 2019) (Kaluža, 2022) (S. Liu et al., 2022)	2019 2022 2022	250 214 155
Cluster 6	17	Platform-specific dynamics	Platforms, diversity, media exposure, polarisation, personalisation, digital technologies, user behavior and agency	2019	2022	(Kitchens et al., 2020) (Cardenal et al., 2019) (Seargeant & Tagg, 2019)	2020 2019 2019	40 37 35
Cluster 7	15	Leveraging ideological polarization	Ideological polarisation, echo chamber, social media, automated	2017	2022	(Spohr, 2017)	2017 2018	232 84
		and automated serendipity	serendipity, selective exposure, search engines			(Beam et al., 2018) (Fletcher et al., 2018)	2018	41

Source: Authors elaboration using Vos Viewer

The triple filter bubble helps to comprehensively understand how information filtering happens at three levels – Individual, social and technological. The triple filter bubble framework using agent based modelling to understand the interplay of three filtering layers. Information is filtered at the individual level by personal data like cooking and search history (Geschke et al., 2019). Social filtering happens when a user is influenced by the content friends engage in social media. The backbone of technological filtering is algorithms that aim to maximize profits from advertising. Understanding triple filter bubble help to modify recommender systems ensure diversity and mitigate the effects of hyper-personalisation.

Cluster 3- *Audience fragmentation v/s audience duplication* has 15% of publications and encompasses 10% (1871) and 22% of citations. The cross-national study found that audience duplication is dominant in the US and Spain where media consumers use various news sources. Media consumers in the UK and Denmark are fragmented due to specific news outlets like the BBC in the UK owing to consumer loyalty (Fletcher & Nielsen, 2017).

The prominent concepts that emerge from the cross-national study are audience fragmentation and duplication which can be adopted in marketing. The nature of the product will decide if the marketer should choose consumer fragmentation or duplication. Consumers of generic products collect information from various platforms before purchase. Corroborating the paper's findings, high-choice environments lead to audience overlap and broader reach. Marketers should focus on presenting attractive offers across platforms to gather attention from consumers who seek better deals.

Consumer fragmentation is an ideal strategy to target consumers who want to buy niche products. Earth Rhythm is a brand that makes 100% natural skin care cosmetics that align with the vision of a specific group of people. Fragmentation is breaking down the audience into smaller groups catering to specialized needs (Haim et al., 2018). Consumer loyalty draws the success of niche brands. With this, the niche product must create a strong identity by establishing exclusive shopping applications and campaigns.

Understanding whether a product benefits from fragmentation or duplication helps marketers effectively position products and engage their ideal audience.

Cluster 4 – *Misinformation challenges* has 11% of the publication and 7% of citations. The social media platform is an agent for spreading false or wrong information. The paper primarily focused on misinformation in YouTube and found out how personalisation affects the level of misinformation especially based on users' watch history. The audit study brought attention to the need to prioritize relevance and credibility.

Common social media ads that promote misinformation are green washing – falsely labelling a product as eco-friendly, exaggerated promises about product effectiveness – diet chocolates, creating fake urgency – only 2 left in stock, false testimonials shared by social media influencers, AI- deep fake ads and fake reviews to boost sales. These practices reap profits in short term at the cost of affecting trust, brand image and raising ethical concerns.

Similar audits should be conducted on other platforms like Facebook, Instagram .The audits help to identify the sources of misinformation, improve transparency and develop credible advertisements.

Cluster 5 – *Understanding Filter bubble structure* covers 11% of the publications and 24% of citations. Experimental studies on social bots analysed 1.3 million messages to understand the internal structure of filter bubble. Filter bubble is identified as a dense community of users with similar preferences, demographics, and needs. The use of personalized algorithms creates filter bubble and polarized groups (Kakiuchi et al., 2018). The internal structure of the filter bubble explains the state of intellectual isolation where users reject of personalised information after a certain level. According to bounded rationality theory the user pays limited attention and integrates a certain amount of information (Simon, 1990). When their memory is full, they forget bits of information to integrate new ones and reject irrelevant information that is not fitting to its attitudinal memory space. Frequent online recommendations are ineffective not only due to limited memory retention but also as the consumer feels irritated and stalked (Gupta et al., 2024). This highlights the significance of a real-time updating of AI algorithms based on consumer actions, feedback and tracking eye ball movements.

Cluster 6: *Platform specific dynamics* encompassed 11% of publications and 5% of citations. Research on Facebook, Twitter, and Reddit revealed that social media behavior is moderated by platform usage (Shore et al., 2018). The content and engagement style varies as per the audience visiting the social media platform. While Facebook has strongly opinionated people, Reddit has users with moderate viewpoints, and Twitter users are not affected by personalized information (Kitchens et al., 2020). The demographic differences in the online platforms enable marketers to customize their advertisements. E-cigarettes were directly promoted in Twitter while Facebook had advisory-based announcements as its marketing strategy (Chu et al., 2015). The strategy would vary from direct interactions to informative messages as per the demographics of the platform users.

Cluster 7 – *Leveraging ideological polarization and automated serendipity* covers 9% of publications and 14% of citation count. Automatic serendipity provides a diversity-sensitive design that offers a mix of suggestions that consumers are already aware of and 'significantly different' product recommendations (Helberger et al., 2018). Ideological polarization happens because of selective exposure and filter bubble. Consumers gravitate to sources that resonate with their beliefs due to selective exposure. Personalized algorithms curate content based on a person's personal experiences, beliefs, and consumption history, leading to filter bubbles (Rader & Gray, 2015). A sophisticated marketing approach should leverage insights from automated serendipity and ideological polarization. Eco-conscious consumers will be impacted by the 'sustainability-focused message' as it resonates strongly with their ideology. A marketer should use automated serendipity while targeting on general consumer base for the same product. The dynamic ad control relevance and reduce ad fatigue due to too-much of personalisation.

8. IMPLICATIONS

Although this research focuses on the application of scientometrics and the exploration of filter bubble research in academia, it also has practical relevance. Practitioners can benefit from current research findings in various ways.

Studies suggest focusing on exposure diversity to mitigate the effects of hyperpersonalisation. The diversity-sensitive recommender system can provide a desirable level of exposure diversity by providing personal autonomy and choice to the consumers. A marketer needs to adopt certain practices and metrics to provide 'ideal recommendation'. Continuous modifications in the systems as per consumer response, collection of survey responses after an advertisement is shown, Eg Youtube, and providing people the power to control the extent and exposure of recommendations. Certain metrics to understand consumer response to these systems by studying navigation behavior, measuring the attention span by tracking eye movements, pages followed in social media will help to design a consumer-specific design system.

The strategic application of the triple-filter framework allows marketers to broaden exposure and stimulate curiosity, mitigate the impact of filter bubble. The dynamic interaction among individual, social, and technological filters helps to better consumer experiences and leads to brand discovery.

For example, a Riya prefers a specific makeup brand. The cognitive bias makes her loyal to the brand is a part of individual filter. In her social filter, she is reinforced by her choice due to her social friends. Nykaa, an e-commerce application shows ads on that specific makeup brand based on the recommender system. The dynamics of three filters has created a filter bubble. The marketer need to carefully understand the triple filter interplay to introduce a new product by 'serendipitous recommendations' to convert latent interests into an exploration phase.

It clear that each social networking platform has different levels of usage and appeal for certain demographics (Kitchens et al., 2020). Social media marketing differs in targeting specific groups based on platform-specific dynamics based on user demographics. Product promotions would vary from hashtags, influencer posts, interactive polls, and organic conversation as per the platform catered. Facebook users respond strongly to algorithmic filtering while Twitter users do not algorithmic filtering due to strongly held opinions. Marketers can use highly engaging polls for Facebook and real time conversations via hashtags in Twitter. Comprehensive studies on platform-specific dynamics are valuable, as social media serves as an effective marketing tool.

Audit studies conducted on YouTube reveal are algorithmic filtering misleads consumers (Robertson et al., 2018). The audit research can help inform the development of algorithms that prioritize both relevance and credibility, ultimately leading to a more positive and trustworthy experience for users across different digital platforms.

Although the academic community has conducted substantial research on filter bubbles in recent years, a push for practical action is still required, particularly from the perspective of developing countries. Policymakers, research centers, and institutions studying the impact of filter bubbles should consider related research findings. Business managers can benefit from this research's results to better understand customers' behavioral intentions and decision- making in the filter bubble. In this way, they can implement the value-creating initiatives suggested by academia.

9. CONCLUSION

This paper presents a comprehensive overview and clearly visualized analysis of publications related to filter bubbles until March 2023 in the Scopus database. The bibliometric analysis focuses on filter bubble-related journal articles, which reveal several bibliometric indicators, such as influential authors, journals, and academic institutions. Through the analysis of these indicators, possible inter-collaborations and hot topics were found in this knowledge domain. This crucial information lays the foundation for future research.

To provide a comprehensive view of the filter bubble and social media, this study has worked on three research questions covering research trends; global collaborations in terms of author, country, and institution.

The maximum Quality over Quantity is true in academia. Helberger, who has published the maximum number of research articles, did not have the highest citation-to-publication ratio. On the other hand, a paper titled Should we

worry about filter bubbles? has been cited by many authors (C/P - 235) and co-authored by Boda, Vresse, and Borgeius. This paper discusses how personalized content on social media affects news readers, proving the maxim of quality over quantity.

It is interesting to note that the USA has strong collaboration with other European countries The USA was also a pioneer research country. Many European institutions have led further collaborative research. Studies contributed by Asian countries are at a nascent stage, which suggests the need for further collaborative research among continents for insightful work. The institutional overlay initialization network shows that the University of Amsterdam has been a leader in collaborative research.

The latter part of the paper discusses how personalized marketing strategies have led to hyperpersonalisation. Traditional recommender systems offer personalized recommendations by adopting content-based filtering and collaborative filtering. Albeit, traditional recommender systems have created filter bubble that isolates the users from other alternatives. Filter bubble leads to ad fatigue and passive user responses. Highly accurate recommendations make advertisements boring and irritating. The bibliographic coupling brings insights into triple filter bubble, misinformation, and audience fragmentation. Strategies like automated seredipidity and ideological polarisation can be a pill for hyper-personalisation. Platform- specific dynamics elevates the marketing strategies as per user behaviour across social media platforms. These insights help marketers to build effective strategies.

10. LIMITATIONS

This study has several potential limitations in the bibliometric analysis. The results were based on scholarly articles indexed in the Scopus database. Inclusions of research work from Web of Science and Google Scholar could have provided a wider perspective on the research topic. The PRISMA Protocol adopted in this study only included research articles in English. However, the exclusion of conference papers, book proceedings, editorials, and book chapters omitted significant results and findings. Nonetheless, the above-mentioned bibliographic limitations can be overcome by conducting further research. The research may be extended to other databases, including other knowledge sources that can boost studies. The research study provided a comprehensive view of filter bubbles by adopting visualization and science mapping techniques.

DECLARATION

I, Ruth Mathews, hereby confirm that the manuscript titled "A Bibliometric Approach to Decoding the Filter Bubble Phenomenon" authored by Ruth Mathews, Dr. Amit Malhotra and Dr. Harpreet Kaur, has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to International Management Perspective Conference (IMPeC) 2025.

I/we declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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Digital Strategies for Consumer Engagement: Analyzing Online Sales Promotions for Large Appliances in the Indian E-commerce Ecosystem

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ABSTRACT

This research investigates consumer attitudes toward online sales promotions in India, focusing on large appliances such as refrigerators, washing machines, air conditioners, and dishwashers. The aim is to identify key factors shaping consumer perceptions, offering actionable insights for e-commerce platforms to craft effective promotional strategies. A quantitative methodology was employed, utilizing a survey of 467 Indian consumers with 17 Likert-scale statements to capture perceptions. Data reliability was validated through Cronbach's Alpha, while factor analysis identified five core factors influencing attitudes. These factors include Savings, emphasizing financial benefits and budget relief; Quality, which assures product excellence and brand upgrades; Convenience, highlighting ease and efficiency in purchases; Status, reflecting personal pride and emotional fulfilment from smart shopping; and Variety, offering access to diverse products and opportunities for brand exploration. Together, these factors account for 73.7% of the variance in consumer attitudes. This study is novel in its focus on large appliances within the Indian e-commerce context and introduces "status" and "variety" as new dimensions in understanding consumer perceptions, broadening established theoretical frameworks. While its reliance on convenience sampling and specific product focus may limit generalizability, the findings provide critical insights for optimizing digital marketing strategies. Practical implications include tailoring promotions to highlight savings, quality, convenience, and product diversity, particularly for price-sensitive consumers. Socially, the research underscores the role of online sales in enhancing accessibility to essential consumer durables, improving living standards, and promoting economic inclusivity in India.

Keywords: e-commerce, online sales promotions, large appliances, consumer perception

1. INTRODUCTION

The fundamental goal of any business is to enhance the sales of its goods or services (Ofoegbu & Udom, 2013). Various methods such as advertising, direct selling, and affiliate marketing contribute to this objective, with sales promotions being a particularly well-researched tactic. Short-term promotional offers can attract new customers and increase market share (Liu et al., 2011); however, their misuse can jeopardize profitability (Ofoegbu & Udom, 2013; Pauwels et al., 2002). The growing competition in the retail sector forces marketers to implement strategies that establish their brands as leaders in the market (Marais et al., 2014). While maintaining cost efficiency, businesses must balance efforts to acquire new customers and retain existing ones, as acquiring customers is often more expensive than retaining them (Khamitov et al., 2019).

In the current retail environment, effective consumer communication is paramount for showcasing available products and services, making the marketing communication mix—especially sales promotions—an indispensable element (Majid & Laroche, 2019). Sales promotions employ tactics to inform, persuade, and stimulate purchases (Kotler & Armstrong, 2017). Marketers strive to design captivating promotions that draw consumers' attention and boost their intent to buy (Nagar, 2009; Rao, 2009). To influence consumer purchase decisions effectively, it is critical to adopt promotional strategies that align with the target audience's preferences (Jee, 2021). Customers are often enticed by the promise of monetary savings, delivering utilitarian value (Amara & Kchaou, 2014), as well as by hedonic rewards like symbolic satisfaction and emotional gratification (Hirschman & Holbrook, 1982). Recognizing how consumers perceive and benefit from sales promotions is essential to optimizing their success (Chandon et al., 2000). This study explores consumer attitudes toward online sales promotions for large appliances offered by Indian e-commerce platforms. By identifying the attributes that consumers value most, the research seeks to assist e-commerce companies in creating marketing campaigns that effectively resonate with their audiences.

2. REVIEW OF LITERATURE

Sales promotion

Sales promotion, an integral component of the promotional mix, plays a direct role in shaping consumer behavior and driving purchasing decisions. It serves as a cornerstone of contemporary marketing, where businesses utilize a variety of strategies to attract attention and prompt immediate purchases (Shimp, 2010). Broadly, sales promotions can be

divided into two categories: monetary (price-based) and non-monetary approaches, both of which aim to increase brand visibility, stimulate purchase intentions, and encourage product trials (Farrag, 2017; Carpenter & Moore, 2008).

Sales promotions leverage a range of tools to elicit swift consumer responses across diverse products and services (Kotler, 2012). They perform critical functions, including enhancing brand image, increasing store traffic, creating favorable price perceptions, and clearing surplus inventory (Blattberg & Neslin, 1990). In online retail, sales promotions encourage immediate consumer engagement, often resulting in impulsive purchases that meet instant demands (Rook & Hoch, 1985). These promotions deliver both hedonic benefits, such as enjoyment and experience, and utilitarian benefits, including savings and convenience (Chandon et al., 2000). Leveraging these benefits in impulsive purchasing scenarios can significantly boost consumer engagement and sales.

Sales promotion, customer acquisition and retention

Sales promotions are widely acknowledged as a powerful tool for expanding customer bases and retaining existing clients. The increasing use of online coupons by U.S. households illustrates how digital sales promotions facilitate customer acquisition (Forrester, 2014). Internet-based tools also allow businesses to tailor promotions to individual customer preferences (Kannan & Kopalle, 2001). Techniques such as discounts and promotional suggestions can trigger impulsive buying behavior in online settings (Dawson & Kim, 2010). Research by Palazon and Ballester (2011) highlights how well-planned promotions effectively boost purchase intentions, with discounts often driving greater impulsivity (Liao et al., 2009; Tinne, 2011; Virvilaite et al., 2009).

Sales promotion and marketing mix

Promotion is a fundamental aspect of the marketing mix, designed to inform, persuade, and remind consumers of a product's benefits to influence their attitudes and purchasing decisions (Stanton et al., 2007). Sales promotions offer a quick way to generate consumer responses and accelerate sales. As noted by Kotler and Keller (2012), these promotions act as strong incentives for attracting consumers and boosting purchase volumes. Agrawal (1996) emphasizes that promotions also help establish brand loyalty and deter customers from switching to competitors. Marketing managers frequently deploy price-based promotions, such as coupons and discounts, to appeal to price-sensitive consumers and drive revenue (Cui et al., 2016). Today, heightened consumer awareness about deals ensures that promotional strategies are more effective, particularly among budget-conscious shoppers (Yeshin, 2006).

Monetary sales promotion

Price promotions, often referred to as monetary promotions, appeal to consumers by offering savings and convenience (Chandon et al., 2000). These promotions are particularly effective for task-focused shoppers with specific goals (Büttner et al., 2015). Studies reveal that monetary promotions tend to outperform non-monetary ones in driving purchase decisions (Alvarez & Casielles, 2005; Gilbert & Jackaria, 2002). They are favored across both utilitarian and premium product categories (Palazon & Delgado-Ballester, 2009; Kwok & Uncles, 2005) and resonate strongly with consumers loyal to high-awareness brands (Owens et al., 2001). Millennials, in particular, view monetary promotions like discounts as highly appealing due to their practical approach to shopping (Antunes et al., 2022).

Non-monetary sales promotion

Non-monetary promotions, offering added benefits such as gifts, bonuses, and contests, enhance brand value without reducing perceived quality. These promotions are often more effective in long-term brand building than monetary offers (Yi & Yoo, 2011). They are particularly advantageous for establishing product quality perceptions and are impactful for both utilitarian and hedonic products (Montaner & Pina, 2008a). Non-monetary promotions cater to consumers seeking enjoyment, exploration, and value expression, with such experiences often tied to activities like gaming or gambling (Reid et al., 2015).

Benefits of sales promotion

Sales promotions deliver a wide array of advantages that shape consumer perceptions and behavior. These benefits can be classified into utilitarian (savings, quality assurance, and convenience) and hedonic (value expression, entertainment, and exploration) (Chandon et al., 2000). Utilitarian benefits align with rational decision-making by offering tangible value, while hedonic benefits evoke emotional satisfaction and self-expression. Both types of benefits significantly influence purchase intentions and foster customer loyalty (Chiu et al., 2014; Santini et al., 2016).

Utilitarian benefits of sales promotion

Utilitarian benefits focus on practical and economic aspects, appealing to consumers driven by rational motivations (Solomon et al., 2007). Price-conscious shoppers particularly value savings, convenience, and quality assurance (Esfahani & Jafarzadeh, 2012). These benefits enhance perceived value by emphasizing practicality and affordability (Sanchez-Fernandez & Iniesta-Bonillo, 2006). Millennials, known for relying on peer opinions, often view monetary savings as a key motivator for purchases (Antunes et al., 2022).

Hedonic benefits of sales promotion

Hedonic benefits revolve around emotional gratification and sensory experiences during purchases. Hirschman and Holbrook (1982) introduced the concept of hedonic consumption, emphasizing enjoyment and intrinsic satisfaction. Elements like value expression, exploration, and

entertainment are key hedonic benefits that influence buying behavior (Chandon et al., 2000). Promotions for hedonic products often encourage impulsive purchases, as they appeal to the enjoyment factor (Liao et al., 2009).

Consumer behavior and purchase decision

Consumer purchase decisions are driven by a blend of utilitarian and hedonic motives, necessitating promotional strategies that address both orientations (Hirschman & Holbrook, 1982; Kivetz & Zheng, 2017). While utilitarian purchases cater to functional needs, hedonic purchases fulfill emotional desires and excitement (Strahilevitz & Myers, 1998). Promotions that balance these aspects positively influence purchasing behavior (Chandon et al., 2000). Throughout the purchase decision process—from need recognition to post-purchase evaluation—marketers can guide consumers by providing relevant information and minimizing perceived risks (Schiffman & Kanuk, 2007).

Sales promotion, corporate social responsibility and store environment

Corporate social responsibility (CSR) initiatives and store ambiance are increasingly recognized as significant factors influencing consumer purchase decisions. Studies suggest that these elements create a supportive shopping experience and strengthen positive perceptions (Hanaysha, 2018). Online retailers can enhance impulse buying tendencies by improving website quality and integrating promotional strategies with user-friendly credit card options (Akram et al., 2018). By aligning sales promotions with CSR initiatives, brands can further enhance consumer trust and engagement.

3. RESEARCH GAP IDENTIFICATION

An investigation of literature suggests that there are very few studies focussing on sales promotion in E-commerce channel. Though, some of these emphasizes on consumer durables, almost a minuscule part of it relates to sale of large appliances on E-commerce sites and its relationship with online consumers. The role played by online sales promotion and the consumer conduct to monetary and non-monetary benefits are less explored areas, which warrants a thorough investigation. As the sales promotion tools used in E-tailing platforms assume significance in recent times, there is a need to study the consumer responses to these. Hence, the research aims to study this gap for relevance of sales promotion in purchase of large appliances in consumer durables segment specifically refrigerator, washing machine, air conditioner and dishwasher and attempts to provide evidences from the E-commerce industry.

4. METHODOLOGY

Research organization

A survey was conducted to assess consumer perceptions of online sales promotions implemented by e-commerce platforms in India. The study collected data from 467 respondents through a custom-designed questionnaire, of which 421 responses were considered valid for analysis. The questionnaire comprised two sections: one focused on sales promotions and the other on socio-demographic details. The sales promotion section included 17 items measured on a 5-point Likert scale, where 1 indicated "Completely disagree, " 5 indicated "Completely agree, " and 3 represented a neutral response.

Convenience sampling was utilized for data collection, and the survey statements were adapted from several established sources, including Chandon et al. (2000), Childers et al. (2001), Garretson & Burton (2003), Ivanova (2012), Buil (2013), Pilelienė & Bakanauskas (2015), and Zhi-Kang & Ogawa (2017). The survey was administered online using Google Forms and conducted over a six-month period from January to June 2023 in India. The gathered data were subsequently analyzed using relevant statistical and analytical techniques to derive insights.

Relevance of the research results

To assess the reliability of the gathered data for subsequent analysis, a reliability study was conducted, yielding a Cronbach's Alpha value of 0.887. This value suggests that the constructs are dependable, given that it exceeds the threshold of 0.7, as depicted in Table 1.

TABLE 1 – Reliability Statistics

S. No	Reliability Method	Calculated Value
1	Cronbach's Alpha	.887

Source: Authors' own

Furthermore, the suitability of the data for factor analysis was assessed using the KMO measure and Bartlett's Test. Table 2 indicates that the KMO measure surpassed 0.5, and Bartlett's criterion ($p < 0.01$) supported the rejection of the null hypothesis (H0: The correlation matrix is an identity matrix).

TABLE 2 – KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.833
Bartlett's Test of Sphericity	Approx. Chi-Square	3638.563
	df	136
	Sig.	.000

Source: Authors' own

After confirming the reliability and appropriateness of the data, the factor analysis can proceed.

5. FINDINGS

A study was undertaken to gauge consumer sentiment towards online sales promotions, an aspect that E-commerce

firms in India should prioritize to enhance sales through their websites and apps. The main aim of the study was to assess attitudes toward online sales promotions, specifically focusing on consumer durables, particularly large appliances viz. refrigerator, washing machine, air conditioner and dishwasher.

Given that the fundamental statements representing the core of online sales promotions employed by E-commerce firms in India were utilized to gauge attitudes towards sales promotions, it became necessary to rearrange them using factor analysis. Initial Eigenvalues were calculated and then rotated to ascertain the proportion of variance in the total sample explained by each factor. Following Kaiser's criterion, only factors with Eigenvalues exceeding 1 were retained for further scrutiny. As depicted in Table 3, five factors elucidate 73.687 percent of the total variance. The Eigenvalues of the factors underwent changes post-rotation, refining the factor structure. Factor 1 contributed to 20.149 percent of the variance, factor 2 to 16.824 percent, factor 3 to 13.519 percent, factor 4 to 12.210 percent, and factor 5 to 10.984 percent of the variance.

TABLE 3 – Total Variance Explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.340	31.413	31.413	3.425	20.149	20.149
2	2.522	14.833	46.246	2.860	16.824	36.973
3	2.173	12.781	59.027	2.298	13.519	50.493
4	1.485	8.738	67.764	2.076	12.210	62.703
5	1.007	5.922	73.687	1.867	10.984	73.687
6	.568	3.341	77.028			
7	.554	3.259	80.286			
8	.496	2.916	83.203			
9	.451	2.653	85.855			
10	.443	2.606	88.461			
11	.395	2.323	90.785			
12	.332	1.954	92.739			
13	.301	1.772	94.510			
14	.288	1.692	96.202			
15	.260	1.529	97.731			
16	.216	1.272	99.003			
17	.170	.997	100.000			
Extraction Method: Principal Component Analysis						

Source: Authors' own

Table 4 illustrates the communalities, which reveal the portion of variance accounted for by each of the five factors across every component. Communalities of a variable signify the percentage of its variance ascribed to the common underlying factors among the variables. Components are deemed adequately informative when their communalities surpass 0.2. As depicted, all components exhibit communalities exceeding 0.2, suggesting their informativeness.

TABLE 4 – Communalities

Component	Extraction
Availing online sales promotion offers for consumer durable, gives me the impression of being a smart shopper	.777
With online sales promotion offers, I can remember what consumer durable products I need	.784
Online sales promotional offers for consumer durables relaxes the budget constraints on my family's spending	.737
I sense that I get good deals during consumer durable purchases made using online sales promotional offers	.798
During online sales promotion, I can have consumer durable products with excellent features	.626
When I shop for consumer durables using online sales promotion, I pride myself as a winner	.766
I save time for choosing the right consumer durable product with the use of online sales promotion	.764
Using online sales promotion would be convenient for me for purchasing consumer durable products	.689
I can buy consumer durable products of consistent quality, by availing online sales promotion offers	.727
By using online sales promotion offers, I can upgrade to a better consumer durable brand	.749
I can afford a better-than-usual consumer durable product through online sales promotion offers	.755
Availing online sales promotion offers, helps me to really spend less while buying the consumer durable goods	.789
I really save money, while purchasing consumer durables during online sales promotion offers	.815
When I make wise decisions on purchase of consumer durables using online sales promotion offers, I feel genuine joy	.628
I am reminded of the consumer durable products, during online sales promotion offers	.722
During online sales promotion offers, I can purchase consumer durable goods that are not dealt with in physical stores	.727
During online sales promotion offers, I get excited for trying new consumer durable brands	.674
Extraction Method: Principal Component Analysis	

Source: Authors' own

The study outcomes facilitated the categorization of the 17 components representing consumer attitudes toward online sales promotion into five factors, explaining nearly 74% of the overall variance. Table 5 illustrates the allocation of components into factors utilizing the Rotated Component Matrix, employing the Varimax rotation method with Kaiser normalization.

TABLE 5: Rotated component matrix

Component	Factor	Dimension
I really save money, while purchasing consumer durables during online sales promotion offers	1	Savings
I sense that I get good deals during consumer durable purchases made using online sales promotional offers		
Availing online sales promotion offers, helps me to really spend less while buying the consumer durable goods		
Online sales promotional offers for consumer durables relaxes the budget constraints on my family's spending		
I can afford a better-than-usual consumer durable product through online sales promotion offers	2	Quality
By using online sales promotion offers, I can upgrade to a better consumer durable brand		
I can buy consumer durable products of consistent quality, by availing online sales promotion offers		
During online sales promotion, I can have consumer durable products with excellent features		
With online sales promotion offers, I can remember what consumer durable products I need	3	Convenience
I save time for choosing the right consumer durable product with the use of online sales promotion		
Using online sales promotion would be convenient for me for purchasing consumer durable products		
Availing online sales promotion offers for consumer durable, gives me the impression of being a smart shopper	4	Status
When I shop for consumer durables using online sales promotion, I pride myself as a winner		
When I make wise decisions on purchase of consumer durables using online sales promotion offers, I feel genuine joy		
During online sales promotion offers, I can purchase consumer durable goods that are not dealt with in physical stores	5	Variety
I am reminded of the consumer durable products, during online sales promotion offers		
During online sales promotion offers, I get excited for trying new consumer durable brands		

Source: Authors' own

Table 5 illustrates how each factor encapsulates a distinct facet of consumer attitudes toward online sales promotion. These attitudes closely mirror the benefits delineated by Chandon et al. (2000), albeit with some adjustments. Through factor analysis, it was revealed that components related to savings, quality, and convenience echoed Chandon et al.'s (2000) observations, while status and variety emerged as newly revised components, replacing value expression, exploration, and entertainment. Hence, the findings depicted in Table 5 indicate that consumer attitudes toward online sales promotion can be summarized by five fundamental benefits: savings, quality, convenience, status, and variety.

6. IMPLICATIONS

E-commerce companies can enhance engagement by tailoring promotional strategies to emphasize savings, quality assurance, seamless shopping experiences, and an extensive product range. These insights are particularly relevant for optimizing campaigns targeted at price-sensitive and digitally native consumers. The research highlights the potential of online sales promotions to make essential consumer durables accessible to a broader audience, contributing to improved living standards and economic inclusivity in India.

7. LIMITATIONS

The study faces several limitations that impact the generalizability and scope of its findings. The use of convenience sampling may not fully represent the diverse Indian consumer base, particularly in rural and semi-urban areas, limiting the applicability of insights across all demographics. Additionally, the research focuses exclusively on large appliances, which restricts its relevance to other product categories such as electronics, fashion, or FMCG, where consumer behavior and promotional strategies may differ significantly. Another limitation is the temporal scope of the study, which captures consumer attitudes during a specific time frame (January to June 2023) and does not account for potential seasonal or economic changes that could influence behavior.

Furthermore, while the study effectively examines traditional sales promotions, it overlooks the role of emerging digital innovations, such as AI, machine learning, and big data, in optimizing promotional strategies, which are increasingly critical in modern e-commerce. Finally, the reliance on quantitative data fails to delve into the deeper psychological motivations and barriers affecting consumer responses to promotions, missing the nuanced insights that qualitative approaches could provide. Addressing these limitations in future research could offer a more comprehensive understanding of consumer behavior, enhancing the effectiveness of sales promotion strategies in the evolving e-commerce landscape.

8. FUTURE RESEARCH AGENDA

This study identifies five core consumer benefit components—savings, quality, convenience, status, and variety—that shape attitudes toward online sales promotions. Future research could explore these elements in greater depth to understand their impact on consumer behavior, with comparative analyses across industries, longitudinal studies tracking changes in perceptions, and qualitative insights into consumer motivations. Examining contextual influences and testing managerial interventions could offer actionable guidance for e-commerce platforms to refine their promotional strategies. Overall, further research in this area promises to yield valuable insights and broaden understanding of consumer engagement with online promotions.

9. CONCLUSION

Sales promotion is often seen by businesses as a direct approach to attract customers and boost sales, frequently proving more effective and persuasive than advertising or other marketing communications. For maximum effectiveness, however, sales promotions must be carefully tailored to meet customer needs. These promotions can be divided into price-based (monetary) and non-price-based (non-monetary) types, each impacting consumer perception differently. While the scholarly debate continues on which type is more effective, it is crucial for organizations to identify which promotion style resonates best with their customers. Understanding consumer attitudes toward sales promotions enables e-commerce companies to design more effective strategies. This study identified five primary consumer attitudes toward sales promotion: savings, quality, convenience, status, and variety. Based on these insights, Indian e-commerce firms should focus on highlighting monetary savings, reliable product quality, streamlined purchasing processes, an enjoyable shopping experience, and a diverse product selection in their promotional strategies to attract and retain customers.

10. DECLARATION

I, Supratim Pratihar, hereby confirm that the manuscript titled "Digital Strategies for Consumer Engagement: Analyzing Online Sales Promotions for Large Appliances in the Indian E-commerce Ecosystem" authored by Supratim Pratihar, has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to International Management Perspective Conference 2025 (IMPeC-25).

I declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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9

Humour in the Digital Age: Examining Generation Z's Comedic Preferences and its Social Media Marketing Implications

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ABSTRACT

This paper seeks to address the humour preference of Generation Z, particularly their inclination towards nonsensical and absurd humour, as has been reported through recent digital trends on platforms like Instagram, Reddit, and YouTube Shorts. The research seeks to understand how these humour preferences are related to broader cultural shifts and psychological trends within this Generation. On top of that, the study will examine how marketers may effectively interact with this emerging market, using humour driven marketing strategies.

Utilizing qualitative research technique, the study involves in-depth interviews with Gen Z participants to learn about their preferences in humour and media habits. Furthermore, secondary research examines how brands are incorporating humour in marketing, offering a compressive picture of both cultural and commercial implications.

The intended outcomes of this study include insights of social and psychological aspects that influence Gen Z's humour consumption. As well as practical recommendations for brands aiming to connect with this generation. This paper further contributes to the field of media, marketing and cultural studies by providing a nuanced understanding of how digital humour has affected Generation Z's identity and consumer behaviour.

Keywords: Gen Z Nonsensical Humour Absurd Humour Cultural Identity Digital Media Social Media Marketing Community Consumer Behaviour Memes Brand Engagement Marketing Strategies

1. INTRODUCTION

From constant evolving culture, societal norms & psychological shifts each generation has shown a completely different theme from their previous era, even with their preference in Humour. With today's overly saturated digitalized modern world, the Generation Z[1] humour has morphed more towards Absurdity, Brevity and Nonsense. This study is spurred by the motive of figuring out the mindset of the neo gen whilst consuming Humour, how it's shaping new landscape both culturally and psychologically through contemporary digital media.

Main Rational and Motive of the study

This new generation's humour defies convectional comedic preferences mainly due to the emergence of digital platforms such as Instagram, Reddit, & TikTok for the western world. Generation Z has embraced nonsense in their humour, often leaving the earlier generations astonished. As digital platforms continue to evolve, they have paved the way for "memetic nonsense, " a form of humour built on bizarre, random elements that resonate deeply within Gen Z communities . Nonsense has forever been a way of communication, in art and culture, it has become prevalent due to digital media and there's now a slim boundary between memetic expression and nonsensical communication. These nonsensical texts usually form a repetitive patten amongst its users, and then produce more interconnected meaningless memes, that all of its associates share like an inside joke. The viral trend "Skibidi Toilet[2], " where absurd and surreal humour thrives on TikTok, is a prime example of how this humour has entered the mainstream, solidifying Gen Z's identity online . "Digital Memetic Nonsense" isn't something that would be traditionally or academically be accepted. One of the finest examples of this wide spread nonsense would be "Skibidi Toilet" that has also acquired Hollywood. This study wants to make sense of comedic shifts, psychological and cultural positioning and how the acceptance of Absurdity has affected the social dynamics.

Awareness and Understanding of the existing research.

There have been several studies on humour, and also with parameters studying its evolution in digital age, yet the previous studies have taken a dive into a variety of topics, including memes, the involvement of absurdity in comedy, the effect of digital platforms in the spread of humour. There are books on humour theories, with chapters introducing the basic concept of absurdity and senseless comedy as a genre. Linguistic silliness acts as a social glue in online communities. In addition, study on virality[3] draws focus to

[1] Generation Z- Demographics succeeding Millennials (1917 – 2012)

[2] Skibidi Toilet - YouTube animated series about an army of human headed toilets taking over the world

[3] Virality- Trending or circulating rapidly on internet

the emotional and aesthetic appeal of its content again infused with humour. However, there is a gap in exploring how nonsensical humour builds new social bonds among Generation Z, where platforms like TikTok and Reddit encourage the creation of unique linguistic patterns and meme-based communication. There is still a gap in understanding how all of it is interlinked to the peculiar taste of the Gen Z, especially due to their early access to the digital technology and active involvement on Gaming and platforms like Roblox or Reddit or Instagram, which has also been the major contributor of development of pseudo words[4] and "Brain rot[5] Humour". This "brain rot humour, " characterized by disjointed animations and surreal gibberish, now permeates mainstream media, further illustrating the randomness and absurdity driving digital content. This study seeks to address the gap by providing a thorough analysis of all the trends within the context of Gen Z's Cultural and Psychological landscape.

Proposed Research Objective and Expected Results

The objective of this research is to study how Gen Z's preference for humour, particularly nonsensical and absurd humour on digital platforms, influence their interaction with a brand, and how marketers can harness these humour styles for effective, humour driven marketing.

2. RESEARCH QUESTIONS

1. What humour styles are preferred by the Gen Z, and where does nonsensical humour stand within these preferences?
2. How do social media platforms shape gen Z's preference for brevity, randomness and instant gratification factors?
3. How has gen Z humour reflected broader cultural shifts, and how might these trends shape future content and marketing strategies?

3. LITERATURE REVIEW

Broad Understanding of humour

Humour has forever been an important facet of social interactions, and shaping cultural identity, serving as a facilitator of communication across socioeconomic boundaries. Traditional humour theories like slapstick, dark humour, to numerous styles of comedies like incongruity, absurdity, and even aggressive humour, each of these genres serving its own unique social function, all of these have emphasized humour as a reaction to cognitive surprise and emotional relief. An explanation of incongruity theory suggests that humour emerges when there is dissonance or in simple terms a mismatch between expectations and reality, that elicits an emotional surge. Relief theory posits that, humour relieves the pent up psychological or social tension, mainly in times of crisis.

Humour has evolved along with society. But only through digital media, new ways for humour have emerged, mainly for younger generations use of internet for both entertainment and social interactions. These new forms of humour, notably absurd and nonsensical, stand out for their rejection of traditional logic, and how they favour unpredictability and brevity. This shift in humour is linked with today's fast-paced digitally saturated environment, where material is consumed rapidly and is spread across networks . Based on this context, absurdist humour has taken a significant toll. What once was considered mindless and irrelevant has evolved into a form of social expression and has a meaning within its specific sub culture.

In the digital era, memes, inside jokes and cryptic memes and slangs all demonstrate a shift in how humour is consumed now and shared among the younger audiences Memes-the brief comedic nonsensical bits of content, travel quickly throughout social networks, representing the new wave of nonsensical humour that feeds on unpredictability, and the inside jokes that require proper context to comprehend and fully understand.

While gen Z's humour has completely embraced absurdity, it is important to analyse the generational transition that happened with millennials. Millennials were the first generation to adapt to internet into their everyday social and cultural lives, which had a bigger impact on their humour preferences. Millennial humour was more about the classic characteristics of dark humour or self-depreciating humour, with the spontaneous and rapid nature of digital content.

Millennial Humour: Transition from Traditional to Digital

Millennials enjoyment of absurd humour reflects broad societal and cultural trends, more like a growing feeling of disillusionment and anxiety in face of sociopolitical changes. The dark and absurd humour to them provided an outlet or a coping mechanism for their fears. This generation was also the forefront of meme culture, contributing to the shifts from traditional forms of media to more flexible, shareable versions online, like, Vine, YouTube, etc. Materials that were frequently short and silly, and disconnected, laying the base for Generation Z's preference.

Millennial humour too, deviated quickly from traditional narrative based comedic skits to content that was quick, spontaneous, and frequently nonsensical. This shift reflected fragmentation of content in digital era, when attention spans are shorter and people need instant gratification. Millennials engagement with this medium of humour helped establish social media platforms as key spaces for comedic content generation and consumption, which has now become fundamental to Gen Z's humour.

[4] Psudo Words - Meaningless words that are pronounceable, slangs
[5] Brain Rot - Low quality content on the net and its adverse effects

Gen Z's Comedic Preferences moulding new Cultural Identity

Building on the trends of the millennials, Gen Z has also taken their shift towards digital absurd humour to new extremes. The continuous exposure of this gen to digital screens of apps like TikTok, Instagram, Reddit & YouTube Shorts, where brevity & spontaneity are valued has shaped their preferences. Moreover, these platforms allow the rapid creation and dissemination of absurd content or "The Digital Memetic Nonsense" referring to the humour of the new gen that purposefully rejects traditional narratives and logic in favour of incoherence, and serving as a form of social bonding. Thriving on Randomness, inside jokes and the fast-paced short video format content, have all contributed to this kind of humour, which has led to fostering a collective sort of identity among Gen Z, where meaning is secondary to emotional connection created by content .

Memes particularly have become a cornerstone of Gen Z humour. The new age digital Artifacts Memes range from surreal images to absurd statements, that often serve for community bonding on digital platforms. Memes provide a common shared culture for those who empathize with its ridiculousness and the hidden meaning behind it. Furthermore, the cryptic nature itself gives an appeal of inside joke for the communities, which further splits into younger and older audience demographics, the older often finding it difficult to relate to. There is an air of exclusivity that Gen Z humour gives them with their unique comic taste, giving rise to a generational gap with the rest .

Not just the humour becoming more popular but it also implies deeper cultural and psychological changes. Gen Z has become accustomed to fragmented content due to the early exposure to digital technology, where all of the information is demanded to be easily ingestible without in-depth involvement. Any material is now simply for momentarily diversion that it provides individuals, diminishing the value of what they consume leading to Brain Rot – providing a way to cope with overwhelming nature of modern-day living . For Gen Z humour has become an essential component, then more than just a form of entertainment – it's a part of their cultural identity. Their taste in humour tilting towards absurdity & stupidity, which speaks to wider existential concerns that this age finds relatable.

The Marketer's Angle

The marketer's angle to these comedic preferences of Gen Z their new target segment is that, these brands what to connect with the humour driven generation and their culture as they are gaining market share. However, the challenge here is adjusting to the comedic appeal that often is illogical, random and absurd. As traditional advertising relies on much structured narratives and clear messaging, gen Z may not be as receptive. Rather mimicking the content now found on Instagram or YouTube is where marketers are resorting to. In order to communicate with the Gen Z effectively, marketers need to understand their psychological drivers. Content that appeals to the group should mainly address their demand for instant gratification and their appeal to inside jokes. Brands that can successfully integrate absurdity, nonsensical and self-aware humour into their marketing campaigns are likely to capture Gen Z's attention. This change in marketing approach will reflect a broader societal impact for digital humour, where content is short and sharable and emotionally resonant. The use of humour appeal in advertising is not a new concept, but the specific style of humour that resonates with the Target requires a fresh approach. Brands that adopt the faced paced digital humour style often see higher engagement, as that's where the masses are present. In addition, the emotional resonance and nonsensical aspect in humour, both combined with its viral potential on social media makes it a powerful tool for brand building and loyalty among the audience.

4. RESEARCH GAPS AND CONTRIBUTIONS

Despite all the research on Digital Humour, little is known about absurdist and nonsensical humour's influence on the Generation Z forming new cultural identity, and social connections, also the brand interactions. While the existing studies on the evolution of humour ignore the early exposure factor of digital media, that has moulded Gen Z's identity – away from the convectional standards. Furthermore, less attention is given to how emotional resonance, visual absurdity, and linguistic brevity in meme has fostered social connections. Additionally, nothing is known on how humour has driven marketing strategies on brand loyalty withing Gen Z demographic. By examining how Gen Z uses absurdist humour and how brands might interact with this cultural change, this study aims to bridge these gaps.

5. METHODOLOGICAL APPROACH AND RATIONALE

Research Design

For better understanding of how Gen Z responds to absurdist and nonsensical humour and how brands can leverage these preferences in their marketing strategies this study follows a Qualitative research design. Qualitative approach is ideal for this as it provides thorough examination of the attitudes and experiences of the participants. The study intends to explore cultural, psychological and social factors that influence Gen Z's Humour, through qualitative methodologies.

Research Method

This study employs a mixed approach, with secondary and primary research. The secondary research is already conducted in support to analyse humour-driven marketing strategies used by two Indian brands, Swiggy and Nykaa. Both brands have used the absurd brain rot humour in their recent campaign commercials, making it a suitable for the

study. The secondary research assesses how these brands are moving their base towards the younger consumer and using engagement methods to make the Gen Z individuals brand loyalists. The primary research, currently is in IRB approval phase, it involves semi structured interviews with Gen Z audience, to gain insights about their humour preferences, digital media habits and reaction to brain rot humour ad campaigns. This will provide a nuanced understanding that will complement the secondary research findings.

Research Instrument

In-depth interviews are planned, with standardised yet flexible guidelines, allowing the participants to elaborate more and thus give rise to new themes. The interview will cover topics such as:

- Types of humour participants prefer on digital media platforms
- Their reaction to nonsensical humour reels.
- How humour has influenced their social connections and identity.
- Reaction to Brands marketing campaigns leveraging Nonsensical humour.

The interview will contain both Open and Closed ended questions to allow the respondents to freely express and build on their thoughts, ensuring that all the research objectives are met. Some interviews will be conducted in person and rest online to accommodate interviewees preference and logistic constraints.

Sampling

For this study, a purposive sampling style with elements of snowball sampling will be used to recruit participants. The sample will consist of 16 individuals falling in the Gen Z strata the age range of which is 18 to 25, a crucial life phase for forming cultural identity and social connectives influenced by digital media. The samples would be split equally – males and females, to have a fair perspective. Starting with recruiting individuals from personal networks and social media platforms, ensuring they fit the age range and regularly consume digital content. Over the course of 2 months, almost half interviews are assumed to be already conducted personally and rest half online using platforms like Google Meet, Zoom Call, etc. This combination allows flexible scheduling and accommodates the preferences of all participants, while maintaining geographical diversity.

Analysis of Reels and Memes Used by Brands for Social Media Marketing

Nykaa

Qualitative analysis of content

Nykaa's usual content strategy, characterizes influencer testimonials, product promotions, makeup tutorials, and celebrity endorsements, but with their recent collaboration with @majedar_kahani_official marked a distinct departure, towards nonsensical humour or brain rot humour. The reel leveraged "brain rot" and Gen Z slang, garnered 1, 528, 928 or 1.5M likes, surpassing their typical engagement, which usually ranges in hundreds to few thousand on their influencer collaboration reels, such as the one with @thevishnukaushal, who received significantly less engagement, around 187k likes than Majedar Kahani's Ganji Chudail Reels. Majedar Kahani has established presence on YouTube with around (10M subscribers and 79k followers on Instagram, which has contributed to this surge in their brand collaborations with Swiggy Instamart, Shaadi.com, Colors Tv, YouTube, MX Player, etc.

The content mainly garnered on:

- Trends: Infusing surreal visuals, with nonsensical dialogues and themes that are appealing to the Gen Z's newfound internet culture.
- Relatablity: Even though the situations in the plot were hyperbolic and exaggerated, they catered the usual beauty issues faced by their audience.
- Edginess: Tangenting from their usual, they showed unfiltered and unprofessional tone that would rather resonate with their younger audience.

Analysis of Audience reaction

The reel's content fully embraced the absurdity of the trending humour, which seem to have struck a chord with the audience, as overwhelmingly favourable responses were seen. Viewers commented, "what a story 🤣😂😂😂😂" while acknowledging the chaotic humour tone, "Nykaa campaigns getting wild, " "Someone at Nykaa might need a friend to talk to😂💀" . This reaction demonstrates a shift towards the younger audience through humour that is relatable to them, a tone Nykaa has rarely adopted. However, the engagement with the reel underscores the power of trending nonsensical humour, that amplified Brand visibility, by breaking routine patterns and generated audience engagement. Themes emerging from this include the effectiveness of humour in digital marketing, the use of trends to increase reach and audience adaptability to unconventional brand storylines.

Shift in demographics: A shift in their usual audience was seen as the reel clearly was serving Gen Zs, also the enthusiastic reception by commenters say that the humour was tailored to reach the audience with like cultural sensibility.

The themes emerging out of this:

The analysis clearly showcases that the break in their usual monotone campaigns, and leveraging the trends, increased reach, also demonstrating the brands adaptability to unconventional narratives.

My Nykaa [@mynykaa]. Reel made in Collab with [@majedar_kahani_official], Instagram, 22 September, 2024 https://www.instagram.com/p/DAN83fKP8sE/

Swiggy

Qualitative analysis of Content

On the other hand, Swiggy India and Swiggy Instamart have aligned themselves as per Gen Z taste and trends. Swiggy always had the brand tone inclined towards humour, they have substantially shifted towards nonsensical humour, incorporating collaborations with absurd brain rot animated content. Unlike Nykaa, whose content is rarely humorous, Swiggy's influencer collaborations, animations, food related puns, and utilizing other such Gen Z's trendy memes, like the Low-quality cat gif memes, their overall tone has inclined to catering the younger audience more. Swiggy's humorous content, especially the ones with "brain rot" humour, frequently receives massive engagement from its 580k Instagram followers. One such recent reel, depicting animated characters in an odd nonsensical plot, and with a mix of various brain rot memes earned 68, 994 likes while another received 145k likes.

Swiggy has always showcased:

- Adaptability by integrating viral trends: Using meme inspired product promotion strategy and dialogues, that not only give out the brand message but also sreve the ongoing digital media trends.
- Brand Consistency: Though swiggy has always been about humor, they tangented slightly to the nonsensical side of humor, to include the emerging Gen Z audience, by elevating absurd and exaggerated plots in their campaigns.
- Not missing out on Relatiblity: Though they used nonsensical humor, they did not yet stray away from

delivering their core message, or addressing the pain points of the clientele, such as struggles of group ordering, a campaign that mixed both humor with over the top plot.

Swiggy India [@swiggyindia]. Reel, Instagram, 11 October, 2024 https://www.instagram.com/p/DBEETaVxRsD/

Swiggy India [@swiggyindia]. Reel made in Collab with [@swiggy_instamart], Instagram, 23 March, 2024 https://www.instagram.com/p/C427CMjSbaS/

Swiggy's content usually draws comments appreciating their trend driven marketing strategy, with viewers addressing Swiggy as "CEO of Brain rot advertising" or more such comments pointing out at the interactions the brand has with its sub brands or audience "I just saw Swiggy talk with Swiggy in brain rot language 😭😭😭" it shows Swiggy's adeptness at not only creating such content but also engaging with it, showcasing a strategic move to immerse themselves in the ongoing meme culture. Their use of low-quality memes, and Gen Z slangs showcases their ability to capitalize on viral and relatable content, outperforming the likes on traditional humour skits.

This approach positions Swiggy as a brand that actively participates, not just observes the online culture. The themes arising from their strategic approach include leveraging on trends, fostering engagement through self-aware and playful interactions, and embracing low quality meme culture that caters the brevity and short attention span of its audience, and creating a more accessible and humorous brand identity. Swiggy's consistent humorous tone resonates with its target audience, cementing its image as a trend savvy, approachable brand.

Swiggy India [@swiggyindia]. Reel, Instagram, 23 March, 2024 https://www.instagram.com/p/C_St56GMrNr/

Recently, embracing its humorous tone Swiggy released a reel to promote its newly launched group ordering feature, which lets 40 customers place order items in the same cart, simplifying the food ordering for large groups. The reel shows a chaotic and hilarious side of groups ordering process, bringing together internet sensation animated character "Ganji Chudail" and other infamous memes and brain rot inspired trending instagrammers. The reel opens with a relatable group ordering struggles, diving into an absurd plot, with viral icons. Each scene embraces nonsensical humour, blending trending memes and chaotic dialogues with over-the-top visuals.

Analysis of Audience reaction

Comments like "Swiggy's reels feel like my 2 a.m. imagination 💀" and "Who even approves this level of chaos 😂🔥" shows audience engagement with reels unapologetic absurdity. The reel amassed about 610, 131 likes, showing Swiggy's ability to blend humour with relatable situations, and even though fans praised Swiggy for its creativity, saying "CEO of chaos marketing strikes again!" . The reel's virality and overwhelming reception suggests that Swiggy

struck a chord with its Audience well, evident by the engagement metrics like:

- Massive engagement: Likes on each of their reels from 60k to 600k itself suggests that featuring nonsensical humour and viral memes is working out for Swiggy.
- Audience engagement and feedback: All the comments either questions what Swiggy marketers sanity, or their own for staying put until the end and indulging on their content, indicating high relatability and appreciation for the digital media marketing of the brand.

Overall, the themes that can be drawn out of Swiggy's content are:

How they have understood the importance of Relatability with a Chaotic side to it. How shared experience of audience builds a connection with the brands. Trend savviness and mastering meme culture cements the brand's identity in the brains of its Target Market and the brand is then termed as innovative and approachable. Lastly, the interactions the brand has with its audience, how Swiggy strategically and playfully, humanizes its brand to foster deeper engagement with the people is what makes it remarkable. *Risks & Rewards Analysis of the Swiggy's Memevertising*[6] *Campaigns Debate:*

Some critiques such as Azazul Haque, Group Chief Creative Officer, Creativeland Asia said that humour overshadows the brand message in the long run . (*Azazul Haque. (September, 2024). Saw the new Swiggy Ganji Chudail Video and realized Swiggy is struggling to deliver a message as much as it struggles to deliver a product. LinkedIn. https://www.linkedin.com/posts/azazul-haque-9912469_saw-the-new-swiggy-ganji-chudail-video-and-activity-7236556861208940544-CMjg?utm_source=share&utm_medium=member_desktop)*

He in his LinkedIn post highlighted how such campaigns are a potential long term risk, as they tend to Dilute the message of the brand, how Swiggy's core message would be difficult to recall when used such nonsensical characters or campaigns. Haque even drew an example of CRED campaigns, which were memorable yet left the audience in dilemma. Also, how Swiggy and Swiggy Instamart have a thin separation, and with such campaigns they tend to blur the difference because of their meme-heavy content. The lack to create a distinct positioning in the minds of their audiences, weakening the brand's identity. Despite gaining short term virality, as the nonsensical humour is a trending aspect of today's generation, it's going to soon erode as its again just a trend, and can't position brand for the long run.

Defending the Swiggy Strategy a lot of counter critiques, held the argument against Haque strong, by pointing out the Resonance that these campaigns have with their target audience. Abhishek Dhairyawan, CEO of Dawn Media, argues that, Swiggy's largest audience is Gen Z, that are fluent in meme culture. For those demographics, memevertising is the way to go, it aligns with their preferred form of digital interaction . The cultural relevance of a meme marketing campaign is just as effective as a traditional product focused campaign, as it is accepted by the people following that particular culture. Another Copywriter added by saying, Swiggy created the Buzz it was expecting out of the campaign, the message they wanted to deliver was simple, "Use Swiggy".

Meme- heavy ads encourage sharing and generate organic engagement, making it a cost-effective strategy, also by staying on top of people's minds. Here the emphasis should be on creating a balance between internet's fast growing humour trends, while maintaining brand's core persona for a lasting and effective brand campaign.

The discussion made a clear divide in the different demographics that Swiggy's meme campaigns are perceived by. Gen Z users sided with Swiggy, while the older industry professionals were called Boomers. Swiggy's campaign demonstrates the power of memevertising and its immediate engagement rate particularly with Gen Z. However, the polarised responses state the importance of humour not overshadowing the brands' purpose.

6. IMPLICATIONS OF THE STUDY

This study is important because it dwells on the changing humour preference of Gen Z, specifically the ridiculous or the nonsensical humour, a topic that has yet received attention in existing literature. With the rapid shift from convectional to digital humour, understanding these tendencies provides valuable insights, on how digital media has transitioned from existing humour, social bonding and identity factors among younger generation. Furthermore, in this research a significant gap in how marketers can might effectively engage Gen Z audiences using humour driven marketing methods.

The research's planned objective is to get a better understanding of what content resonates with Gen Z's unique humour preferences, fostering stronger connections with the brands using it and building brand loyalty. By keeping the focus on nonsensical humour; the study highlights major psychological drivers such as instant gratification and randomness or unpredictability – factors important to curb attention of this digitally native generation.

Finally, this study offers valuable applications in both cultural and marketing contexts, helping brands and marketers better understand and make use of the insights on the comedic trends that define Gen Z. The findings will assist in improving communication strategies for better engagement with Gen Z, bridging the gap between content and audience preference in this evolving digital landscape.

[6] Memevertising – new age marketing strategy using memes

7. DECLARATION

I, Ayushi Hiren Chheda, hereby confirm that the manuscript titled "Humour in the Digital Age: Examining Generation Z's Comedic Preferences and its Social Media Marketing Implications" authored by Ayushi Hiren Chheda, has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to International Management Perspective Conference 2025.

I declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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10

Effectiveness of Neighbourhood Stores in Last Mile Delivery for Online Shopping

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ABSTRACT

Technological advancement has made retail as one of the most competitive industry. Partnership between large pure online retailers and supermarkets/department stores indicates a new strategy of how big corporations are intending to dominate the retail market through online platforms and efficient delivery process. Thus there is the potential of an uneven competitive environment between large and small retailers which may give rise to technological populism. However, there is still an opportunity especially for small neighbourhood retail stores to join the competition of last mile delivery as they are located in close proximity to consumers' residence. Therefore, this research investigates the effectiveness of the collaboration between pure online retailers and small neighbourhood retail stores in fulfilling the last mile delivery. A mixed method comprising of two focus groups and online questionnaire survey will be employed. Implication of the study facilitates policy makers to create healthy competitive retail environment that ensures the survival of small retailers. Further enabling collaboration between small neighbourhood retailers and e- commerce companies in delivering efficient online shopping experiences.

Key words: Last mile delivery; online shopping; In-store browsing

1. INTRODUCTION

There is an increase in the partnership between large e-commerce companies with large sized supermarket stores to achieve efficiency in the last mile delivery especially the 'click and collect' concept (Jindal et al., 2021, Piotrowicz and Cuthbertson, 2019). With such partnership the supermarkets are also expected to gain through increase consumers footfall (Jindal et al., 2021). Consequently, the small retailers could be in the losing end. The strategic partnership between e-commerce firm and supermarket stores could also lead to technological populism as small retailers cannot draw on the same level of resources and capacity as their larger competitors. In other words, technology innovation will likely become a tool that will benefit only the elite or large companies. Further, this phenomenon may also challenge the existing spatial theories that determines consumers' choice of store specifically in-store parcel pickup.

The aim of this study is to explore the potential of small retailers in facilitating last mile delivery for e-commerce businesses specifically the in-store parcel pickup. Focus was given to neighbourhood small retailers as they have the competitive edge in terms of proximity to consumers' residence. Therefore, this study investigates the significance of spatial models that have been successful in determining consumers' store choice. Distance to and Size of the centre are considered an important factor for the choice of shopping destination according to the spatial models (Dawson, 2012). However, these factors are yet to be tested in terms of consumers' choice of store for online parcel collect. Thus the objective of the current study are 1) to access the knowledge of consumers online shopping behaviour and 2) to determine consumer's preference of physical store as pickup store for online shopping by assessing the size of and distance to the store and in-store consumer browsing behaviour.

2. LITERATURE REVIEW

In marketing literature consumers' store choice is usually determined by spatial properties (Fotheringham, 1988). Therefore, this study reviews some of the prominent spatial theories that has contributed significantly in understanding consumers' store choice. The central place theory is one of the spatial theories that attempted to understand consumers' choice of store. This theory made the assumption based on the 'economic man concept' that considered a person to possess all the relevant information for making the best decision

(McGoldrick and Thompson, 1992). Derived from this assumption is the 'nearest centre' hypothesis. The hypothesis states that a consumer shall acquire the goods and services from the nearest shopping centre (Dawson, 2012). The 'nearest centre' hypothesis was criticised by various researchers and is considered as an over-statement of behavioural realities (Dawson, 2012). However, the assumption of this theory may likely hold true in terms of consumers' choice of store for collecting parcel purchased online.

Further development on the theory of consumer spatial behaviour relating to choice of store has been made. Spatial interaction theory was derived from the work of Reilly (1929) on the law of retail gravitation. Huff's gravity model was considered to have the most significant contribution in the spatial interaction theory (Wee and Pearce, 2015). According to Huff's model consumers' determine their choice of store based on the size of and distance to the store

(Wee and Pearce, 2015). Further, the model also considered the impact of other alternatives stores which was missing in the central place theory (Wee and Pearce, 2015). The assumption of Huff's model supports the collaboration strategy between large pure e- commerce companies with large sized supermarket stores to facilitate the last mile delivery.

Expanding on the existing spatial theories on consumers' store choice Baker (2006) developed the Retail Aggregate Space Time Trip (RASTT) model. The RASTT model states that the temporal factors affect every individual regardless of their socio-economic status (Stimson and Haynes, 2012). For example, shoppers visiting a particular shopping centre are deemed to be affected if the centre is closed at that moment (Stimson and Haynes, 2012). In the intra-urban retail environment, the temporal factor and the distance of the shopping trip also influences consumers' store choice (Warnes and Daniels, 1979). For example, a shopper travelling by a car will have much more spatial and temporal shopping opportunities than an individual travelling by public transport. Hence examining the shopping behaviour of low income consumers will be relevant in establishing the potential of small neighbourhood retailers to facilitate last mile delivery specifically in-store parcel pickup.

3. METHODOLOGY

In this study a concurrent mixed method was employed to achieve the research objective. The main reason for selecting a mixed method was to conduct methodological triangulation.

Target population

According to Xia (2010) young shoppers were considered to be crucial to the success of small retailers. In addition, Valentine and Powers (2013) found young consumers especially students to frequently engage in online browsing for products but made fewer purchases due to their limited income and trust issues. This age group especially female was also shown to have returned the online purchases if there was any defect. Association of pure online retailers with physical retailers may help in enhancing the level of trust and also the efficiency of the delivery and return process. Therefore, in the current study, the data collected from youth population will generate relevant information. In India the age range between 15-35 years are considered as youth population (Planning Commission, 2008). The data was collected from Bangalore City, India. Bangalore is one of the Information Technology hub of India and has all the right infrastructure facilitating businesses to engage and adapt to new technological development rapidly.

Online focus groups discussion

Since the findings of focus groups discussion cannot be generalized to a larger population as mentioned by Stewart and Shamdasani (2014), the current research employed convenience sampling to recruit the participants in the two focus groups with eight individuals in each group as recommended by Galvin (2015). The two focus groups discussions were carried out on different occasions as suggested by Guest et al. (2017) in order to have sufficient discussions and a wide range of views for a minimum of ninety minutes as suggested by Nyumba et al. (2018). The questions were semi-structured open ended and followed the funnel approach. The recruitment of the focus groups and the actual conduct of the discussion process was organised online due to the ongoing pandemic. The unique identification code represents the statement of the focus group participants and they are allocated from R1 to R16.

Online survey

The online survey technique was employed in the current study to collect the questionnaire survey. The questions in the questionnaire survey were self-developed. Previous study by Sprotles and Kendall (1986) and Forsythe et al. (2006) helped in developing the questions in the current research. Design of the questionnaire in online mode was based on Dillman et al. (2014). The questionnaire survey in this study employed the 10- point ordinal scale to measure the variables. Nominal scale was used for socio-demographic variables. Weijters et al. (2010) suggested that the response categories in the ordinal scale should be fully labelled (i.e., 'Dislike– 'Like') in order to derive reliable data when developing a new scale. The response categories in the survey questions in the current study were fully labelled. The questionnaire survey was closed-ended. The online questionnaire survey was distributed through social media platforms. The questionnaire survey consists a total of 70 questions.

With a 95 percent confidence interval and ± five percent margin of error (Barlett et al., 2001), the required sample size for the current study was estimated at 385. The total usable sample was 415 after deducting the incomplete responses. After collecting the data, Cronbach's alpha was employed using R software to calculate the reliability and internal consistency of the ordinal scale by using polychoric correlation matrix (Gadermann et al., 2012). The result met the minimum threshold of 0.70.

4. FINDINGS

The participation in the focus groups and questionnaire survey was voluntary. The youth population in the focus group and questionnaire survey were mostly students (96%) and unmarried (approx. 99%). The sample comprised of 55% female and 45% male participants. The majority of the youth population in the sample comes from a family that consist of four members. Results in Figure 1 explains the behavioural dynamics influencing consumers' decision to select the option of in-store parcel collection for online purchases. From the Exploratory Factor Analysis (EFA) result, variables greater than 0.5 factor loadings were retained. The findings

indicate that an increase in the frequency of customer assistance required for conventional products both online and in-store will make consumers more willing to 'purchase online and collect from store'. When visiting the store for parcel collection these consumers may likely engage in in-store browsing and make an impulse purchase. Thus, there is a potential for retailers to generate profits from 'in-store parcel pickup'.

Figure 1: Exploratory Factor Analysis

Latent Variables (in-store pick up)	Fact or Loadings	Latent Variables (online shopping)	Fact or Loadings	Latent Variables (store choice)	Fact or Loadings
Do you prefer seeking customer assistance at a physical store for products that are purchased repeatedly?	0.7	How often do you engage in online purchases in general?	0.7	Do you prefer to collect the parcel from department store?	0.9
Do you prefer seeking customer assistance at online platform for products that are purchased repeatedly?	0.7	How often do you compare products and services online?	0.7	Do you prefer to collect the parcel from super market?	0.8
How often have you engaged/experienced to make impulse purchase at the store where you are collecting the online parcel?	0.6	Do you enjoy browsing products in online stores?	0.7	Do you prefer to collect the parcel from nearby small-sized store?	0.7
How much time do you spend online browsing for products that are purchased repeatedly (you make purchases every now and then)?	0.6	How frequently have you purchased online during the pandemic?	0.6	_____	_____
How often have you purchased online and collected the item from a physical store?	0.6	How often do you engage in browsing products online for leisure purposes?	0.6	_____	_____
How much time do you spend in deciding where to shop?	0.6	Do you prefer home delivery of online purchases?	0.6	_____	_____
Did you experience any inconvenience with the home delivery services (e.g., danger to one's privacy)?	0.5	How often do you determine to purchase the product based on the information available online?	0.6	_____	_____
How often have you engaged in browsing the store when collecting the online parcel?	0.5	How much time do you spend browsing online for products that is one-time purchased?	0.6	_____	_____
Do you trust the information presented online by non-reputed organisation?	0.5	Do you trust the information presented online by reputed organisation?	0.6	_____	_____
----------	------	Do you have trust on online transaction you make?	0.5	_____	_____
Cronbach Alpha	0.822	Cronbach Alpha	0.842	Cronbach Alpha	0.862
Cumulative Variance	17	Cumulative Variance	33	Cumulative Variance	43

Further, results in Table 1 indicates that retailers that have low brand equity were likely to influence the level of trust from consumer's end in regards to the information's presented/ advertised in the online platform. Although the results also indicate that there is a positive outcome if the retailers are able to gain the trust of consumers on online platform. For example, an increase in consumers trust on the information presented online will likely encourage consumers to make an online purchase. These consumers may also choose to collect the parcel from store. One of the main reason identified in this study is the inconvenience of the delivery process that can cause security issues for the consumer. Such as consumers work and study schedule could prompt them to collect the parcel from store if they perceived that the home delivery in their absence could invite danger to one's privacy and security of their home premises. The focus groups also acknowledge that there might be some security issues that may make store pickup more favourable. As one participant explained the security issue related to home delivery.

I would prefer to collect from store if I am not available at home. I would not ask one my neighbours to pick up the parcel as it might create inconvenience to them. Now days nobody knows what is inside the parcel and that is why it might be risky to collect someone else parcels (R10).

The result also indicates that the time taken to decide where to shop may influence consumers to purchase the product online and collect in-store. Further, if consumers perceived to spend more time in browsing the products online especially conventional products that are purchased on regular basis they may prefer to collect the parcel from store. Need for customer assistance and instant gratification may be the contributing factors for these consumers to prefer collecting parcel in store for their online purchases.

However, consumers browsing/purchasing products that are non-conventional or one- time use online may not prefer for in-store pick-up. Results indicate that for such products consumers may usually prefer for home delivery. Despite being one-time use consumers may not seek customer assistance as they usually prefer to purchase these products from reputed brands that they know very well. Further consumers may frequently browse for such products online for leisure purposes. Hence they are likely to spend some time browsing the product online and keeping updated on regular basis.

Consumers browsing for non-conventional products online is likely to compare the best alternative and also stalk for discounts of their favourite brand. They do not have to travel frequently to stores to check if there is discount. Thus online shopping can be more favourable than in-store in purchasing the product at lower price. In other words, consumer may be less concerned about instant gratification and accept to wait longer for delivery to happen.

Covid-19 pandemic may have given a boost to consumer frequency of online browsing/ purchasing and product comparison as result suggest. Lockdown situation during the pandemic could also be a contributing factor in the preference for home delivery service for online purchases. The focus groups also indicated that online shopping is sought to achieve convenience in terms of time and travel activities. As one of the participants stated……*Shopping online stuff maybe when I am not going to stores. That's why I would prefer to have home delivery. But when I am not available at home I would prefer to choose the nearest store for online parcel pick-up. Again it depends on the circumstance if I have to make grocery shopping then I will prefer to choose supermarket to accomplish both parcel collection and grocery shopping (R2).*

The above statement also indicates consumer willingness to select in-store parcel collect under extreme condition where they must have to leave home for an urgent call or work. In doing so they may choose to visit a large store such as supermarket or consider the nearest store available from their residence. Many focus group participants indicated that the option of picking up of online parcel from a store was influenced by the idea of multitasking or one-stop shopping. For example, one participant (R6) noted: *"I will visit a nearest store or supermarket to collect online parcel only like I have the opportunity to accomplish grocery shopping or stuff 's that I require for immediate consumption"*. Thus based on the circumstance and consumers perceived convenience will decide their choice of store for collecting the parcel. The exploratory factor analysis also indicates that the spatial determinants such as size, distance and presence of alternative centre may not be relevant in determining consumers store choice to collect online shopping parcel. Results indicate that consumers will have equal preference for department store, supermarket and neighbourhood small stores in collecting the parcel.

5. CONCLUSION

This research contributes in understanding the potential of small retailers to successfully facilitate the process of last mile delivery for online shopping by enabling customers to pick up the parcel in-store. This study identified that 'click and collect from store' concept was likely to be successful under certain circumstances. Conventional products that are purchased on regular basis was more likely to be collected from stores then non- conventional products that are purchased for one-time use. Therefore, small neighbourhood stores that are looking to integrate 'click and collect from store' may likely be successful when they are dealing with conventional products.

Efficiency in providing customer assistance will be another important factor that small neighbourhood retailers must focus. This study has identified that consumers will choose to collect parcel from those store if they perceived to be able to accomplish multiple task which includes the possibility of achieving expert advice. In other words, good expert advice may offset the importance of size of and distance to the centre in determining store choice. Previous study has also observed that consumers visiting stores with the intention to acquire customer assistance were more likely to make a purchase (Goodman and Remaud, 2015). Therefore, there is economic benefit or imperative for any type of physical store retailers that are able to provide expert knowledge to their customers.

Finally, this study also identified the importance of home delivery service especially for non-conventional products. There will be consequences on future online purchases and company brand image if customer starts to perceived dissatisfaction with the home delivery service for these products. Therefore, e-commerce company must work on the improve the efficiency of home delivery service for non-conventional products. Consumers also browsed for these products more frequently online and may be enticed to purchase directly online.

6. LIMITATIONS AND FUTURE RESEARCH

Generalisability of the result may not be possible as the scale created in this study needs to further undergo confirmatory factor analysis. Therefore, future research will be required to conduct the confirmatory factor analysis on a new set of independent sample to confirm the factors established in exploratory factor analysis. Further, the current study was conducted on youth population who are the main browsers in-store. Future research can target on other age groups and non-browsers in-store.

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TRACK 2: HUMAN RESOURCE MANAGEMENT

11

Technology Integration with Application Programming Interface to Track, Fetch and Maintain Employment Laws in the Areas of Organizational Operations

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ABSTRACT

Invigorating compliance management and implementing technology- supported change are crucial for businesses. The regulatory landscape is intricate and dynamic. Employers must deal with a complex web of regulations that call for in-depth knowledge, quick response, and efficient cooperation. Annual filings and compliances make up the regulatory environment. This regulatory environment is always changing due to regulatory revisions. Failure to follow the rules may result in fines, legal implications, and severe damage to the company's reputation. The study's main focus is on the use of emerging technology to simplify the task of following employment laws across diverse businesses' operational areas.

Adherence to employment regulations is essential for the prosperity and longevity of organizations in the fast-paced commercial world of today. However, these rules are always evolving, it may be difficult for firms to remain compliant. This paper examines how incorporating technology especially, Application Programming Interface [API] can improve organizational operations by streamlining the monitoring, retrieving, and upkeep of employment legislation. It addresses the advantages, difficulties, and useful uses of this integration and offers suggestions for how best to put them into practice.

1. INTRODUCTION

Employment laws are crucial for ensuring that workers receive fair treatment and for regulating organizational procedures. Upholding moral values and avoiding legal repercussions depend on adopting these rules and regulations. These laws address anything from workplace safety regulations to labor standards. However, firms may find it challenging to keep up with legal changes because of the complexity and frequency of changes in employment laws. Tradition-based manual research and monitoring techniques are often time-consuming, error-prone, and inefficient.

The basis of compliance consists of numerous documents, including applications, acknowledgments, forms, receipts, licenses, and registers. Regretfully, a significant amount of compliance material is still in paper form and has little or no digital capabilities. Because of the volume of documents involved, employers find it difficult to maintain them manually. Nonetheless, most businesses use manual, ad hoc, paper-based procedures for compliance management. As a result, inadvertent delays, defaults, and lapses pose financial and reputational concerns. Share prices may be impacted by even minor infractions that create the appearance of lax corporate governance. The organization's compliance responsibilities grow rapidly as it expands.

2. METHODOLOGY

When an organization's whole compliance lifecycle is dependent on its employees, there is a significant chance of mistakes, omissions, and delays. The costs of poor compliance simply outweigh the benefits of stricter inspections and steeper penalties, which would promote corporate accountability. Employers can now handle their own compliance needs with the aid of ingenious, efficient, and fruitful digital compliance management technologies that leverage the web, mobile, cloud, and analytics. They also allow companies to go from "reactive" to "dynamic" compliance, which adapts to the changing regulatory environment. As a result, businesses across the country are rapidly automating their compliance procedures.

The new technology-enabled compliance administration arrangements include end-to- end computerization, information preparation, statutory recording arrangements, advanced record maintenance, counting, and administration, as well as programmed detection of possible non-compliance. Businesses may digitize their whole data and process flow thanks to these technologies. They are able to automatically identify delays and defaults. These systems also incorporate regulatory updates to ensure accurate and timely compliance. They provide centralized report transfer, report generation, endorsement, and conservation capabilities in accordance with the appropriate standards and guidelines. Entrepreneurs are cautious about getting into trouble with the law, whether intentionally or unintentionally, because of the significant penalty for non- compliance. Additionally, the management's approach to regulatory compliance becomes more demanding and attentive. Businesses are increasingly actively looking for solutions that give them greater visibility and control over their compliance functions because of the

serious consequences of non-compliance. Ad hoc, manual, recounted, and people- driven forms are being swiftly abandoned in favor of more standardized, computerized, traceable, and event-based compliance management. In a sense, it makes it increasingly possible for business visionaries to stay ahead of the curve rather than empowering superior permeability and control over compliance skills.

Digital compliance software is quickly displacing manual and ad hoc procedures thanks to its distinctive features, which include personalized checklists, real-time regulatory updates, automated alerts and reminders, and periodic analytics. A businessperson can ensure compliance without any lapses, delays, or defaults by going computerized. Astute and automated compliance management can enable projects to consistently stay alert, aware, and innovative. In order to improve control and perception of compliance capabilities, businesses must adopt astute and automated compliance arrangements.

Computers and other machines that possess artificial intelligence (AI) are able to reflect on and adjust to their surroundings. A manufactured insights application, machine learning, or ML, enables computer frameworks to learn from engagement and create better expectations. Compliance with Insights (AI) involves removing the complexity of assembly controls by using machine learning and insights to check and proactively address compliance requirements. The system can forecast and recommend changes to employers with the aid of technology. By granting users permission to make manual document uploads, document production, approval, and preservation capabilities, can also be used to modify the system itself. By offering recommendations or warnings prior to submitting or having to apply any documents, organizations can identify additional human error in the various compliance-based procedures they must follow. Additionally, by using AI and ML to analyze an organization's policies and procedures, various change recommendations can be highlighted by the system that can support the organization's growth by meeting the present needs of both employers and employees.

Because organizations operate in a wide range of industries, it can be challenging to remember all the rules and regulations that need to be adhered to. It may be simpler for organizations with multiple businesses to comply with laws, rules, and regulations with the aid of emerging technology.

Since businesses frequently operate in multiple countries, complying with employment laws that are in line with international rules and regulations also entails difficult tasks. Therefore, by defining the guidelines to be followed and maintaining them current, AI and ML can assist with tasks. The software can analyze the different situations when events or processes need to be carried out for multiple countries at once in order to comply with the rules and regulations while keeping all countries in mind.

Ethical practices need to have tools for tracking risks, identifying conflicts of interest, and fulfilling commitments because of the increasing volume of data and reporting that organizations must manage. However, with the increasing advancement of technology, human intervention is also necessary to verify the various processes, policies, and data.

3. TECHNOLOGY INTEGRATION

The Application Programming Interface (API) facilitates data interchange across various software programs by acting as a communication channel. Technology solutions that integrate APIs offer a more automated and efficient way to track, update, and retrieve employment legislation. Real-time data retrieval, automatic compliance monitoring, and customization according to organizational requirements is made possible by this connection.

Benefits of Technology Integration

Real-time Overhauls: API integration ensures convenient compliance by enabling organizations to receive real-time notices and upgrades regarding modifications to business laws.

Productivity and Accuracy: By automating law enforcement and recovery processes, human error is reduced and manual labor is reduced, which increases operational productivity.

Customization: By combining features like industry compliance guidelines and geo-specific instructions, organizations can customize API-integrated arrangements to meet their unique needs.

Information Analysis: API-enabled platforms provide information analytics tools that help businesses identify trends, anticipate administrative changes, and make informed decisions.

Practical Applications

HR Administration Frameworks: Highlights of work law compliance, including archive administration, representative preparation, follow-up, and review trails, can be consistently consolidated through API integration in HR programs.

Legitimate Compliance Stages: By utilizing API integration, specialized stages provide thorough plans for adhering to and monitoring business regulations, providing administrative enhancements, compliance checklists, and tools for risk assessment.

Industry-specific Arrangements: Certain industries, like healthcare, have work controls that must be followed. API-integrated solutions tailored to these companies promote hazard mitigation and compliance verification.

4. RESULT

As technology develops, so does our comprehension and application of AI in various sectors, including compliance.

Organizations must provide a strong and trustworthy framework for monitoring the continuous operation of AI, rather than being totally open about its use.

Ensuring that understanding local employment laws and regulations is the responsibility of at least one management team member. The time and resources needed to learn about and understand those laws and regulations. Any legal concerns should be discussed with a legal expert. Reviewing current practices to ensure that everything is set up correctly. In order to transform compliance administration forms across various businesses, innovation and Application Programming Interface (API) for adhering to, obtaining, and maintaining work laws in organizational operations are balanced. Businesses can expect a paradigm shift in their approach to administrative adherence by utilizing API-integrated agreements. Improved efficacy and accuracy are guaranteed by real-time overhauls and automated compliance checks, which also reduce the risk of non-compliance and the workload associated with manual investigation. Additionally, the unalienable customization capabilities of API integration enable organizations to consistently join industry benchmarks and geo-specific controls while customizing compliance arrangements to meet their unique needs.

The long-term advantages, such as retrieved investment funds and advancements in decision-making through information analytics, far outweigh the initial endeavors and increase support costs. Furthermore, the ability to reduce real risks, foster a positive workplace culture, and enhance representative satisfaction highlights how important innovation integration is to compliance management. Generally speaking, integrating innovation with API offers businesses a revolutionary chance to confidently and skillfully navigate the intricate administrative landscape, positioning them for sustained success in the state-of-the-art business environment.

5. CONCLUSION

Every HR priority list places legal compliance, ethics, and cultural sensitivity at the top. Ensuring that when conducting business internationally, the team is equipped to handle cultural differences, international labor laws, virtual work environments, ethically sound policies, and the development of international talent. Having equal employment opportunity policies in place, adhering to more recent regulations, and ensuring that the policies are compliant with the nation's employment laws.

An innovative way to monitor, implement, and maintain business laws in organizational operations is to combine innovation with Application Programming Interfaces (API). Businesses can improve compliance, reduce risks, and maximize operational proficiency in navigating the complex administrative scene by utilizing API-integrated arrangements. Although there are obstacles, crucial planning, careful implementation, and ongoing evaluation are essential to achieving the full potential of innovation integration for business law supervision.

6. DECLARATION

I, Aishwary Vilas Datalkar, hereby confirm that the manuscript titled “TECHNOLOGY INTEGRATION WITH APPLICATION PROGRAMMING INTERFACE TO TRACK, FETCH AND MAINTAIN EMPLOYMENT LAWS IN THE

AREAS OF ORGANIZATIONAL OPERATIONS” authored by Aishwarya Vilas Datalkar, has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to the International Management Perspective Conference 2025 (IMPeC-25).

I declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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Navigating the Digital Era: Critical Antecedents for Effective Digitalized Organizational Career Management Systems

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ABSTRACT

The digital transformation of industry has impacted workings of all departments and systems in organizational setup leading to state of continuous flux, essentially changing the nature of work.This study explores key factors enabling effective implementation of Digitalized Organizational Career Management Systems (DOCMS) in digitally transforming organizations. DOCMS are critical for aligning career management with technological and strategic goals in modern workplaces. Using the Fuzzy Delphi Method (FDM), the study synthesizes expert insights from HR and digital strategy fields, identifying three main antecedent factors as crucial to DOCMS success: (1) digital HR tools, (2) comprehensive career planning and management practices, and (3) flexible work models, including remote and hybrid options.These findings suggest that effective DOCMS rely on robust digital tools, career planning and management and adaptable work environments, which enhance DOCMS responsiveness to changing organizational needs. This research contributes to the limited literature on DOCMS by defining essential preconditions for its effectiveness, providing organizations with a framework to prioritize tools and strategies that align with digital transformation goals.The study's implications are practical: organizations can enhance their DOCMS by focusing on digital infrastructure, strategic career planning, and hybrid work environments. Socially, better DOCMS supports workforce resilience and continuous learning, helping organizations foster adaptable, future-ready environments. As organizations continue to digitalize, this research underscores the importance of aligning DOCMS with evolving digital and HR demands, benefiting both individual career growth and organizational adaptability.

Keywords: Digitalized Organizational Career Management Systems, Technological Progression, Strategic HRM Integration, Flexible Work Models

1. INTRODUCTION

In In today's day and age of rapidly evolving business environment, digitalization has transformed many organizational processes, including career management systems. Digitalized Organizational Career Management Systems (DOCMS) have emerged as a powerful tool for fostering employee development also enhancing career planning. A transformative approach is represented by Digitalized Organizational Career Management Systems (DOCMS) to managing careers within organizations by leveraging digital technologies. These systems integrate various digital tools and platforms to facilitate career planning, development, and management, aligning individual career goals with organizational objectives **(Harris et al., 2017)**. Digitalized organizational career management systems are rapidly getting integral to ultramodern human resource operations, driven by the need for effectiveness, flexibility, and strategic alignment with organizational objectives. However, the implementation of DOCMS is influenced by several antecedents that determine their success, such as Technological Progression, Strategic HRM Integration, and Evolving Work Environments This study aims to explore and determine key antecedents factors of DOCMS in an organizational setup. For this process Delphi research method has been used for retrieving expert opinions and imbibing it to narrow down relevant results. Organizations trying to enhance workforce management in digital era **(Mosca, 2020),** for the same it is crucial to Identify the antecedents of digitalized organizational career management systems. By acknowledging and identifying these antecedents, organizations can make themselves ready for digital transformation, optimize their human resource processes, utilize new systems and improve overall performance.

Problem Statement

This study seeks to address the Gap of understanding antecedents that leads to Digitalized Organizational Career Management Systems' (DOCMS) effective utilization in an organization, thereby providing insights for organizations aiming to optimize their HR practices in the digital age.

Research Objectives

1. To identify key technological antecedents factors (e.g., Digital HR Tools, Career Management Platforms, e-HR Systems) that influence effective Digitalized Organizational Career Management Systems
2. To identify key Strategic HRM antecedents factors (e.g., Talent Management Systems, Career Planning and Management influence effective Digitalized Organizational Career Management Systems
3. To identify key evolving work environment antecedents factors (e.g., Remote and Hybrid Work Models, Digital

Transformation) that influence effective Digitalized Organizational Career Management Systems

2. LITERATURE REVIEW

Digitalized Organizational Career Management Systems' are sustained by several antecedents that support their development and perpetration. Crucial among these are technological advancements, strategic HRM integration, and the evolving nature of work surroundings. These factors inclusively contribute to the metamorphosis of career management practices within organizations**.**

Technological Progression

This progression is reshaping how organizations manage careers by integrating advanced technologies into talent management and organizational controls. Digitalization is fundamentally altering talent management by enabling more efficient and effective processes. It allows for the integration of digital tools that enhance talent acquisition, development, and retention strategies (Marin, 2023). It is mentioned in literature the transformative impact of digitalization on organizational structures, processes, and career management systems, asserting the need for organizations to adapt to these changes to remain competitive. The use of digital platforms facilitates better data management and analytics, providing insights into employee performance and potential, which are crucial for career development planning (Marin, 2023). with digitalization Organizational career management systems are transforming, this evolution provides new methods for measuring and enhancing career development practices (Zhao et al., 2022) Digital tools enable organizations to offer personalized career paths and development opportunities, aligning employee goals with organizational objectives (Zhao et al., 2022). Through new digital tools which can lead to improve decision-making and performance management digital transformation is drastically influencing management control systems by (Seppänen et al., 2024) The integration of technologies such as artificial intelligence and big data analytics into management controls supports more informed and strategic career management decisions (Seppänen et al., 2024). Organizational career management systems are evolving with digitalization, which provides new methods for measuring and enhancing career development practices (Zhao et al., 2022). Digital tools enable organizations to offer personalized career paths and development opportunities, aligning employee goals with organizational objectives (Zhao et al., 2022) Understated factors of technological progression have been gathered via literature review process which are poignant and will be further comprehended.

- **Digital HR Tools:** The incorporation of digital HR tools akin to online platforms, electronic document operation, and AI- driven analytics is pivotal for the digitalization of career management systems. These tools increase the effectiveness of HR departments by automating routine tasks and enabling data- driven decision. (Maslennikov et al., 2020)(Baykal, 2022).
- **Career Management Platforms:** Platforms that offer dynamic career operation capabilities allow workers to explore career openings, close skill gaps, and align their career related aims with organizational objectives. These platforms frequently incorporate features like skill assessments and customized career paths, (Harris et al., 2017).
- **e-HR Systems:** The emergence of e-HR systems has revolutionized HRM conditioning, including career management, by furnishing web- based and computer-based operations that restructure HR processes and concentrate on strategic activities. (Baykal, 2020).

Strategic HRM Integration

It is a critical factor in enhancing organizational performance and innovation. It acts as a precursor to the development of digitalized organizational career management systems, which are pertinent for alignment of HR practices with business strategies. SHRM emphasizes aligning HR practices with organizational goals to enhance performance. It involves integrating HR strategies with business strategies to ensure that HR activities contribute to achieving organizational objectives (Hayati et al., 2021) (Al-Bahiri, 2015). The integration of SHRM with digital systems like e-HRM can significantly influence organizational career management by streamlining HR processes and enhancing strategic alignment. in this literature review the role of SHRM as an antecedent to digitalized career management systems is focused upon, exploring its integration with e-HRM and its impact on organizational outcomes. The integration of SHRM with digital systems like e-HRM can enhance organizational effectiveness by automating HR processes and improving decision-making capabilities (Marler & Fisher, 2013). SHRM practices, when effectively implemented, can lead to a competitive advantage by ensuring that recruitment, selection, training, and development are aligned with strategic imperatives (Al-Bahiri, 2015). Handling career development within organizations comes under OCM , focusing on aligning individual career goals with organizational objectives(Zhao et al., 2022) SHRM and e-HRM can act as an antecedents to effective OCM by providing the necessary infrastructure and strategic alignment to support career development initiatives(Zhao et al., 2022) The integration of SHRM and e-HRM can enhance OCM by providing data backed insights and facilitating personalized career development plans (Zhao et al., 2022). Following factors of Strategic HRM Integration have been gathered via literature review process which are of relevance to DOCMS and will be studied further.

- Talent Management: Digital metamorphosis in HRM highlights the significance of Talent Management, which includes career development, succession planning, and

employee engagement. These fundamentals are critical for streamline career operation systems with broader organizational strategies (Arora et al., 2024).

- Career Planning and Management: Effective career development is achieved through the amalgamation of individual career planning and organizational career management, which are considerable antecedents of career development programs (Chetana & Mohapatra, 2017).

Evolving Work Environments

The evolving work environments, particularly through digitalized organizational career management systems, are reshaping how organizations manage careers and talent. This transformation is led by the amalgamation of digital technologies, which have become essential in modern business practices. Digital workspaces have emerged as a critical component of modern work environments, facilitating remote work and collaboration. The distinction between "Digital Workspace" and "Digital Workplace" is crucial, with the former focusing on the tools and platforms that enable work, and the latter encompassing the broader organizational and process changes required for digital transformation(Pushpa et al., 2024) (Micic et al., 2022). The literature highlights the impact of digitalization on workspaces, employee engagement, talent management, and organizational efficiency. These changes are not only altering traditional work environments but also influencing the antecedents of organizational career management systems. The digital transformation of HRM strategies involves personalized development programs and flexible work arrangements, which improve employee experience and retention. These strategies are crucial for attracting and retaining talent in a competitive market(Husen et al., 2024) (Gričnik et al., 2024).

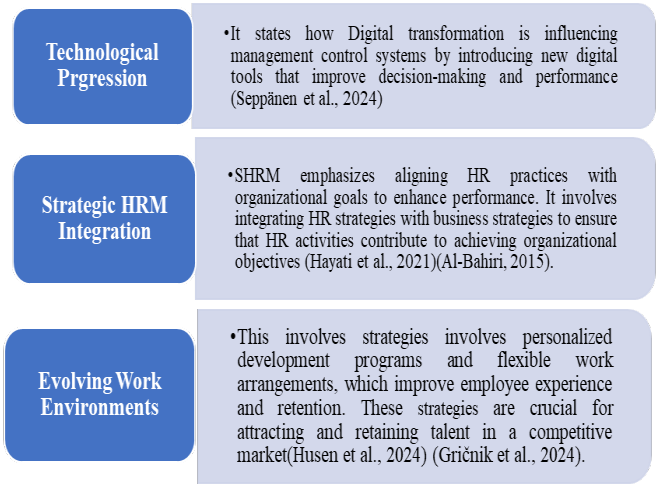

Figure I. Explanation of Key Antecedents

- Remote and hybrid Work Models: The shift towards remote and hybrid work models necessitates the adaption of career operation systems to support flexible work arrangements and ensure nonstop employee development (Monje Amor, 2023)

- Digital Transformation: Organizations are increasingly espousing digital transformation strategies that encompass HR processes, including career operation, to maintain competitive advantages and address the challenges of changing business landscape (Nosyreva & Beloborodova, 2024).

3. METHODOLOGY

Research Design and Process

The Fuzzy Delphi Method (FDM) is an advanced approach that enhances the traditional Delphi technique, particularly useful for making long-term forecasts under uncertainty. This method addresses the limitations of the classical Delphi Method, such as low convergence and the potential loss of critical information during expert consultations **(Saffie et al., 2016).**By integrating fuzzy theories, FDM allows for a more nuanced understanding of expert opinions**.**

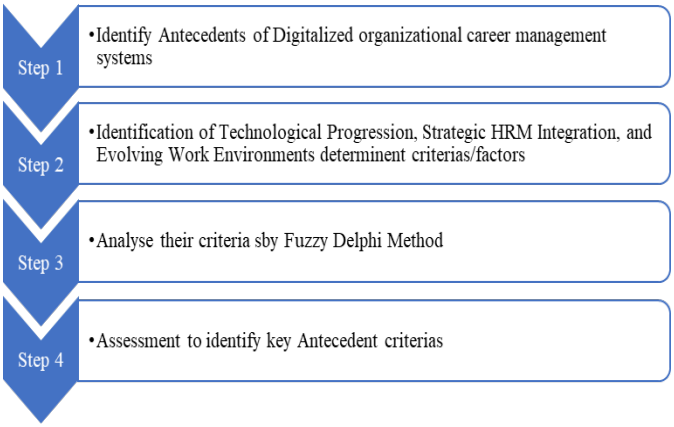

Figure II. Research Process Chart

This paper is grounded on a literature review and secondary research in the field of DOCMS. In a stepwise process, we enforced a methodical review of the literature to consecutively explore the antecedents of DOCMS, in order to examine the substantiation. On the other hand, we applied the FDM to access antecedents of DOCMS. The antecedents' factors of DOCMS are complex and uncertain, the vagueness essential in the evaluations of experts leads to query and, so, FDM was considered doable for the same. To estimate criteria linguistic variables were used, which were based on Five- point scale in a Delphi questionnaire. An agreement on the expert opinions on weights and conditions was acquired by FDM, as the verbal scores were converted into fuzzy figures. According to the literature, for the ideal number of expert actors, the suggested range is 5 experts for a homogenous population to further than 15 experts for a miscellaneous population with people from different social and professional estates (Delbecq et al., 1975**)**. A aggregate

of 16 survey questionnaires were returned and analyzed in the evaluation. The backgrounds of the experts are mentioned in table 1.

TABLE 1: Experts' Background

Expert ID	Expert Designation	Years of experience
01	HR head	5-10 years
02	HR executive	Less than 5 years
03	Assistant Professor	11-20 years
04	Founder	11-20 years
05	Associate professor	11-20 years
06	Research Scholar	Less than 5 years
07	Principal Architect(Founder)	5-10 years
08	Business owner	5-10 years
09	Founder	5-10 years
010	Research Scholar	Less than 5 years
011	Partner	5-10 years
012	Cluster head	5-10 years
013	Executive	Less than 5 years
014	HR head	5-10 years
015	Administrator	5-10 years
016	Sole proprietor	5-10 years

Demographics of Expert Panel

The expert panel consisted of 16 participants from diverse backgrounds and experiences. To get holistic opinions and suggestions a mix of entrepreneurs, academicians and human resource experts were gathered with exposure and knowledge of some form of DOCMS. Participants were selected based on their expertise and recognized contributions to the field. The panel was diverse in terms of age, gender, experience and designation. Maximum participants age fall in the range of 25 to 34 as this age group has maximum likelihood of understanding these systems. The panel comprised 43.8% male and 56.3% female experts. Participants held a variety of positions in private, government and industry setup. The prominent years of experience fall between 5-10 years.

Fuzzy Delphi Method

The significant criteria or factors of antecedents of DOCMS were determined through the integration of fuzzy sets using the Delphi system, and the ranking for the criteria was established consequently. **(Akyuz & Celik, 2015)** have noted that a favorable fuzzy representation used for evaluation is the triangular fuzzy number(TFN), defined as a trinity(l, m, n) where l, m, and n denote the lower, medium(i.e., utmost probable value), and upper figures of the fuzzy sets, in which $l \leq m \leq n$, and l, m, and n are real figures. Grade, ranging between zero and one, is assigned to each object **(Zadeh, 1965)** (**Kahraman et al., 2003).** The class function for a TFN **is** defined by Equation (1)

$$\mu_A(x) = \begin{cases} 0 & x < l \\ (x - l)/(m - l) & l < x < m \\ (n - x)/(n - m) & m < x < n \\ 0 & x > n \end{cases} \quad (1)$$

In a Delphi based survey, the questionnaire which is to be created should be practical for data collection. Questions taken out from the literature should be conveyed to experts in a structured manner.

Identifying antecedents criteria of DOCMS

We developed DOCMS antecedent criteria by two ways for exploring relationship between DOCMS outcome and its internal elements. First one consist of identifying frequently emerging DOCMS antecedents' factors in literature and later on preferred antecedents factors were narrowed down by applying fuzzy delphi method. List of selected criteria are hereby given in table

TABLE 2: List of DOCMS Antecedent criteria/ factors

Antecedents	Criteria	References
Technological Progression	Digital HR Tools	(Maslennikov et al., 2020) (Baykal, 2022)
	Career Management Platforms	(Harris et al., 2017)
	e-HR Systems	(Baykal, 2020)
Strategic HRM Integration	Talent Management	(Arora et al., 2024)
	Career Planning and Management:	(Chetana & Mohapatra, 2017)
Evolving Work Environments	Remote and hybrid Work Models	(Monje Amor, 2023)
	Digital Transformation	(Nosyreva & Beloborodova, 2024).

4. DATA ANALYSIS

In order to explore the antecedents of DOCMS the expert evaluation is conducted via fuzzy set selection. For Technological Progression we considered three main factors or criteria within the periphery of an organizational setup, further to that Strategic HRM Integration comprise of two factors from discrete perspective and lastly factors related to Evolving Work Environments were two. In entirety seven factors were confirmed and analyzed. The fuzzy weight

average for each factor was calculated, as shown in the center column of Table 3. Then we attained the crisp values by defuzzification (DF), allowing us to obtain the ranking order for each interface (shown in the rightmost column)

TABLE 3: Labelled Antecedents of DOCMS with conforming items

AVG Fuzzy Weight						
INTERFACE	Criteria	l	m	n	Defuzzified	Ranking
Technological Progression	Digital HR Tools	0.166666667	0.541666667	0.625	0.493055556	1
	Career Management Platforms	0.25	0.458333333	0.625	0.451388889	2
	e-HR Systems	0.333333333	0.458333333	0.541666667	0.451388889	2
Strategic HRM Integration	Talent Management	0.25	0.541666667	0.541666667	0.493055556	2
	Career Planning and Management	0.25	0.666666667	0.416666667	0.555555556	1
Evolving Work Environments	Remote and hybrid Work Models	0.166666667	0.5	0.666666667	0.472222222	1
	Digital Transformation	0.166666667	0.25	0.916666667	0.347222222	2

After estimation by experts, the key antecedents' factors for DOCMS; Technological Progression was found to be Digital HR tools, for Strategic HRM Integration crucial factor was Career Planning and Management and for Evolving Work Environments paramount importance is of Remote and hybrid Work Models. The assessment revealed that overall key factors aimed at future readiness in digital era.In context of technological progression it is evident from result that presence of digital tools is key component for digitalized career management systems as via them only one access technology. For strategic HRM integration result favoured career planning and management and it is it is crucial to have strategies related to career planning and for an organization to cultivate alignment of employee goals and company goals then only further digitalization of process will come into place. Lastly as work environments are evolving remote and hybrid work models are digitalized systems inevitable so we can summarize that results were logical as digitalized systems are the future and their antecedents should be acknowledged.

5. FINDINGS AND DISCUSSION

Evaluation of FDM clearly shows that among various antecedents factors of DOCMS primarily amongst technological progression, Digital HR Tools have maximum impact secondarily from factors of strategic HRM integration ,career planning and management appear pertinent and lastly within factors of Evolving Work Environments , Remote and hybrid Work Models surfaced as critical antecedents factor.The outcome comes to distinguish crucial conditions and factors , which is valuable for future research on DOCMS considering preconditions which act as an antecedents of DOCMS. In accordance with objectives of study the top factor antecedent was "digital tools", "career planning and management appear"," Remote and hybrid Work Models" which are all associated with future development. In Other words these are all relevant if DOCMS are to be put in place or utilized, regardless of which generation they belong to.

Digital HR Tools and technologies serve as a crucial antecedent factor in the development of digitalized organizational career management systems. These tools facilitate the integration of digital technology into various business processes, fundamentally transforming how organizations operate and deliver value to their employees (**Petrova & Lashmanova, 2020**). By enhancing operational efficiency and streamlining career management practices, digital tools enable organizations to better support their workforce in navigating career paths and development opportunities. Moreover, digital maturity as a concept comes into play in this context. Organizations that have successfully adopted and integrated digital technologies into their operations are better positioned to leverage these tools effectively, thereby enhancing their career management systems (**Shpak et al., 2022)** This integration not only improves the functionality of career management systems but also aligns them with the evolving needs of the workforce.

Career planning and management are pivotal antecedent factors in the effectiveness of digitalized organizational career management systems. These systems aim to align individual aspirations with organizational goals, thereby enhancing employee performance and growth **(Dara & Jyothi, 2015**). Effective career planning not only facilitates this alignment but also serves as a foundation for employee development, which is crucial for retention and motivation **(Heyse & Heyse, 2005**) Moreover, career guidance plays a significant role in this context, as it helps employees navigate their career paths through leadership roles, skill development, and constructive feedback **(Dara & Jyothi,**

2015). This guidance is essential for creating a comprehensive and flexible life and career plan tailored to individual profiles, which further supports informed career decisions **(Baruch, 1996).**

The transition to remote and hybrid work models has emerged as a significant antecedent factor influencing the development of digitalized organizational career management systems. As organizations adapt to these flexible work arrangements, they recognize the need for systems that effectively manage employee career development and performance in a digital context. Hybrid work models, which combine remote and in-office work, have been shown to enhance employee engagement and job satisfaction, thereby necessitating robust career management systems that align with these new dynamics **(Naqshbandi et al., 2024)** (**Singh & Joshi, 2022**). The flexibility inherent in remote work allows employees to choose their work environment, which has been linked to improved physical and mental health, further emphasizing the importance of tailored career management approaches **(Boyraz & Gilbert, 2024) (Eng et al., 2024)**.Organizations that implement digitalized career management systems can better support employees in navigating their career paths within these flexible frameworks, ultimately leading to higher retention rates and reduced turnover **(N. Vanitha & Dr. Shailashri V. T, 2024)**. Also understanding the factors that impact job satisfaction in hybrid settings can contribute in the design of these systems, making sure they address the unique challenges and opportunities provided by modern work environments **(Eng et al., 2024)** Thus, the integration of digital tools in career management is not only a response to the rise of remote and hybrid work but also a strategic move to enhance organizational performance and employee well-being in an evolving workplace landscape **(N. Vanitha & Dr. Shailashri V. T, 2024**)

6. IMPLICATIONS

The study talks about 7 factors and FDM lead to highlighting of prominent ones. As study is conducted with an understanding that working scenarios are gradually transforming into digitalized world which will eventually lead to various new factors emerging in systems. Understanding the working, formation and suitable conditions for these factors to merge with least possible fiction will lead to smooth transition. Studies similar to this assist in understanding nuances of systems like DOCMS so their utilization and application can be done as cohesively possible.

7. LIMITATIONS

Industry Focus: Although the panelists were chosen from various fields, the study mainly centered on industries that have already adopted or are in the process of adopting DOCMS. Consequently, the findings may not apply to industries that are still hesitant to embrace digitalized career management systems.

Technological Evolution: DOCMS is a rapidly evolving field, and the systems studied during this research may quickly become outdated as new technologies emerge. The findings may need to be revalidated in the future as newer versions of DOCMS with advanced functionalities come into play.

8. FUTURE RESEARCH DIRECTIONS

Exploring Sector-Specific Variations: Future research could explore how DOCMS function across different sectors such as education, healthcare, manufacturing, and government. A comparative analysis between industries with varying levels of digitalization could yield more nuanced insights into how DOCMS are tailored to meet sector-specific career development needs.

Integration of Emerging Technologies: The rapid advancement of artificial intelligence (AI), machine learning, and predictive analytics in DOCMS warrants further research. Future studies could explore how integrating these technologies into DOCMS enhances career planning, personalized learning, and employee satisfaction.

Employee Perception Studies: While this study focused on expert insights, future research should also incorporate employee perspectives on DOCMS. Employee perception studies could highlight gaps in system usability, identify additional motivators or barriers, and provide practical feedback for improving DOCMS.

9. CONCLUSION

This study aimed to explore that amongst various factors, which are part of antecedents' namely technological progression, strategic HRM integration and evolving work environment, which are impacting Digitalized Organizational Career Management Systems (DOCMS) the most. By using Fuzzy Delphi Method we evaluated 7 factors and concluded that Digital tool, career planning and management and Remote and hybrid work models has high impact on Digitalized organizational career management Systems and subsequent utilization. The results highlight the importance of a well-supported Digital HR Tools, career planning and management and Remote and hybrid work models establishes a culture that encourages continuous learning and career development resulting as prerequisite to DOCMS. Despite the limitations of the study, such limited factors and the evolving nature of technology, the research offers valuable insights for organizations looking to implement DOCMS effectively. Recommendations for organizations include investing in robust technological systems and actively engaging employees in career management processes. In conclusion, DOCMS can significantly contribute to effective career management when

implemented with the right organizational supports and technological tools.

10. DECLARATION

I, Timsy kakkar hereby confirm that the manuscript titled " Navigating the Digital Era: Critical Antecedents for Effective Digitalized Organizational Career Management Systems" authored by Timsy kakkar and Dr. Bharti has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to International Management Perspective Conference (IMPeC) 2025

we declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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TRACK 3: FINANCE & ACCOUNTING MANAGEMENT

13

Enhancing Customer Relation Management in the Banking Sector: A PLS-SEM Analysis

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ABSTRACT

Customer satisfaction is the main component of success of any business. The research highlights the significance of customer satisfaction within the banking industry, highlights the high-quality services that can provide a competitive edge and enhance customer loyalty. An examination of the connection between customer satisfaction and loyalty reveals that happy consumers are more likely stay with a bank and increase its profitability. Data's were collected from 500 participants in India. Banks often distribute to gather feedback on their services. PLS-SEM analysis was used in the study to assess how service quality affected customer happiness and loyalty. Customer Relation Management systems help banks track customer interactions and satisfaction levels, using data to improve services. Banks assess loyalty through repeat business, recommendations and overall satisfaction with the Banks's services.

Keywords: Bank sector, Customer satisfaction, customer loyalty, PLS-SEM, Customer Relation management

1. INTRODUCTION

Customer satisfaction is at the heart of any successful business entity. Many businesses find it difficult to retain customers because of the quick changes in the competitive business environment, which have raised customer expectations and demands. Quality is a key factor in ensuring customer satisfaction, according to numerous academics. To increase customer happiness, many businesses place a high priority on resolving issues with service quality. Hospitals try to identify the critical components that will determine their survival and future success. For management to be effective, these strategic aspects must be identified. Many earlier researches have revealed that customer satisfaction and the quality of services provided by an organization are interrelated. One of the things that affect a customer's loyalty to an organization is their level of satisfaction. However, the performance of organizations is positively impacted indirectly by growing consumer loyalty. Customer satisfaction is a major concern for numerous companies. Achieving customer satisfaction allows organizations to declare success (Supriyanto et al., 2021).

Even though, banks continue to strive for improvement in order to meet the needs of their clientele (Ali and Omar, 2016). Researchers worldwide assert that providing high-quality services can provide a lasting competitive edge for any business. This is a widely held belief among experts in the field. The customers' current needs can be fulfilled satisfactorily by them, as well as their future needs can also be anticipated. It is possible to predict the needs of the future, which enables clients to consistently receive high-quality services and feel satisfied. As a result, there is a significant increase in customer satisfaction and consumer loyalty to these businesses (Khan and Fasih, 2014).

A key component of the banking sector's success is the customer base. Banking organizations must therefore provide a variety of creative and inventive banking services. Customers' expectations should be fulfilled or exceeded by these services. In the end, they should ensure customer loyalty and maximize satisfaction among customers. An important subject in the banking sector is brought to light by this study (Al-Slehat, 2021).

In this study, PLS-SEM (Partial Least Squares-Structural Equation Modeling) analysis was used to assess the performance of small and medium-sized businesses, significantly lessening the influence of marketing strategy. The findings demonstrated a strong relationship between marketing strategy and customer loyalty. Questionnaires were used in the study and distributed to over 500 customers in India.

2. LITERATURE REVIEW

This section reviews literature related to the study's key concepts: customer satisfaction in banking sector.

To find out which E-Banking service quality dimension might potentially have the biggest impact on customer satisfaction, the relationship between the dimensions and satisfaction is explored. So that, Hammoud et al. (2018)

examined how customer satisfaction in the Lebanese banking industry was affected by the quality of e-banking services. The quantitative method involved distributing a survey to bank customers in Lebanon and utilizing SEM with AMOS to examine the results. It discusses several challenges like, ensuring high-quality banking services in order to fulfill client expectations, measuring and improving customer satisfaction in the context of backing. Addressing technical problems that can affect the reliability and usability of e-banking services. Managing security risks to protect customer data and build trust in banking.

Islam et al. (2020) looked into how several components of service quality affected customer satisfaction in Bangladesh's private banking sector, including accessibility to services, employee commitment, responsiveness, visibility, and reliability. In addition, he looked into the relationship between loyalty and customer satisfaction as well as the impact of demographic factors. By utilizing the Confirmatory factor analysis (CFA) and structural equation modelling (SEM) the data's were analyzed. Some of the limitations like, reliability and accessibility which had customer satisfaction in the private banking sector is greatly reduced by the insignificant impact. This might be because of issues such as unreliable services and poor accessibility, which could be areas of concern for banks that are aimed to improve customer satisfaction.

In the context of Saudi Arabian commercial banks, Alkhaibari et al. (2023) looked at the impact of the quality of E-banking services on customer satisfaction. The author employed a combination of qualitative and quantitative research approaches in this study. Here were identified the eight characteristics of service quality: transactional efficiency, customer assistance, convenience of use, security of the service, satisfaction with the quality of the service, and service content. The quality of the services provided by Saudi Arabian commercial banks has a significant influence on the degree of client satisfaction with online banking. It is useful for the management of commercial banks of Saudi Arabia, enabling them to identify customer complaints and problems and improve service quality. The challenges of implementing the findings is it had a technological infrastructure, Customer Adaptation Regulatory compliance and continuous improvement.

3. CUSTOMER RELATION MANAGEMENT

The development of relationships between customers and the bank is facilitated by various strategies and initiatives implemented by the financial institution. The improvement of customer satisfaction is focused on by incorporating the best technology. Long-lasting customer relationships are created by CRM through the provision of excellent service. The gap in customer retention in CRM practice was filled by this study, using four common customer relationship management dimensions (trust, commitment, customer loyalty and customer satisfaction) to measure the effect of Customer Relationship Management on Customer Loyalty (Abdela et al., 2023).

4. CUSTOMER TRUST

Customers' degree of faith in a company and its capacity to satisfy their requirements and expectations is known as customer trust. Customer trust can be impacted by several factors, namely:

- **Brand reputation:** The importance of a brand's reputation is illustrated by the way that customer trust may affect it. Brands that have a strong track record of dependability, quality, and customer service should expect to see a significant rise in customer trust.
- **Transparency:** Customer trust can be greatly impacted by transparency, which is another important factor. Consumers who are aware of an organization's rules, procedures, and business practices are more likely to trust it.
- **Personalization:** To accommodate individual needs and preferences through customization, customer experience is significantly reduced. Customers may become significantly less trusting of an organization if it is not committed to comprehending and satisfying their demands (Albarq, 2023).

Commitment

Commitment is defined as the precious bond could be maintained by a person's long-term intention. The psychological force of customer commitment, which incorporates the customer into the business organization, is activated. The relations will be viewed as more valuable and unpleasant experiences will be forgotten by commitment. A valuable relation is maintained by an individual's intention to commitment. The commitment of the customer can be formed through affective, behavioural, and continuance commitment in the marketing concept. Companies should support the business sector as much as possible to ensure the formation of a sustained loyalty in order to achieve a continuing commitment (Cahaya et al., 2023).

Customer satisfaction

The customer's reaction upon having their demands met is satisfaction. According to this definition, consumer satisfaction is defined as their satisfied state when consuming a good or service and includes satisfaction that exceeds their expectations. Satisfaction is defined as the degree to which an individual's sensory state matches their expectations and desires with the outcomes they received from the product or service. They may result from past experiences, personal needs, or external information like advertisements or word-of-mouth from friends, family, and relations. Thus, the difference between received and expected results correlates with the level of satisfaction. Customers may experience one

of the three levels of satisfaction listed below: Customers experience dissatisfaction if the performance falls short of their expectations and satisfaction if the performance meets their expectations. The customer is delighted if the real advantages exceed their expectations (Duc, 2022).

Customer Loyalty

Customer loyalty is essential for the success of any business, as it can lead to increased revenue, positive word-of-mouth referrals, and a competitive advantage in the marketplace. By prioritizing customer satisfaction and consistently delivering high-quality experiences, businesses can build strong relationships with their customers and foster loyalty that will benefit their bottom line in the long run. Customer loyalty is related to fortitude and a sense of virtual community for achieving customer satisfaction. The choices made by banks and credit union customers in India and their satisfaction towards the loyalty programs are being focused on by the loyalty program (Hasim et al., 2015).

Conflict handling: Conflict arises when there are differences between the intended and actual responses between two or more social entities. This can be characterized as a chance for the business to demonstrate to its client how committed it is by resolving the conflict and being willing to communicate honestly about the reasons and possible satisfactory solutions. The ability of a provider to prevent potential conflicts, settle obvious differences before they become issues, and candidly explore solutions when issues do arise has been characterized as conflict handling. The most important elements influencing interpersonal conflict are the frequency and bi-directionality of communication; therefore, it is important to use suitable, supportive, and relevant communication to increase its effectiveness as a component of customer loyalty. Handling conflicts well has a favorable effect on customer loyalty.

Communication: "Communication is the degree to which a company maintains a friendly and personal relationship with its regular customers." Such a relationship is shown by sentiments of familiarity and friendliness, personal knowledge, and the use of the customer's family name or first name on the sales spot. Additionally, buyers and sellers exchanging and sharing timely and pertinent information are described as being communicated in both formal and informal manner. Communication is the process of providing accurate and timely information.

Competence: Maintaining the organization's goals requires the coordinated deployment of its assets, which are all tangible and intangible resources that the company can use in its processes for creating, manufacturing, and/or presenting its products to a market. Customer perceptions define the level of skills, abilities, and information that the other party needs in order to perform or provide a function effectively. Customer loyalty is significantly affected by competence. Figure 1 depicts about the Framework of Customer Relation Management.

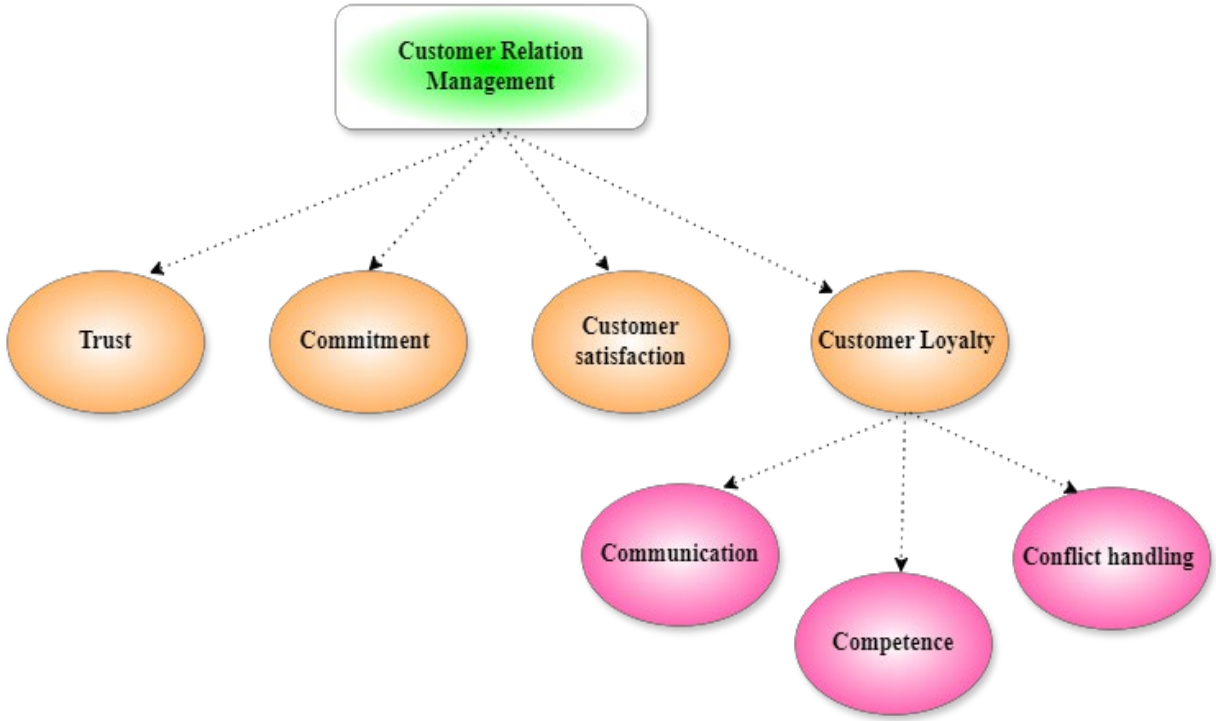

Figure 1: Framework of Customer Relation Management

5. ANALYTICAL METHOD

Version 3 of Smart PLS and IBM SPSS Statistics 23.0 were utilized to analyze the data. The adopted approach was a variance based PLS-SEM. While measurement errors in the structural model are addressed, PLS-SEM allows for the simultaneous estimation of causal links among all latent components. PLS-SEM is thought to be the most appropriate fit for this investigation because it is explanatory in nature. Prior to evaluating the structural model, the measurement models were assessed independently. In addition, a number of tests (such as the non-response bias test, common-method variance bias test, data screening for missing values, etc.) were carried out in addition to other validity and reliability checks to determine the consistency and quality of the data for the structural model prior to PLS-SEM analysis (Boadi et al., 2019). While classical statistics have been utilized for descriptive analysis, partial least square (PLS) based structural models are employed to assess testable propositions.

6. DATA COLLECTION

Thousand five hundred Indian commercial bank customers completed the questionnaire. Following the screening procedure, 100 or 85% of the study participants were deemed eligible and may be considered responses. Nevertheless, only 500 participants were used in this study after the data were screened. As a result, the response rate can be deemed sufficient for the PLS-SEM analysis. Table 1 presents the demographic results.

TABLE 2: The respondents' demographic profile

Group	Classification	Count	Percentage
Gender	Male	246	49%
	Female	225	45%
	Transgender	29	6%
Age	Below 25 years	123	25%
	26-39 years	203	40%
	40-59 years	121	24%
	60 and above	53	11%
Marital status	Single	289	58%
	Married	153	31%
	Widow/ Divorced	58	12%
Educational level	Schooling	96	19%
	Under graduate	193	39%
	Post graduate	211	42%
Occupation	Unemployed	86	17%
	Institutional staff	92	18%
	Government staff	78	16%
	Entrepreneur	91	18%
	Professional (Eg: Lawyers, Doctors, Engineers)	53	11%
	Others	96	19%
Working experience	0-5 yrs	240	48%
	6-10 yrs	153	31%
	Above 11 yrs	107	21%
Monthly Income	Low (0-50,000)	124	25%
	Average (51,000 – 5,00,000)	216	43%
	High (Above 5,00,000)	160	32%

Table 1 provides a detailed demographic profile of the respondents. It includes various categories such as gender, age, marital status, educational level, occupation, working experience, and monthly income. The respondents are predominantly male (49%), followed by females (45%), and a smaller percentage of transgender individuals (6%). The majority are aged between 26-39 years (40%), with those below 25 years making up 25%, 40-59 years at 24%, and 60 and above at 11%. Most respondents are single (58%), while 31% are married, and 12% are either widowed or divorced. A significant portion has a postgraduate degree (42%), followed by undergraduates (39%), and those with schooling education (19%). The respondents' occupations vary, with 18% being institutional staff, 17% unemployed, 16% government staff, 18% entrepreneurs, 11% professionals (like lawyers, doctors, engineers), and 19% in other categories. Nearly half of the respondents have 0-5 years of experience (48%), 31% have 6-10 years, and 21% have over 11 years. The income levels are categorized into low (25%), average (43%), and high (32%).

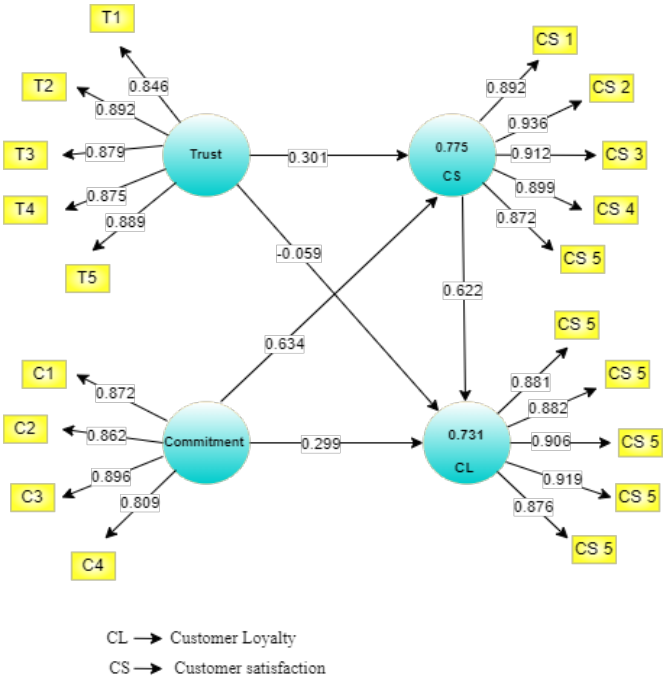

Figure 2. Structural model

TABLE 2: Structural results

Hypotheses	*Mean	** Standard deviation	T stat	ρ values	Result
CS →CL	0.622	0.099	6.793	0.000	Promoted
Commitment → CL	0.299	0.131	2.372	0.021	Promoted
Commitment → CS	0.634	0.061	11.901	0.000	Promoted
Trust → CL	-0.059	0.112	0.399	0.701	Not promoted
Trust → CS	0.301	0.072	4.371	0.000	Promoted

TABLE 3: Measurement model results

Variables	Item loading	Composite Reliability	*α Cronbach Alpha	** AVE
Trust		**0.954**	**0.938**	**0.752**
The promises made by my bank can be relied upon.	0.889			
The services provided by my bank are trusted by me	0.875			
The obligations to customers are fulfilled by my bank.	0.879			
The staff at my bank treats customers with dignity.	0.892			
My bank often offers top-notch service.	0.846			
Commitment		**0.969**	**0.882**	**0.739**
My bank provides me with flexible service to meet my demands.	0.872			
Adjustments are made to suit my needs by my bank.	0.862			
The flexibility of my bank is evident when changes are made to its services.	0.896			
My bank provides individualized services to satisfy the needs of its clients.	0.809			
Customer satisfaction		**0.969**	**0.958**	**0.811**
My bank is completely satisfying to me.	0.892			
My expectations are always met by my bank.	0.936			
The services provided by the bank bring me great satisfaction.	0.912			
The quality of my Bank's services is considered satisfactory by me.	0.899			
The bank has always provided me with good experiences.	0.872			
Customer Loyalty				
Changing my bank has never been seriously considered by me.	0.881			
My Bank is considered by me to be a loyal customer.	0.882			
My Bank would be recommended to friends and acquaintances by me.	0.906			
Among other banks in the area, my bank is considered as the first choice	0.919			
I will propagate good word of mouth about my bank and its excellent services.	0.876			

A full assessment of the bank's performance in terms of trust, commitment, customer happiness, and loyalty may be obtained by looking at Table 3, which displays the measurement results. Here, Trust measures the reliability and trustworthiness of the bank from the customer's perspective. It includes items like the bank's ability to keep promises, fulfill obligations, treat customers with dignity, and provide top-notch service. The composite reliability score is 0.954, indicating high consistency in the responses. The average variance extracted (AVE) is 0.752, showing that a significant portion of the variance is captured by the construct. Commitment assesses the bank's commitment to providing flexible and individualized services to meet customer demands. Items include the bank's ability to adjust services to suit customer needs and provide personalized services.

The composite reliability score is 0.969, and the AVE is 0.739, indicating strong reliability and a good amount of variance captured by the construct. Customer Satisfaction evaluates the overall satisfaction of customers with the bank's services. It includes items like the bank's ability to meet expectations, provide satisfactory service quality, and deliver good experiences. The composite reliability score is 0.969, and the AVE is 0.811, reflecting high reliability and a substantial amount of variance captured by the construct. Customer Loyalty measures the loyalty of customers towards the bank. It includes items like the likelihood of recommending the bank to others, considering the bank as the first choice and spreading positive word of mouth. The composite reliability score is not provided, but the items indicate a strong sense of loyalty among customers.

7. CONCLUSION

The article emphasizes the critical importance of customer satisfaction in the banking field. It highlights that quality service is a key factor in achieving customer satisfaction, which in turn fosters customer loyalty. The study underscores that bank must continuously strive to meet and exceed customer expectations through innovative and high quality services. Ensuring high quality services is crucial for customer satisfaction, which in turn influences customer loyalty and organizational performance. Using techniques such as PLS-SEM for data analysis, the study also analyzes the relationship between several aspects of banking service quality and customer satisfaction.

It identifies significant factors such as trust, commitment, customer loyalty and customer satisfaction. Overall, the findings suggest that banks need to focus on customer relationship management and leverage technology to enhance service quality and customer loyalty. By doing so, they can build long-lasting relationships with customers, ultimately leading to improved organizational performance and success. The future work will utilize machine learning algorithms to predict customer satisfaction trends and identify key factors influencing satisfaction.

8. DECLARATION

I, [R. Melba Kani], hereby confirm that the manuscript titled "Enhancing Customer Relation Management in the Banking Sector: A PLS-SEM Analysis" authored by Dr. R. Melba Kani, Dr. S.N. Kumar, Dr.S.Silas Sargunam, Dr. J. T. Pratheesh, Dr.G. Arumugasamy, has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to International Management Perspective Conference (IMPeC 2025).

I/we declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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Drivers of Self-Service Banking Among Millennials: A Systematic Review of Key Antecedents

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ABSTRACT

Millennials in India's business environment is an enormous segment of the India's population. This paper explores the factors that influencing the adoption of self-service banking technology among millennials generation. It identifies the key determinants driving the millennials towards the adoption of self-service banking technology. Secondary data were collected from online database from 2000 to 2024.The research methodology employed in this study involved a comprehensive search of relevant academic databases, including research gate, Emerald, Elsevier, Scopus, Web of Science, and Google Scholar. Technology And Acceptance Model (TAM), Unified Theory of Acceptance and Use of Technology was used as theoretical framework, analysing performance expectancy, hedonic motivations, effort expectancy, facilitating condition, trust, price values factors, impacting the behaviour intention of millennial generation.

Keywords: self-service technology, performance expectancy, TAM, UTAUT, behvaivor intention.

1. INTRODUCTION

The rapid expansion of internet technologies has had a tremendous impact on how banks
operate their business and how they way in which consumers conduct their banking activities (Lee, 2009). With the changing landscape from a product-centric to a customer-centric approach, marketers have shifted their focus towards the customers and their experiences (Garg, Rahman, & Kumar, 2010) (Yousafzai, 2012). Numerous innovative financial solutions for insurance, credit products, and transaction processing services have experienced significant growth over the past few decades (Nejad & Estelami, 2012). The effects have largely been significant in the services sector due to the emergence of self-service technologies (SST) (Kaushik & Rahman, 2015).

Self-Service Technology (SST) is a widely utilized technology that enables customers to carry out banking transactions on their own, without requiring any assistance or interaction from bank employees. It can be defined as a technology interface that allows customers to access services independently of direct employee involvement. Self-service technologies (SSTs) are increasingly changing the way the customers interact with banks, necessitating the research to better understand customers' attitudes toward service providers and the technologies (Meuter, Ostrom, Roundtree, & Bitner, 2000). It includes Automated Teller Machine (ATM), internet banking, mobile banking, e-banking, e wallets etc.

Understanding the antecedents of technology acceptance represents a promising strategy for increasing the likelihood of success in technology-based service introductions and for promoting their adoption across different generational cohorts. Millennials generation represent the attractive market. They are distinct from their earlier generations in adapting quickly the innovative changes in technology (Purani, Kumar, & Sahadev, 2019), thus they are known as the technology savvy generation (Oliveira, Gonçalves , Martins, & Branco, 2018). Consequently, the millennials have been found to be the largest user of latest technology.

2. LITERATURE REVIEW

This section examines the consumer technology acceptance models used in online banking, leading to the theoretical framework chosen for this study. This section also examines the factor that influencing the adoption of self-service banking technologies.

Several theoretical models have been developed to explain the acceptance and utilization of technology, based on theories of psychology and sociology (Yergali & Yongsun, 2021). Consumer acceptance is the foundation of e-commerce success. Unlike e-commerce, m-commerce customers use mobile information systems (IS) and related applications (Imtiaz, 2018). Various theories have been developed to clarify the factors that explain the consumers eagerness to adopt and use new technologies (Al-Saedi, Al-Emrah, Ramayah, & Abusham, 2020).

2.1 Theory of Reasoned action (TRA) – this theory is developed by Fishbein and Ajzen (1977). It is based on the interaction between attitudes, intentions, beliefs and behaviour. According to this theory Human behavior can be explained through three primary cognitive components; Social norms, intentions, and attitudes (Taherdoost, 2018)

2.2 Theory of Planned Behaviour (TPB) – a new variable, perceived behavioral control (PBC), is incorporated into this model to extend theory of Reasoned Action. Perceived bahvioral control is characterized by the availability of resources, opportunities, and skill and along with the importance of those resources in achieving desired outcomes (Taherdoost, 2018) . In Theory of Planned Behavior (TPB) model three major factors that influence behavior intention is subjective norms, behavioral attitude, perceived behavioral control.

2.3 Technology Acceptance Model (TAM)- The Technology Acceptance Model (TAM), originally created to forecast the acceptance and use of ICT in work environment, has been adapted for various Information system (Venkatesh, G. Morris, Davis, & Davis, 2003). It has been developed for understanding the factors that influence whether individual will accept or reject technology (Marangunic & Granic, 2014). The Technology Acceptance Model explains user motivation through three major aspects: perceived ease of use, perceived usefulness, attitude towards using the technology (Masrom, 2007).

2.4 Unified theory of acceptance and use of technology (UTAUT)- (Venkatesh, G. Morris, Davis, & Davis, 2003) built upon previous Technology Acceptance Model (TAMs) and introduced the Unified Theory of Acceptance and Use of Technology (Alshammari, 2020) with the significant factors effort expectancy (EE), performance expectancy (PE), facilitating condition (FC), Social influence (SI). This model is utilised to describe the user's intention to adopt technology and their subsequent behavior, providing a detailed representation of the technology acceptance process (Alshammari, 2020).

2.5 Unified theory of acceptance and use of technology 2 (UTAUT2)- UTAUT 2 is an advanced version of the original UTAUT framework. It incorporates additional key constructs and relationship to better suit a consumer use context (Venkatesh, Thong, & Xu, Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology, 2012). Consequently, UTAUT2 includes constructs price value (PV), hedonic motivation (HM), and habit in addition to the four previously listed constructs Included in UTAUT (Venkatesh, Thong, & Xu, Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology, 2012).

2.6 Unified theory of acceptance and use of technology 3 (UTAUT3)- UTAUT3 expands the UTAUT2 by including perceived risk (PR), trust as key drivers of BI (Penney, Agyei, Ofori-Boafo, Boadi, & Abrokwah, 2021). It anticipated that trust and perceived risk will be prominent factors for the acceptance and use of an online bank (Gertze & Petersen, 2024).

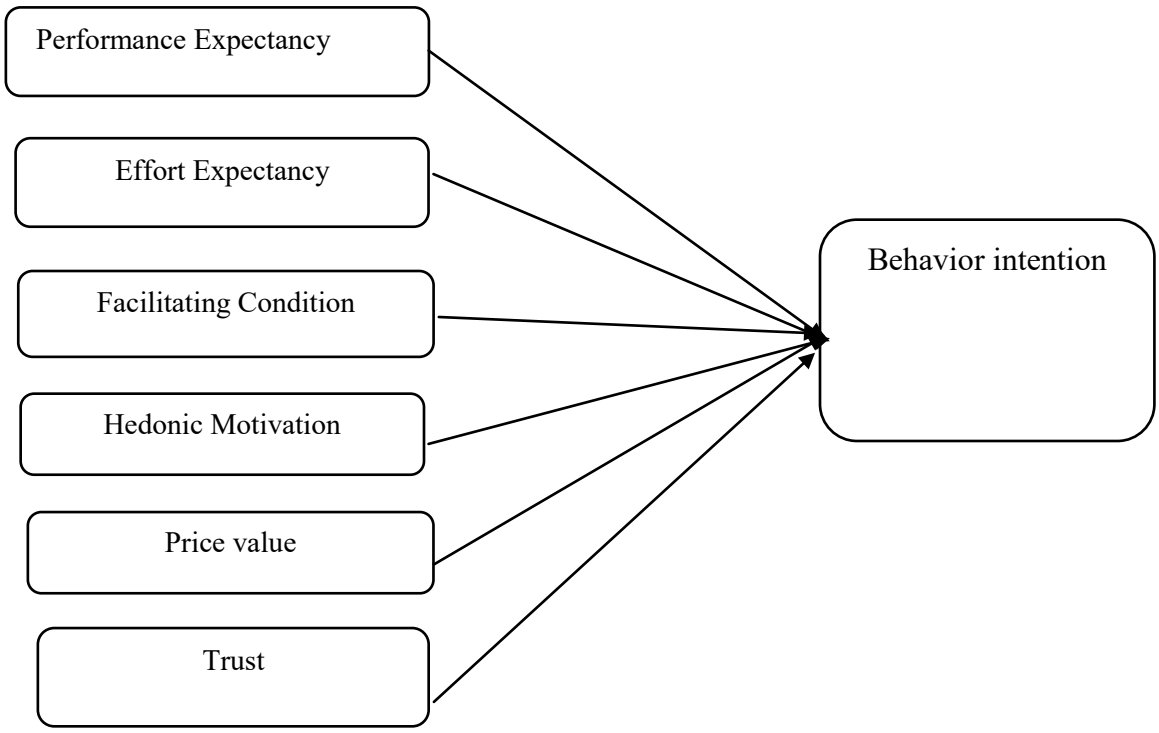

Fig. 1. theoretical framework

3. RESEARCH METHODOLOGY

Before conducting research, reviewing the existing literature is key to better understanding the state of the research in the area, which involves discerning patterns in the development of the field. Secondary data were collected from online database from 2000 to 2024.The research methodology employed in this study involved a comprehensive search of relevant academic databases, including research gate, Emerald, Elsevier, Scopus, Web of Science, and Google Scholar. The keywords used were "millennials generation", "TAM", "UTAUT", "Digital Payment", "mobile banking", "Self-service banking technology", "behavior intention" etc..

In the next stage, the publications were reviewed to find those articles studying the factors of adoption of technology and those impacting the behavioral intention. After reviewing, 40 publications were selected for in-depth analysis. These selected publications included those papers that met the criteria of (a) studying the factors impacting technology adoption, among millennials (b) specifically consider digital payment and self- service banking, (c), emphasising conceptual models. These articles were critically reviewed in detail, and the broad categories of determinants were identified to developed a conceptual framework relevant to adoption of self-service banking technology.

4. DISCUSSION

This study examined the factors affecting the acceptance and use of self-service banking technologies. The main research question is: what are the factors influence the adoption of self-service banking technologies among millennials? There is limited research conducted to analyze the millennials behavior towards self-service banking technologies. Various theories had been examined and theoretical framework had been developed. Seven constructs have been identified as effectively capturing the factors that influence people's adoption and use of self-service banking technology.

Performance Expectancy: performance expectancy is the degree to which an individual believes that using the system will help him or her to attain gains in job performance (Ghalandari, 2012). Performance expectancy in internet banking context is the degree where an individual believes that using internet banking will help him/her to attain gains in performing banking tasks (Martins, Oliveira, & Popovic, 2014). (Alalwan, Dwivedi, & Williams, 2014) it is proposed that performance expectancy is viewed as a measure of the usefulness experienced when using internet banking. upon reviewing the literature, it is evident that several studies within the IB context have shown inconsistenscies. (Yu, 2012) asserted that PE significantly impacted customers BI to use the system. Similarly (Tarhini, Hone, & Liu, 2014) (Tarhini, Hone, & Liu, Measuring the Moderating Effect of Gender and Age on E-Learning Acceptance in England: A Structural Equation Modeling Approach for An Extended Technology Acceptance Model, 2014) (Tarhini, Hone, & Liu, The effects of individual differences on e-learning users' behaviour in developing countries: A structural equation model, 2014) determined that perceived usefulness played a crucial role in explaining technology acceptance.

Effort Expectancy: Effort expectancy is the degree of ease associated with customers' use of technology (Venkatesh, G. Morris, Davis, & Davis, 2003). According to UTAUT effort expectancy positively influence the Behvaior intention to use technology (Venkatesh, G. Morris, Davis, & Davis, 2003). Users are more likely to self-services if they find them easy to use and requiring minimal effort. (Yoon & Steege, 2013) founds that effort expectancy influenced behavior intention, but it was not the strongest predictor. Similarly, (Martins, Oliveira, & Popovic, 2014) founds that Effort expectancy has a significance positive influence on behavior intention.

Facilitating Condition: facilitating condition as the extent to which an individual believes that there is adequate organizational and technical infrastructure to support the use of the sysetm (Venkatesh, G. Morris, B. Davis, & D. Davis, 2003). (Zhou, Lu, & Wang, 2010) it is clear that utilizing IB services demands specific skills, resources, and technical infrastructure, which are not typically available at no cost to customers. Facilitating condition can be assessed based on customers perceptions of their ability to access the necessary resources and support requires to use self-services technology.

Hedonic motivation: According to (Venkatesh, Thong, & Xu, Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology, 2012) hedonic motivation is defined as the sense of cheerfulness, joy, and enjoyment that arises from using technology. Self -services banking has been considered as more modern and pioneering technology, characterized by greater innovativeness and a focus on novelty (Riffai, Grant, & Edgar, 2012). For self-service technologies (SSTs), hedonic motivation can be conceptualized as the degree to which using these technologies enhances customers sense of enjoyment and entertainment (Hassan & Farmanesh, 2022).

Price Value: price value refers to the consumers mental evaluation of the balance between the benefits they perceive from using the applications and the cost they pay for accessing them (Venkatesh, Thong, & Xu, Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology, 2012). While using a technological service, users often evaluate the price they paid for the technology against potential discounts they could receive from ongoing use of the service (Dwivedi, Kapoor, Williams, & Williams, 2013)

(Baabdullah, Alalwan, & AL Qadi, 2018). Users who cannot afford the necessary payments to continue using upgraded technology tend to lose interest in maintaining its use (M. Baabdullah, Alalwan, P. Rana, Kizgin, & Patil, 2019).

Trust: In technology adoption trust come out as an important factor as consumer worry about misuse of their personal data or security breaches which can lead to financial and reputational losses (Dastan & Gurler, 2016). Trust is explored from the viewpoint of merchants, users, and service providers (Kalinic, Marinkovic, Molinillo, & Cabanillas, 2019). The original TAM theory does not include trust as one of its factors however, many studies include it as an external variable in TAM (Chauhan, 2015). Trust is conceptualized as a belief about another person's trustworthiness concerning a particular matter at hand emerges under conditions of unknown outcomes (Robbins, 2016).

5. CONCLUSION

This study explores the factors that affect the adoption and use of self-services technology among millennials. The investigation is based on various models such as TAM, UTAUT, UTAUT2, UTAUT3, referenced in existing literature. The six key constructs performance expectancy, effort expectancy, price value, trust, facilitating condition, hedonic motivation were used to identify the factor influencing millennials acceptance of self-service technologies. Our study have certain limitations. The study focus on previous research done in the context of self-service technologies. Future research could explore their loyalty and the factors affecting their loyalty towards the usage. Moreover the impact of risk-taking willingness, government policies, technological aptitude on the adoption of self-service technology should be considered. These factors could enhance millennials behavior towards adoption of self-service technologies.

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The Role of Digital Payment Systems in Advancing Financial Inclusion in India

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ABSTRACT

The emergence of digital payment systems has been a powerful tool in the advancement of financial inclusion in India, enabling millions of individuals who were previously outside the banking system to access formal financial services. The study uses the Theory of Planned Behavior (TPB) with the inclusion of additional variables in the model. The study's specific goal is to investigate how people's attitudes toward digital payments, perceived social norms, and perceived behavioral control influence their intention to use these systems, as well as how these intentions contribute to greater financial inclusion in underserved populations. Furthermore, the study will look into the mediating role of trust in the relationship between the intention to use digital payment systems and actual financial inclusion. Data was collected from 436 individuals against the target of 384 from Uttar Pradesh. Structural Equation Modeling (SEM) was used to evaluate the hypotheses established. The major findings indicate that the attitude toward digital payment systems and perceived behavioral control have significant impacts on the intention to use these systems, with subjective norms playing insignificant role. Trust appeared as an effective mediator, magnifying the impact of intention on financial inclusion. The findings imply that increasing trust in digital financial services is critical for promoting financial inclusion in India.

Keywords: digital payment, financial inclusion, attitude, trust, intention.

1. INTRODUCTION

The digital revolution in India is currently on the rise, and its first step towards a cashless economy was accomplished by the digitalization of payment systems. While the financial inclusion revolution through this transformation is purely technological, it is a game-changer for reinforcing financial inclusion across the country. Digital payment options are growing rapidly, driving financial inclusion. Government programs like Digital India and technological advancements have created a perfect platform to fill this gap through the adoption of digital payment systems. Not having a bank account or limited access to banking makes it difficult at best, but the ability to use digital techniques means new opportunities.

From peer-to-peer transfers to e-commerce transactions, digital payment systems have become an essential part of modern economies, contributing to financial inclusion, reducing cash usage and promoting economic growth. It means the payments that are made electronically or through digital channels as opposed to physical cash transactions. Electronic payment (both the payer and payee using a digital device, such as a computer or smartphone, debit or credit cards, etc.) transfer of funds between payment accounts. Digital payments are fast and easy to complete, with a tap, click or swipe. Also, there should be an account for both the payer and payee with a bank, online banking method, electronic device (ex. computer, internet enabled mobile) from where they can make the transaction as well, as mode of transmission for the electronic transaction to take place (Khaitan, 2024) There are many benefits of digital payments and receipts and increasingly consumers and businesses are expecting digital payment options to be offered for faster, safer and cost-free transactions.

Improving financial inclusion is critical to achieving larger socioeconomic goals, spurring economic growth, and reducing poverty. The World Bank defines it as follows: “Financial inclusion is the availability of practical and affordable financial services and products that meet the needs of individuals and businesses (including credit, insurance, savings, payments and transactions), and is provided in a fair and sustainable way.” Financial inclusion has been acknowledged to make it possible for 7 of the 17 Sustainable Development Goals (Overview, n.d.). According to the 2023 assessment from the Global Financial Inclusion Index, there has been marginal improvement in global financial inclusion across the 42 markets studied when compared to the previous year. The evaluation identifies three main supports for financial inclusion: the financial system, employers, and the government. The second support highlights how financial providers boost global financial inclusion. It looks at how easy it is to get and use different financial products and services that are key to making this happen. The evaluation shows that countries with digital financial systems are making the quickest progress in financial inclusion. So, to improve fair financial access worldwide, companies in this field - including those that offer digital payments - should focus on areas that lack digital services in their global growth plans (Huszárik, 2024).

The rest of the paper is structured as follows: The review of literature is covered in Section 2. The research gap is described in Section 3. Section 4 discusses conceptual framework along with hypotheses formulation. Research Methodology is explained in Section 5. We discuss the outcomes of hypothesis testing, assess the measurement and structural model, and offer the data analysis in Section 6. The discussions, theoretical and practical implications, limitations and scope for further studies, and conclusions are then presented in further sections.

2. REVIEW OF LITERATURE

2.1 Digital Payment System and Financial Inclusion

The rise of digital payments in India has seen a major boost from innovations like the Unified Payments Interface (UPI) and the e-Rupee. These new tools back the government's "Digital India" plan to cut down on cash use and get more people into the banking system (Govind et al. 2024). India's digital payment scene has grown fast, with all digital payments jumping from 2,071 crore in FY 2017–18 to 18,737 crores in FY 2023–24 growing at 44% each year on average. Plus, in just the first five months (April–August) of FY 2024–25, transactions hit 8,659 crores (DFS Drives Expansion of Digital Payments in India and Abroad n.d.-b). The Unified Payments Interface (UPI) has grown the most, with over 50% growth. Indian payment products are gaining popularity because they're safe, fit well with online markets, and more banks, finance companies, and tech firms are using them (Gandhi & PwC India 2024).

Digitalization has made money services easier to get for more people. In India, using digital payment systems has made it simpler to access basic money services, letting more folks take part in the financial world (Sille et al., 2024). Moving from cash to cashless payments plays a big role in getting more people into the financial system. This change allows for more effective and easy-to-use money services, which can help pull people out of being poor and give the economy a boost (Goldfinch, 2024). Digital payment methods get rid of the things that stop people from using money services. These roadblocks can include not having actual bank buildings nearby, limits based on where you live, and the high costs of old-school banking ways (Garg et al. 2024). Even with the good stuff, there are big problems that make it hard for digital payments to catch on in the countryside. Some of these problems are language differences not-so-great infrastructure, and people not knowing much about tech. To get more folks using money services, we need to tackle these issues (Sharma 2024).

2.2. Theory of Planned Behavior

Originally developed in 1980 as the Theory of Reasoned Action, the Theory of Planned Behaviour (TPB) aims to predict a person's intention to perform a specific behavior at a given time and place. The goal was to provide an explanation for all actions that individuals can control using this theory. Central to this model is the concept of behavioral intent, which is influenced by attitudes regarding the likelihood that a behavior will lead to a desired outcome, as well as personal evaluations of the pros and cons of that result (LaMorte, 2022). This psychological framework is designed to forecast and explain how people are likely to act in certain situations. The theory has garnered significant support from research across various fields. Studies indicate that intentions can be effectively predicted by attitudes, subjective norms, and perceived behavioral control. Collectively, these factors account for a substantial portion of the variability in actual behavior (Ajzen, 1991).

Attitude is an individual's judgment of a behavior, which can be both favorable and unfavorable. Beliefs about the behavior's outcomes and their attractiveness influence this evaluation (Ajzen, 1991). Consumer attitude significantly impacts their intention to adopt digital payment services. According to a survey, consumer attitudes and subjective norms account for around 60% of the intention to use digital payment services. (Ashour et al., 2023). Positive attitudes towards digital payments significantly boost the intention to use these services. For instance, perceived usefulness and convenience are critical in shaping favorable attitudes (Firdaus & Doloksaribu, 2022). Subjective norms explore how social factors affect individual choices to use digital payments. (Putri et al., 2022). It significantly influences the intention to use mobile payment systems, especially when users have access to the service and receive adequate information. Positive social influences can encourage adoption, highlighting the importance of communication in promoting mobile payment usage (De Luna et al., 2023). Perceived behavioral control (PBC) plays a critical role in the early adoption and continued use of digital payment systems. It influences users' confidence in their ability to navigate these technologies, which is essential for fostering innovative behaviors and enhancing user engagement. Perceived behaviour control significantly influences the adoption of digital payment methods. Consumers that believe they have the ability to use these technologies efficiently are more inclined to adopt them. This includes factors such as familiarity with technology and confidence in using digital platforms (Tribhan, 2024b).

3. RESEARCH GAP

Despite the research, on payment systems and how they contribute to improving financial inclusion in India to date many important gaps persist in our understanding of this area. Even though we are familiar with the infrastructural hurdles that need to be overcome there is still a lack of insight into the factors that drive people to adopt digital payments particularly when using frameworks such as the Theory of Planned Behavior (TPB). Components like attitudes norms and perceived control have not been sufficiently investigated within the realm of financial

inclusion, in this context. Trust plays a role, in the adoption of payments and its impact on financial inclusion has not been thoroughly examined yet as a connecting factor with behavioral intentions in this area remains underexplored too. Moreover, the notable gaps in payment acceptance rates, between urban communities have not been extensively researched to explore how behavioral elements and trust levels vary among these groups. Furthermore, current studies fail to address the challenges related to context such as language obstacles, cultural influences and socio-economic factors that uniquely affect Indias population. Few studies have combined TPV concepts, with trust acting as a mediator in a way; additionally, the utilization of statistical validation techniques like structural equation modeling (SEM) is not common practice among researchers in this field of study. It is crucial to fill these gaps in research to contribute towards enhancing inclusion in India by offering advice for decision makers in the finance sector as well, as digital payment service providers.

4. CONCEPTUAL FRAMEWORK AND HYPOTHESIS FORMULATION

The Theory of Planned Behavior (TPB) forms the basis of this model. It looks at how attitude subjective norms, and perceived behavioral control (PBC) shape behavioral intention. This intention then affects financial inclusion, with trust playing a key role in between. Attitude refers to a person's feelings toward the use of digital payment systems, such as whether or not they believe that such platforms are beneficial. Social pressures from friends, family, or society to adopt these systems are known as subjective norms. PBC considers factors including a person's level of tech proficiency and their available resources when determining how confident they are in their ability to use digital payments. These elements come together to create behavioral intention, which hints at whether someone will start using digital payments. Trust acting as a go-between, boosts the chances of behavioral intention leading to financial inclusion. It tackles worries about how safe, reliable, and clear digital payment systems are. This makes people more likely to use digital payment apps often getting more folks involved in the financial world and thus building financial inclusion. This model as shown in figure 1 of digital payments highlights the mental and social factors that drive adoption. It puts trust front and center as a way to reach wider social and economic goals.

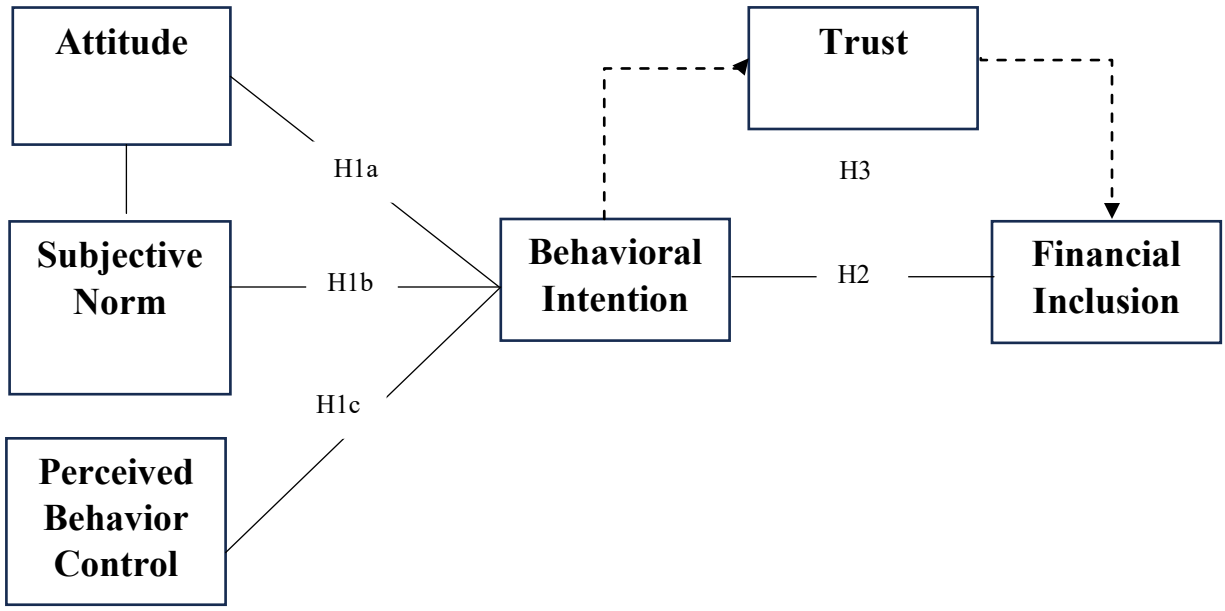

Figure 1: Conceptual and Theoretical Model

Adapting pre-established TPB relationships and incorporating trust as a mediator, the following hypotheses are proposed in the context of the current study:

H1a: Attitude toward digital payment systems positively influences behavioral intention to use them.

H1b: Subjective norms positively influence behavioral intention to use digital payment systems.

H1c: Perceived behavioral control positively influences behavioral intention to use digital payment systems.

H2: Behavioral intention positively impacts financial inclusion.

H3: Trust mediates the relationship between behavioral intention and financial inclusion.

5. RESEARCH METHODOLOGY

5.1 Data Collection and Sample

The study's target audience consists of Indian users of digital payment platforms within the range of 21 to 45 years of age. The sample comprises individuals with varying levels of education, awareness, and experience. A structured questionnaire using the Google forms were created and used for gathering primary data. Individuals received the questionnaire through different online platforms and we got 443 responses in return. After acquiring the responses and sorting them, 436 were found valid for further analysis. In 1977, Cochran developed a method that is regarded appropriate for estimating sample size when the study population is huge. Using the calculation, it was determined that the minimal sample size for this research was 384. Thus, a sample size of 436 is appropriate for this particular study. We used the convenience sampling approach, which had been recommended in previous studies (Alrawad et al. 2023; Amnas et al., 2023; Bajunaied et al. 2023; Senyo and Osabutey 2020). Table 1 presents the demographic profile of the individuals who were part of this survey.

TABLE 1: Demographic Profile of the Respondents

Demographic Variable	Groups	Frequency	Percentage
Gender	Male Female	322 114	73.9 26.1
Age	21-25 26-30 31-35 36-40 41-45	124 158 96 36 22	28.4 36.2 22.0 8.3 5.0
Education	High School Graduation Post Graduation Ph.D. Others	12 122 212 80 10	2.8 28.0 48.6 18.3 2.3
Occupation	Student Private Employee Government Employee Businessman Others	176 102 56 52 50	40.4 23.4 12.8 11.9 11.5
Income	Below 20,000 20,000-40,000 40,000-80,000 80,000-1,00,000 Above 1,00,000	156 72 96 74 38	35.8 16.5 22.0 17.0 8.7

5.2. Data Analysis Technique and Measures

To achieve the research objectives, this study incorporated a construct to the theory of planned behavior. Thus, covariance-based structural equation modelling (CB-SEM) was used to verify and confirm the proposed theory. The aspects of the study include attitude, subjective norms, perceived behavioral control, trust, behavioral intention, and financial inclusion. The scales for the items range from 1 (strongly disagree) to 5 (strongly agree), with each dimension measured using a five-point Likert scale. The appendix contains all scales with the coding of each measuring item used in this study. Furthermore, the quantitative data was examined using statistical methods. IBM SPSS AMOS 21, Microsoft Excel, and SPSS 23 were used to analyse the data that was gathered.

6. DATA ANALYSIS AND RESULTS

For the measurement and structural model analysis, a covariance-based structural equation modelling (CB-SEM) approach was employed. Firstly we will check the reliability and validity of the data and further we will perform assessment of measurement and structural model and lastly we will perform mediation analysis.

6.1. Reliability and Validity Analysis

The measurement model is a key component of covariance-based structural equation modeling (CB-SEM) since it verifies the constructs used in the study by assessing their reliability and validity. Reliability refers to the consistency and stability of a measurement instrument, while validity assesses the extent to which an instrument accurately measures what it is intended to measure (Bolarinwa, 2015). They are both primary for generating reliable and generalizable results. Cronbach's alpha and composite reliability scores are used here to measure the reliability and internal consistency of scales by calculating the correlations between its items. In Cronbach's alpha value of 0.7 or higher typically implies reliability in social sciences (Hair et al., 2014). Composite reliability which is often used in Structural Equation Modeling (SEM) to find the reliability of latent constructs should be higher than 0.7 are regarded as the point of acceptance (Fornell & Larcker 1981). Cronbach's alpha coefficients ranged from 0.748 to 0.917 and composite reliability scores in this study ranged from 0.792 to 0.899, as indicated in Table 2. These values demonstrate reliability and internal consistency among the constructs.

TABLE 2: Reliability and Convergent Validity Analysis

Constructs	Items	Mean	S.D.	λ	CA	CR	AVE
Attitude (A)	A1	4.09	.804	0.807	0.804	0.819	0.603
	A2	4.09	.851	0.673			
	A3	4.15	.853	0.839			
Subjective Norm (SN)	SN 1	4.16	.782	0.732	0.748	0.792	0.560
	SN	4.16	.795	0.685			

Constructs	Items	Mean	S.D.	λ	CA	CR	AVE
	2						
	SN 3	4.19	.838	0.822			
Perceived Behavior Control (PBC)	PBC1	3.96	.903	0.864	0.825	0.866	0.684
	PBC2	3.79	.954	0.797			
	PBC3	4.15	.839	0.818			
Behavioral Intention (BI)	BI1	4.16	.784	0.767	0.906	0.863	0.612
	BI2	4.30	.745	0.827			
	BI3	4.08	.890	0.754			
	BI4	4.29	.787	0.78			
Trust (T)	T1	4.23	.797	0.811	0.862	0.849	0.653
	T2	4.17	.789	0.773			
	T3	4.16	.792	0.839			
Financial Inclusion (FI)	FI1	4.15	.767	0.824	0.917	0.899	0.692
	FI2	4.20	.745	0.841			
	FI3	4.16	.745	0.851			
	FI4	4.16	.772	0.810			

Convergent validity is created based on the high degree of correlation among indicators of a construct. A construct's AVE value must exceed the threshold of 0.50 to establish convergent validity (Hair et al.,2021). Table 2 shows that all constructs in the model have AVE values above 0.50, indicating good convergent validity. Discriminant validity draws the attention on the extent to which the concepts involved in the construction of the model are different from one another. The discriminant validity was assessed using the Fornell-Larcker criterion, which involved assessing the square root of each AVE loaded along the diagonal by off diagonal items. The diagonal elements in table 3 indicates the square root of each construct's Average Variance Extracted (AVE). To ensure discriminant validity, these values should exceed the off-diagonal correlations in their corresponding rows and columns. All constructs i.e., Attitude (0.776), Subjective Norm (0.748), Perceived Behavior Control (0.827), Behavioral Intention (0.782), Trust (0.808), and Financial Inclusion (0.832), meet this criterion. Given that the diagonal values (square roots of AVE) are consistently higher than the inter-construct correlations in their rows and columns, the constructs indicate a good discriminant validity.

TABLE 3: Discriminant Validity Analysis

	AU	SN	PBC	BI	TU	FI
AU	**0.776**					
SN	0.708	**0.748**				
PBC	0.698	0.495	**0.827**			
BI	0.664	0.469	0.633	**0.782**		
TU	0.698	0.600	0.565	0.760	**0.808**	
FI	0.544	0.359	0.563	0.709	0.669	**0.832**

6.2. Assessment of Measurement Model

First-order confirmatory factor analysis (CFA) was used to determine the measurement model in order to evaluate construct validity, CR, and model fit. Additionally, the study used a number of statistics, including CMIN, GFI, AGFI, NFI, CFI and RMSEA, to ascertain the indicators of goodness-of-fit. Table 4 displays the model fit indices for the measurement models.

TABLE 4: Measurement Model Assessment

Fit Indices	*Recommended Value*	*Observed Value*
χ^2 /df	< 5	4.964
GFI	>0.90	0.921
AGFI	>0.80	0.853
NFI	>0.90	0.937
CFI	>0.90	0.949
RMSEA	<0.08	0.072

The measurement model's fit indices suggest an acceptable fit between the data and the hypothesized model, based on widely accepted thresholds. The chi-square/degree of freedom (χ^2/df) ratio is 4.964, which falls within the acceptable range of less than 5, indicating a reasonable fit (Marsh & Hocevar, 1985). The Goodness of Fit Index (GFI) is 0.921, exceeding the recommended value of 0.90 (Hu & Bentler, 1998), suggesting that the model explains a substantial proportion of the observed variance. Similarly, the Normed Fit Index (NFI) and Comparative Fit Index (CFI) are 0.937 and 0.949, respectively, both above the threshold of 0.90 (Hair et al., 2010; Bentler, 1990), further indicating strong model fit. The Adjusted Goodness of Fit Index (AGFI) is 0.853, which is exceeding the ideal threshold of 0.80 (Byrne, 2016), indicating a moderate model fit. Lastly, the Root Mean Square Error of Approximation (RMSEA) is 0.072, which is below the stringent threshold of 0.08, suggests an acceptable fit (Browne and Cudeck, 1993). Overall, the observed fit indices collectively support the adequacy of the measurement model.

6.3. Assessment of Structural Model

Several statistics, including CMIN, GFI, AGFI, NFI, CFI, and RMSEA, were employed to determine the structural model's goodness-of-fit indicators. The model fit indices demonstrate an acceptable and strong overall model fit, as most observed values meet or exceed the recommended thresholds. The Chi-square/df (χ^2/df) ratio is observed at 4.991, which falls within the acceptable range of less than 5, indicating a reasonable fit of the model to the data (Hair et al., 2021). The Goodness of Fit Index (GFI) is 0.930, exceeding the recommended value of 0.90, signifying that the model explains a large proportion of the variance in the data. Similarly, the Adjusted Goodness of Fit Index (AGFI),

with a value of 0.871, surpasses the threshold of 0.80, confirming an adequate adjustment for model complexity.

Additionally, the Normed Fit Index (NFI) is 0.939, and the Comparative Fit Index (CFI) is 0.950, both exceeding the recommended threshold of 0.90, which indicates a strong improvement over the baseline model and an excellent comparative fit. The Root Mean Square Error of Approximation (RMSEA) is 0.076, which is below the threshold of 0.08, confirming a good approximate fit of the model in the population. These results collectively validate the structural model's adequacy and suggest that the hypothesized relationships align well with the observed data, supporting further analysis and interpretation.

Fit Indices	*Recommended Value*	*Observed Value*
χ^2/df	< 5	4.991
GFI	>0.90	0.930
AGFI	>0.80	0.871
NFI	>0.90	0.939
CFI	>0.90	0.950
RMSEA	<0.08	0.076

TABLE 5: Structural Model Assessment

Hypotheses	Structural Path	Path Estimate	P-values	Result
H1a	Attitude → Behavioral Intention	1.089	.013	Supported
H1b	Subjective Norms → Behavioral Intention	-.833	.202	Not Supported
H1c	Perceived Behavior Control → Behavioral Intention	.455	***	Supported
H2	Behavioral Intention → Financial Inclusion	.796	***	Supported

TABLE 6: Results of Hypotheses Testing

The hypotheses testing results in table 6 reveal insightful relationships between the constructs under study. The effect of Attitude (AU) on Behavioral Intention (BI) (H1a) is significant and supported, as indicated by a path estimate of 1.089 and a P-value of 0.013. However, the relationship between Subjective Norms (SN) and Behavioral Intention (BI) (H1b) is not supported, with a path estimate of -0.833 and a P-value of 0.202, implying that social pressures may not strongly influence behavioral intentions in this context. The hypothesis H1c, which posits that Perceived Behavioral Control (PBC) affects Behavioral Intention (BI), is strongly supported with a path estimate of 0.455 and a highly significant P-value (P < 0.001). Additionally, the influence of Behavioral Intention (BI) on Financial Inclusion (FI) (H2) is also significant and supported, with a path estimate of 0.796 and a highly significant P-value (P < 0.001).

6.4. Mediation Analysis

This research has used mediation analysis to examine the role of trust in converting behavioral intentions of the individuals into financial inclusion. Two steps were followed to examine the mediating effect as recommended by (Baron & Kenny, 1986). The first stage involves investigation of the proposed model without the use of trust as a mediator and results show that behavioral intention had a positive and substantial total effect on financial inclusion (c = 0.829, p = 0.004) as shown in table 8. The model was run again in the second stage using trust as a mediator and direct effect was calculated (c' = 0.648, p = 0.004) as shown in table 9. The two-tailed significance of total, direct and indirect effects of 500 bootstrap samples were computed.

TABLE 7: Regression Weights: (Group number 1 - Default model)

			Path Estimate	P- Value
TU	<---	BI	.780	***
FI	<---	BI	.621	***
FI	<---	TU	.223	.001

TABLE 8: Standardized Total Effects (Group number 1 - Default model)

	BI	TRUST
TRUST	.796	.000
FI	**.829**	.228

TABLE 9: Standardized Direct Effects (Group number 1 - Default model)

	BI	TRUST
TRUST	.796	.000
FI	**.648**	.228

TABLE 10: Standardized Indirect Effects (Group number 1 - Default model)

	BI	TRUST
TRUST	.000	.000
FI	**.181**	.000

Based on the tables above, it can be inferred that while the overall influence of BI on FI has a standardized value of 0.829, this impact is lowered to 0.648 when trust is present as a mediator. According to Table 9, there is 0.181 mediation by trust. Thus, we can accept H3.

TABLE 11: Result of Mediation Analysis

Hypothesis	Structural Path	Path Estimate	P-values	Result
H3	Behavioral Intention → Trust → Financial Inclusion	0.648	0.004	Supported

7. DISCUSSIONS

7.1. Results

Digital payment systems have had a major impact on boosting financial inclusion in India. They have made it easier for people who didn't have access to banks before to use financial services that are easily accessible, inexpensive, and secure. India has a lot of people and many different social and economic groups. The country has made big steps towards getting more people into the financial system. This progress is because more people are using digital platforms to make payments. This study offers significant insights into the factors influencing financial inclusion, particularly the roles of attitude, subjective norms, perceived behavioral control, behavioral intention, and trust.

Hypothesis H1a, which postulated that attitude positively influences behavioral intention, was supported (β=1.089, p=0.013) This highlights the critical role of positive perceptions toward digital payment services in shaping the intention to use them. A favorable attitude reflects a strong belief in the benefits, accessibility, and convenience of financial products, which can significantly impact users' willingness to adopt them. Previous studies, such as those by (Ajzen, 1991) and (Fishbein and Ajzen, 2010), have consistently demonstrated that attitudes are strong predictors of intention, reinforcing the relevance of this construct in the current study.

In contrast, H1b, examining the influence of subjective norms on behavioral intention, was not supported (β=−0.833, p=0.202). This suggests that social pressures, such as family or peer expectations, do not significantly motivate individuals to engage with digital payment options in this context. This finding diverges from the Theory of Planned Behavior's original proposition but aligns with research suggesting that in emerging markets, financial behavior may be driven more by personal confidence and experiential factors than by societal expectations (Abrahamse & Steg, 2011). Moreover, the rapid digitalization of financial services may reduce the relevance of traditional social influences, as individuals increasingly rely on personalized financial literacy or institutional trust over peer recommendations. H1c, which examined the impact of perceived behavioral control (PBC) on behavioral intention, was strongly supported (β=0.455, p<0.001). This indicates that individuals' belief in their ability to access and effectively use digital payment services significantly drives their intention to adopt them. As (Taylor and Todd, 1995) suggested, PBC reflects not only self-efficacy but also the availability of resources, such as smartphones, internet access, and institutional support. This is particularly relevant in emerging markets, where resource accessibility plays a pivotal role in fostering financial inclusion.

The results for H2, which found that behavioral intention significantly influences financial inclusion (β=0.796, p<0.001), highlight the importance of strong user intention in driving the adoption of digital payment services. This aligns with the Theory of Planned Behavior, which posits that intention is the most immediate antecedent to behavior (Ajzen, 1991). Furthermore, empirical evidence from studies in developing economies has consistently demonstrated that individuals with a clear intent to use digital payment are more likely to take proactive steps toward inclusion (George et al., 2021). Finally, H3, which investigated the mediating role of trust in the relationship between behavioral intention and financial inclusion, was supported (β=0.648, p=0.004). This underscores the significance of trust as a mediating factor between behavioral intention to use digital payment services and financial inclusion. Trust has been widely recognized as a prerequisite for adopting digital payment services, particularly in contexts where institutions historically lacked reliability or transparency (Zhang et al., 2018). As such, this finding supports the argument that trust serves as both a catalyst and a safeguard for financial inclusion, fostering greater engagement with financial services. These findings collectively validate key components of the theoretical framework and contribute to understanding the predictors of financial inclusion through the lens of behavioral intentions.

7.2. Implications

The research broadens the Theory of Planned Behavior. It adds trust as a mediator between behavioral intention and financial inclusion. This shows that financial inclusion has many sides. It also points out how important psychological variables like trust are when people start using digital payment services. The findings suggest policymakers should look at making efforts to build trust, like making sure that banks are clear and responsible in their operations. Companies offering digital payment services need to work on making people feel secure and making sure they can make payment digitally by providing easy-to-use platforms and help for customers. Educational campaigns emphasizing the benefits of financial inclusion can also improve attitudes and perceived behavioral control.

7.3. Limitations and Future Research Direction

The study focused on a single geographic region, limiting the generalizability of the findings. The data may not accurately reflect the varied socioeconomic and cultural environments seen throughout India because it was only gathered from Uttar Pradesh. There may be regional differences in financial practices, infrastructure accessibility, and digital literacy.

Because self-reported survey responses are used, there is a chance that respondents might exaggerate their favorable opinions or intentions regarding digital payment systems, a phenomenon known as social desirability bias. Even if the sample size surpassed the goal, it might not adequately represent the viewpoints of under-represented groups, such women or rural communities with poor internet access, who frequently encounter particular obstacles to financial inclusion in India.

This study gives a basic overview of the elements that influence the adoption of digital payment systems and their significance in financial inclusion in India. However, there is still a lot of room for experimentation and improvement. Future research should broaden the study's geographical scope to include additional states and regions in India, particularly those with differing degrees of digital infrastructure and financial literacy, to see if the results are generalizable. Incorporating other crucial variables, such as financial literacy, perceived risk, or cultural influences, could provide a more complete picture of the barriers and facilitators to financial inclusion. Furthermore, investigating the role of emerging technologies, such as blockchain-based payment systems and artificial intelligence-powered financial tools, may give light on their potential to transform digital payments and inclusion. Cross-country comparisons in similar emerging countries could provide insights into global best practices, whilst sector-specific studies could assess how digital payment uptake differs between urban and rural people, gender, and socioeconomic classes. These potential channels could considerably deepen the conversation about financial inclusion and inspire targeted policy initiatives.

8. CONCLUSION

This study emphasizes the revolutionary potential of digital payment technologies for increasing financial inclusion in India, particularly among marginalized communities. The study uses the Theory of Planned Behavior (TPB) with trust as a mediating variable to provide a detailed understanding of the elements influencing individuals' intentions to use digital payment systems and their eventual influence on financial inclusion. The findings show that attitudes towards digital payments and perceived behavioral control strongly influence people's intentions to utilize these systems, while subjective standards play a more moderate role. Trust appeared as an important mediator, magnifying the impact of behavioral intentions on financial inclusion. These findings highlight the necessity of promoting favorable attitudes, increasing users' perceived control over digital payment technology, and establishing institutional trust in order to achieve widespread adoption. As digital payment systems evolve, efforts to build confidence and resolve consumer concerns are critical to closing the financial gap and guaranteeing inclusive economic growth in India.

APPENDIX A

Constructs	Items	Questions	Sources
Attitude	**AU1**	Digital payment is advantageous in every domain of transactions.	Srivastava and Singh (2022)
	AU2	Digital payment provides convenience, and it is very trendy.	
	AU3	Use of digital payment is the really thrilling and nice experience.	
Subjective Norm	**SN1**	Most people in my social network use eco-friendly products.	Xu et al. (2022)
	SN2	Most people in my social network want me to use more low-polluting products in the future.	
	SN3	Using eco-friendly products is what most people in my social network think I should be doing.	
Perceived Behavior Control	**PBC1**	I know how to buy through mobile payment.	Taylor and Todd (1995)
	PBC2	I feel that buying through mobile payment is not problematic.	
	PBC3	I have enough time to purchase through mobile payment.	
Behavioral Intention	**BI1**	I plan to use Fintech in future.	Venkatesh et al. (2003); Markus et al. (2004); Senyo & Osabutey (2020)
	BI2	I intend to continue to use Fintech frequently.	
	BI3	I expect my use of Fintech tools to continue in the future.	
	BI4	I will always try to use Fintech services for my transactions.	
Trust	**TU1**	I have no trust on safety and reliability features of fintech innovations.	Shaw (2014)
	TU2	I don’t trust that while using fintech innovations my	

Constructs	Items	Questions	Sources
		financial information is secure.	
	TU3	I don't trust that while using fintech innovations my personal information remains safe.	
Financial Inclusion	**FI1**	It is possible to employ fintech to expand access to banking services in India.	Asif et al. (2023) Pennington et al. (2003)
	FI2	I do not find any reason to be cautious while using fintech tools.	
	FI3	Using the Fintech tools is a good idea.	
	FI4	The probability that I would consider using fintech tools in future is high.	

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16

From Plastic to Apps: Growth Trends of Debit Cards, Credit Cards and UPI Payments in India

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ABSTRACT

Digital payments in India have undergone rapid changes in recent years because of technology advancements, smartphone proliferation, improved internet connectivity, government digitalization initiatives, and the growth of e-commerce. India's payment ecosystem is currently experiencing a "Decoupled Era," with new digital solutions beyond traditional bank-linked accounts attracting new competitors and increasing transaction volumes. The purpose of this study is to examine shifting payment preferences in India over 18 months, beginning in January of 2023, focusing on the growth trajectory of credit and debit cards as well as the competitive landscape of prominent e-wallets. Using publicly available data from RBI and NPCI, the study assesses trends across Point-of-Sale transactions, online purchases, and ATM withdrawals to determine user behaviour. While spending behaviour differs significantly between credit and debit cards, particularly in online and point-of-sale settings, ATM withdrawals have little preference between card types. This indicates that other factors may influence user preferences. In addition, UPI-based payments and e-wallets offer unique value propositions that impact transaction growth. Financial institutions, policymakers, and businesses can use these findings to adapt to changing consumer preferences to increase financial inclusion and strategic innovation. This study provides perspectives for enhancing user-centred payment solutions and advancing digital financial engagement in India.

Keywords: Digital Payment, UPI Payments, E-wallet, Market Share of Payment Platforms, Transaction Volume-value Analysis, Credit Cards, Debit Cards, Average spend per transaction.

1. INTRODUCTION

The digital revolution is transforming the global landscape, and one of the most significant changes is occurring in payment and settlement systems. This revolution has transformed business practices and expanded the number of payment services through a variety of options over the past two decades, promoting inclusivity in the process. Each method serves a specific purpose, and consumers choose their preferred payment option based on the value they associate with it in different contexts. India has emerged as a leader in the global revolution of real-time payments, primarily driven by the remarkable success of its ubiquitous mobile-app-based Unified Payments Interface (UPI). A combination of Government initiatives supported by the Banking regulator Reserve Bank of India (RBI) through policy and regulatory reforms, an increase in internet and smartphone usage, and the rise of e-commerce have led to significant growth in India's digital payments ecosystem. Many private players are contributing to this growth by providing various digital payment services, such as mobile wallets, UPI, and Quick Response (QR code-based) payments. Globally, digital payment adoption is influenced by banking access, technological progress, economic formalization, and a younger population. (IBEF Aug 24 report) As of 2023, India has the highest position in real-time payments (RTP), with transaction volumes nearly ten times higher than those of China. Statistical portal Statista (Raynor de Best, May 2024) supports with data that India's real-time payment transactions exceed the combined totals of 43 other countries, illustrating its dominance in this space (Inder Pal Singh Sethi, Oct 24). The advancements in UPI have set a precedent for different nations, demonstrating how innovative payment solutions can significantly transform the financial landscape.

The growth of India’s payments industry and its potential for rapid development are alluring. An RBI publication dated July 24 reports, based on data collected from 19 banks for credit cards and 29 banks for debit cards, that over the last nine years, credit cards issued by banks grew by 10 to 30%, with some banks reporting over 40% growth, which indicates rapid customer adoption. The growth in the debit card segment hovered in the range of 0-20% across banks, partly due to the large number of existing users reflecting the base effect. Recent trends indicate that credit card transactions have become increasingly popular, especially in e-commerce. Contactless transactions at physical stores have also seen widespread adoption, boosting the frequency of low-value transactions. Debit card transactions dropped in FY23-24, with a 33% decline in volume and 18% in value due to shifting preferences towards UPI’s ease and zero Merchant Discount Rate for merchants, alongside limited debit card rewards (PwC, 2024-2029). With the rise of digital payments, the cash-to-card ratio (ATM withdrawals vs. card

payments) has decreased, signalling a shift towards more cashless transactions. (RBI, July 24)

Could we be entering a new era of payments? As per McKinsey's 2023 Global Payments Report, payments have evolved through distinct phases, starting with paper payments, then moving to plastic with credit cards, and then to digital platforms with seamless transactions without physical cards in the Account Era. In each phase, old payment methods declined as newer technologies took over, reshaping how payments are processed. Currently, with the Decoupled Era on the brink, payment systems are becoming increasingly independent of traditional accounts. Innovations like generative AI and Platform as a Service (PaaS) promise increased convenience, security, and personalization. (McKinsey Global 2023 Payments Report)

The future of digital payments in India looks promising, with expected growth across all methods driven by advancements in financial technology, government support, and increasing consumer acceptance. As digital payment systems become more integrated into everyday transactions, UPI is becoming a dominant force due to its convenience and security, although the amount of debit and credit cards is increasing. This study aims to examine payment preferences, particularly the growth of credit and debit cards and the competitive nature of e-wallets, by examining the national-level databases from January 2023 to August 2024.

2. REVIEW OF LITERATURE

The payment system allows funds to be transferred from one account to another or through cash transactions between payers and beneficiaries. Nilekani et al. (2019) describe digital payments as transactions in which both the sender and receiver rely on digital platforms, which is an important step toward financial inclusion and economic progress. The Indian payment system can be divided into two main types:

- Funds Transfer Payments for the transfer of funds between accounts
- Merchant Payment Systems provides payment for goods and services.

Debit cards, credit cards and Prepaid Payment Instruments constitute a significant share of the payment instruments available in India for merchant payments. Debit cards simplify everyday transactions easier by directly transferring funds from your account. It is popular among middle-class consumers since they increase spending power (Tripathy, 2006). A credit card is a payment card issued by a bank or financial services provider that allows customers to make transactions without using cash by borrowing funds from the issuer. Customers can defer payments, which helps with short-term cash flow issues. Recently, credit card usage has grown, spurred by innovative offerings like virtual and biometric cards. (Bertaut & Haliassos, 2006)

Although card networks can be used for funds transfer, they primarily function as merchant payment systems because they use a three or four-party settlement system. UPI is one of the most widely used funds transfer systems in India, as it provides convenient, simple, and real-time confirmation, making it a popular choice for daily transactions.

In 2015, the Government of India launched a flagship programme called 'Digital India' to transform India into a "Faceless, Paperless, Cashless" economy. In India, digital payment systems play an important role in driving economic growth by facilitating higher consumer spending, financial inclusion, and economic integration. UPI's contribution to financial awareness and accessibility among marginalized people demonstrates its impact on diversity. Furthermore, the Pradhan Mantri Jan Dhan Yojana project supports this goal by encouraging bank account access and digital payments, particularly among rural and low-income communities (Mukaria, 2020; Ferra, 2023; and Rastogi et al., 2021).

Subsequent research revealed the tremendous growth of online payment platforms and digital literacy, particularly during the COVID-19 pandemic, which significantly increased transaction volumes across digital channels (Rabidas, 2022). These trends mark a clear shift towards a cashless economy supported by diverse, accessible digital payment options. These include Unified Payments Interface, Immediate Payment Service, Real-Time Gross Settlement, Electronic Clearance Service, National Electronic Funds Transfer, National Automated Clearing House, Aadhaar Enabled Payment System, internet banking, mobile wallets, Bharat QR, and card-based payments like debit and credit cards. (PwC - The Indian Payments Handbook - 2024-2029).

Unified Payment Interface (UPI), launched by NPCI in 2016, revolutionized real-time interbank payments, allowing users to make instant transactions through mobile applications. Its popularity stems from its zero-cost structure, convenience, and real-time capabilities, making it an important driver of India's digital economy. Payments using QR codes, phone numbers, or IFSC have driven its popularity in both peer-to-peer and peer-to-merchant transactions, indicating a move to a cashless economy (Gochhwal, 2017; NPCI, 2022; Dewangan, 2024; Mahesh & S., 2022). While the Government-backed Bharat Interface for Money (BHIM) app serves as the official UPI app with a straightforward and secure design, third-party apps like Google Pay, PhonePe, and Paytm offer UPI capabilities with additional features to enhance user engagement and loyalty. The table 1 compares the distinct characteristics of the government-operated UPI app and private third-party UPI apps across various aspects, including ownership, primary purpose, security protocols, user demographics, and availability of wallet functions. Each type of app targets slightly different audiences and provides unique benefits, contributing to the overall growth and diversification of digital payments in India.

TABLE 1: Comparison of distinct characteristics of the government-operated UPI app and private third-party UPI apps

Aspect	Government UPI App (BHIM)	Third-Party UPI Apps (Google Pay, PhonePe, Paytm, etc.)
Ownership and Governance	Developed and operated by the National Payments Corporation of India (NPCI) under the Government of India.	Owned and managed by private companies like Google, Paytm, Amazon, etc., with integration via NPCI's UPI infrastructure.
Primary Purpose	Focused on providing a basic, secure, and accessible UPI platform for all Indian citizens, with minimal features beyond payments.	Aims to expand services by offering additional features, rewards, and integrations (e.g., e-commerce, bill payments, rewards) to engage users and drive loyalty.
Security and Privacy	Enforces strict government guidelines for data security and privacy; minimal data is collected.	Generally, follow NPCI and RBI guidelines, but some third-party apps may collect additional user data for analysis and targeted marketing.
User Demographic	Primarily designed for all Indian citizens; particularly appeals to users seeking a simple, official app without extra features.	Appeals to tech-savvy, urban users who are interested in additional services, rewards, and a more personalized app experience.
Availability of Wallet Feature	No wallet feature: transactions occur directly from bank accounts via UPI.	Many third-party apps (e.g., Paytm, Amazon Pay) offer an in-app wallet in addition to UPI, allowing users to store funds separately and pay even without direct bank involvement, along with unique limits and features.
Loan and Credit Facilities	BHIM does not offer loan or credit facilities, focusing solely on enabling secure and straightforward payments.	Many third-party apps (e.g., Paytm, PhonePe, and Cred) offer micro-loans, credit options, and "buy now, pay later" services, giving users access to short-term credit options directly through the app.

According to RBI data, public sector banks are the primary issuers of debit cards, while private banks lead in credit card issuing. State Bank of India controls the ATM infrastructure, while HDFC Bank leads in POS terminals and credit card transactions. RuPay, launched by NPCI in 2012, has greatly increased domestic debit and credit card transactions while decreasing transaction costs (Karunakaran, Shibu, & Devasia, 2021; S., Dash, Chadha, & Nankani, 2019).

The ease of online shopping and benefits like cashback, rewards, and "buy now, pay later" have driven credit card adoption among India's growing middle class (Statista Research Department, 2021). In May 2024, India recorded over 513 million ATM withdrawals and 298 million POS transactions via debit card (Keelery, 2024). Although credit cards represent just one in nine cards, they generate 85% of card-related revenues. Increased card use has contributed an estimated $1.5 billion to India's GDP (Monis & Pai, 2023). However, card payment shares are decreasing amid the rise of UPI (Karunakaran et al., 2021).

Despite these advances, challenges persist. According to Karunakaran et al. (2021), while digital payments have increased, the popularity of UPI and mobile wallets has resulted in a decrease in card transactions as a percentage of retail electronic payments. Furthermore, barriers such as cybersecurity concern, the requirement for financial literacy, and the digital divide, particularly among rural communities, continue to impede digital payment implementation (Sawant, 2023).

3. RESEARCH GAP

Current payment technologies are considered secure and user-friendly, enjoying widespread acceptance. As these trends continue to evolve, we can expect their full potential to be realized, further shaping the future of digital transactions. Although extensive research has been conducted on the adoption and use of digital payments, it is vital to understand how credit and debit cards compare in terms of growth dynamics. Existing studies have focused on aggregate trends, but a granular analysis of month-on-month growth rates for specific types of transaction may reveal valuable information. Despite the significant advancements in UPI adoption, there remains a research gap concerning user-specific preferences for different applications. Understanding these preferences is crucial for stakeholders aiming to enhance their competitive positioning in the market. To inform targeted marketing strategies and product development initiatives, it is essential to investigate transaction data across various UPI apps.

This paper aims to explore the changing dynamics of payment preferences in India focusing primarily on the comparative growth of credit cards relative to debit cards. Additionally, it will examine the competitive landscape among the prominent e-wallets, assessing their transaction growth. By analysing disaggregated data across various payment methods, this study seeks to provide a comprehensive understanding of their growth trajectories and performance.

4. OBJECTIVE OF THE STUDY

1. To evaluate the growth of credit and debit card usage in India at a granular level.
2. To assess the competitive dynamics among leading e-wallets.

Null hypothesis 1: The medians of the growth rates in terms of volume across the 6 categories of transactions for both the card-based payments are equal for the chosen period.

Null hypothesis 2: The medians of the growth rates in terms of value across the 6 categories of transactions for both the card-based payments are equal for the chosen period.

Null Hypothesis 3 The average spending across the different third-party UPI apps (PhonePe, Google Pay, Paytm, Cred, Amazon Pay, and BHIM) is equal for the chosen period.

5. METHODOLOGY

The research employs a quantitative methodology to analyse the growth trends of digital payments in the Cards category, focusing on three primary categories of transactions:

- Online spending,
- Point of Sale (POS) transactions and
- ATM cash withdrawals.

This approach allows for a systematic examination of the month-on-month growth rates in both transaction volume and value across card-based payment methods. Additionally, the study will assess the transaction volumes of leading e-wallet applications to understand their competitive positioning in the digital payments landscape. Monthly data for volume and value of Card/UPI transactions presented in monthly handles were drawn from the following sources and consolidated for the study:

- NPCI Data: This typically includes details related to digital payments, transaction volumes, and usage trends across various payment systems.
- RBI Data: RBI offers extensive datasets on banking statistics, financial markets, monetary policy, payment systems, and financial inclusion metrics.

Period considered for analysis: January 2023 to August 2024.

6. GROWTH RATES ANALYSIS IN PAYMENT METHODS

The study is divided into four sections, designated as A, B, C, and D, focusing on distinct comparisons:

A. Comparison of annual growth rates of credit card, debit cards and UPI

Tables 2a and 2b present transaction figures for three chosen digital payment methods—Credit Cards, Debit Cards, and UPI—for the years 2018-19 to 2023-24. The Compound Annual Growth Rate (CAGR) over these five years shows that transaction volume grew by 15.1% for Credit Cards, declined by 12.33% for Debit Cards, and surged by 89.32% for UPI. In terms of the transaction value, the CAGR shows that Credit Cards posted a growth of 24.86%, Debit Cards posted a slight decline of 0.1%, and UPI recorded robust improvement of 86.9%. These findings highlight the significant growth in UPI transactions, both in volume and value (89 and 86%), while Credit Cards demonstrate robust growth in both metrics and Debit Cards demonstrate a decline in volume and minimal change in value.

TABLE 2a: Transactions through Credit / Debit cards and UPI- Volume (lakh)

	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	CAGR
4.1 Credit Cards	17,626	21,773	17,641	22,399	29,145	35,610	15.1%
4.2 Debit Cards	44,143	50,611	40,200	39,384	34,179	22,860	-12.33 %
2.7 UPI	53,915	1,25,186	2,23,307	4,59,561	8,37,144	13,11,295	89.32 %

TABLE 2b: Transactions through Credit / Debit cards and UPI- Value (Rs Crore)

	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	CAGR
4.1 Credit Cards	6.03	7.31	6.3	9.7	14.3	18.3	24.86 %
4.2 Debit Cards	5.93	7.04	6.63	7.3	7.2	5.9	-0.1%.
2.7 UPI	8.77	21.32	41.04	84.2	139.1	200	86.9%

Source: RBI 4.1,4.2 ,2.7 represent name codes in RBI Tables

Building on the analysis of transaction figures and growth rates for digital payment methods, the next section will focus on calculating month-on-month growth rates for online spending, Point of Sale (POS) transactions and ATM cash withdrawals. This will allow us to further investigate the growth of credit cards in relation to debit cards, providing a more detailed understanding of their performance in the current market.

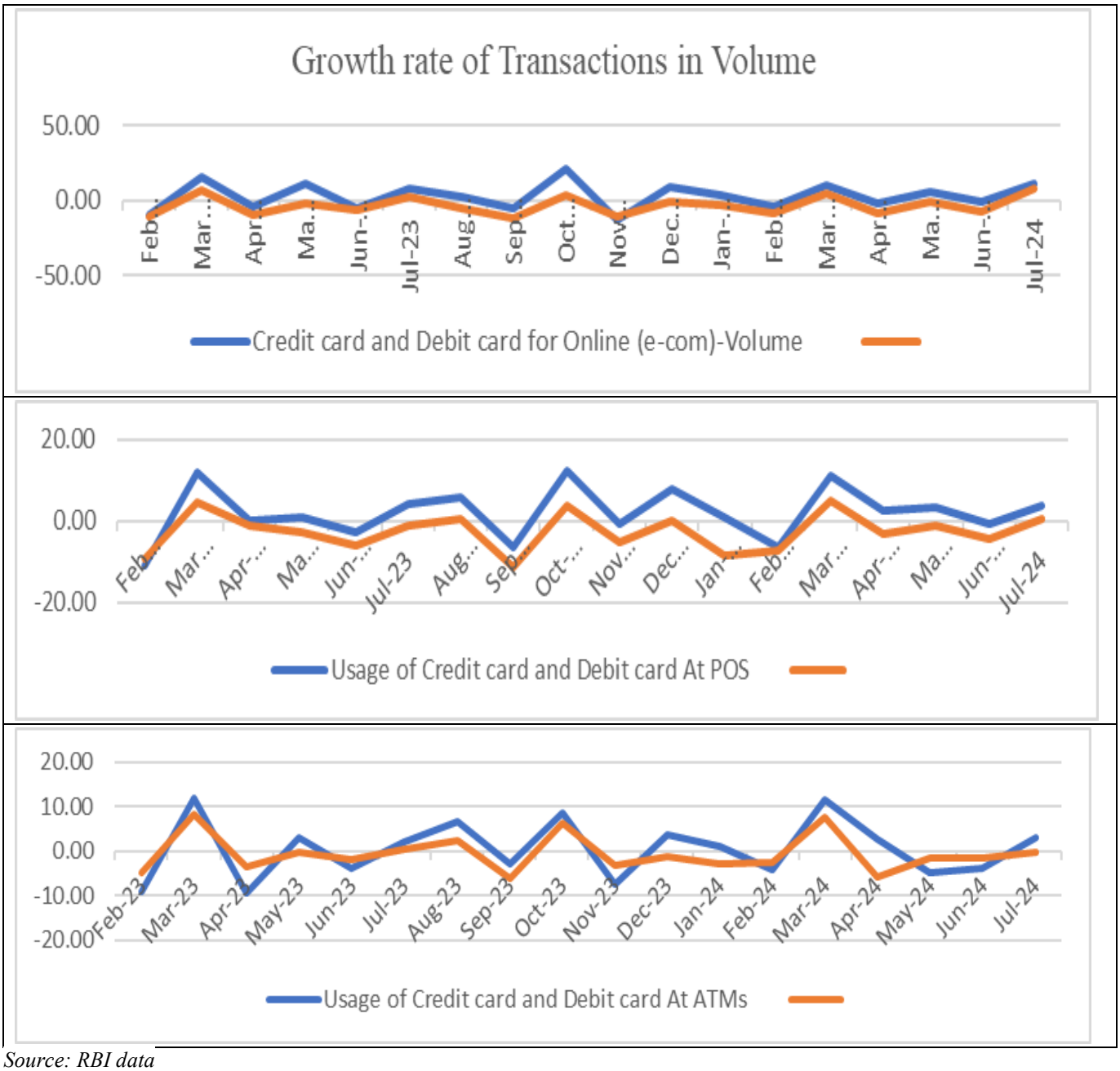
B. Comparison of growth rates of credit card and debit cards in 3 categories of transactions

The RBI publishes Bank-wise ATM, Acceptance Infrastructure, and Card Statistics monthly. We used the last row of the table, which captures the total number of transactions (volume in actuals) and the total value of transactions (in Rs '000), for the selected 18-month period. We then calculated the month-on-month growth rates for each of the six categories.

For visual representation, the monthly growth rates in volume of transactions from January 2023 to July 2024 across various categories are shown below in chart 1. The most notable growth rate for credit card-based transactions

occurred in the month of September 2023, with 21.64% for online spending and 12% for payments at POS terminals, it is reflected in October in the chart. Online shopping is widely growing as the first choice for consumers. It can be a major factor in credit card use as credit is an easy payment option. A declining trend has been observed in the usage of debit cards at Point of Sale (POS), with month-on-month growth rates recorded at (-)11.36% in August-September 23.

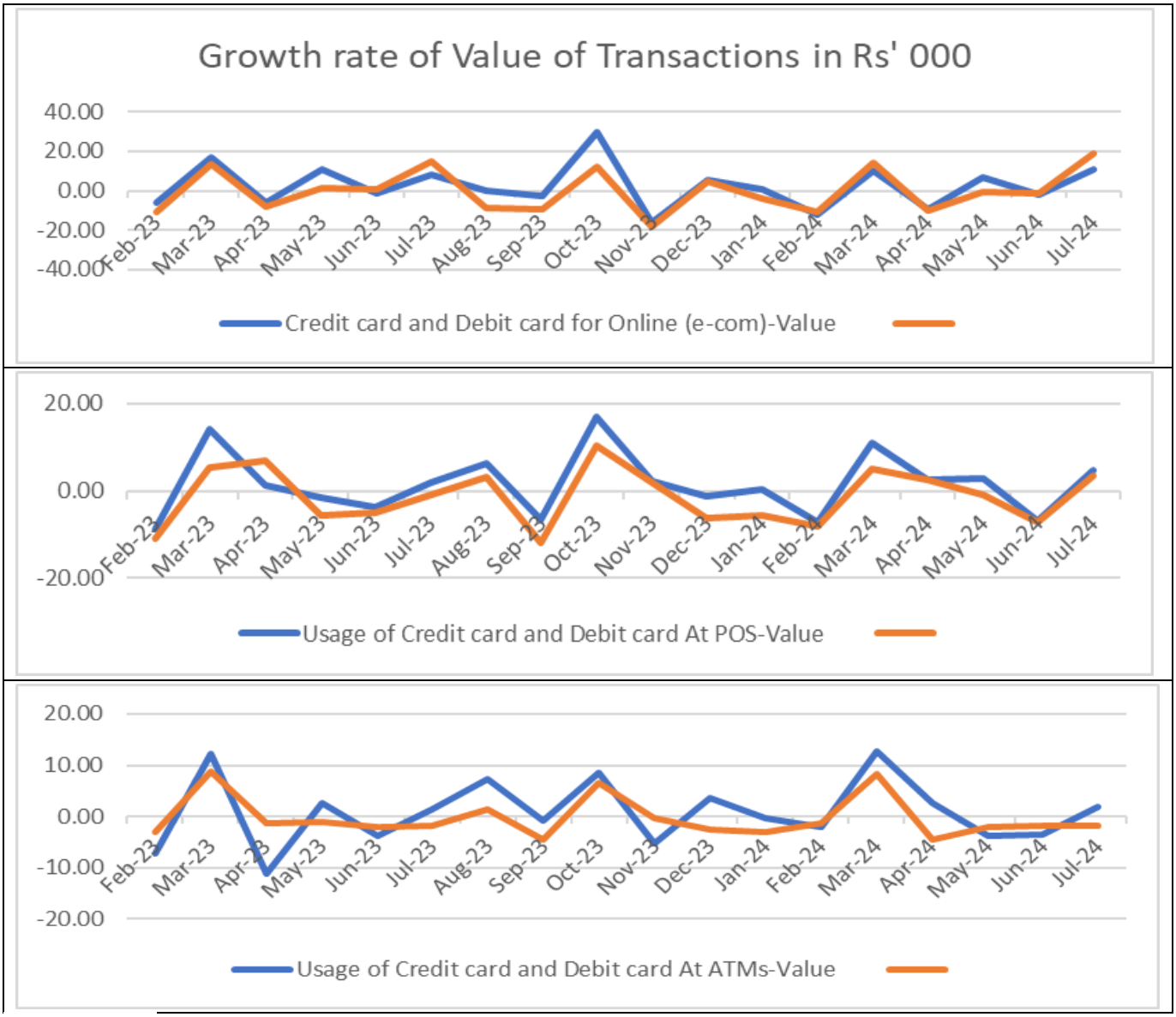
Chart 1: Growth rate of transactions in volume for both cards across 3 categories



Source: RBI data

The following chart 2 illustrates the monthly increase in the value of transactions (in Rs'000) from January 2023 to July 2024 across various categories. Unlike transaction volume, which reflects the number of transactions, the value represents the total monetary amount processed. The most notable growth rate for credit card-based transactions occurred in the month of September 2023, with 30% for online spending and 16.86% for payments at POS terminals, it is reflected in October23 in the chart. Growth rates in terms of value are almost similar.

Chart 2: Growth rate of transactions in Value for cards across 3 categories: card-wise



Source:RBI data

C. Comparing Growth Rates across 6 categories of Card-Based Payment Transactions

Null hypothesis 1: The medians of the growth rates in terms of volume across the 6 categories of transactions for both the card-based payments are equal.

Null hypothesis 2: The medians of the growth rates in terms of value across the 6 categories of transactions for both the card-based payments are equal.

Table 3 below presents the mean ranks for six categories of transactions, based on volume and value, using the Kruskal-Wallis test.

TABLE 3: Mean ranks for 6 categories of transactions: volume

	Category	Mean Rank	Kruskal Wallis test results
Growth_rate_volume	Credit card for Online (e-commerce)	65.97	Chi-Square =11.315 df 5 Asymp. **Sig.= .045**
	Credit card at POS	67.61	
	Credit card for Cash withdrawal	58.5	
	Debit card for Online	39.89	

	Category	Mean Rank	Kruskal Wallis test results
	(e-commerce)		
	Debit card at POS	44.97	
	Debit card for Cash withdrawal	53.61	
Growth_rate_value	Credit card for Online (e-commerce)	59.22	Chi-Square= 2.104 df 5 Asymp. Sig. .835
	Credit card at POS	59.78	
	Credit card for Cash withdrawal	57.31	
	Debit card for Online (e-commerce)	50.89	
	Debit card at POS	49.08	
	Debit card for Cash withdrawal	50.72	

From the table, it can be inferred that the calculated value of the Kruskal-Wallis test ($\chi^2 = 11.315$; $p < 0.05$; $df = 5$) is statistically significant at the 5% significance level ($\alpha = 0.05$) for transaction volume. This indicates that there are significant differences in the growth rates of transaction volume across the six categories, hence, null hypothesis 1 is rejected, in contrast, the results for transaction value are not statistically significant, suggesting that there are no meaningful differences in growth rates for value among the categories. This distinction highlights that while category-specific factors may influence volume, value does not show the same level of variability.

Next, we will examine each of the 3 categories within both the cards, to compare the category-wise difference in growth performance for the study Period using the Mann-Whitney U test. The detailed picture is given in Table 4.

TABLE 4: Comparison of mean ranks of card-wise growth rates in 3 categories of transactions

Growth rate		Mean rank –Credit card/debit card	Mann-Whitney U	Test Statistic
Growth_rate_volume	Online e-com)	22.44 /14.56	91.00 @Z=-2.246	**0.025**
	POS	23.39 /14.84	92.00@Z=-2.401	**0.016**
	Cash withdrawal	19.28/17.22	148@Z=-0.443	0.658
Growth_rate_value	Online (e-com)	19.44/17/56	145@Z=-0.538	0.606
	POS	20.5/17.58	144@Z=-0.820	0.425
	Cash withdrawal	19.61/17.39	142@Z=-.633	0.542

A category-wise comparison was performed using the Mann-Whitney U test for both debit and credit cards. The analysis revealed the following:

Online Transactions: There is a significant difference in the month-on-month growth rate of the volume of transactions for online transactions at the 2.5% significance level.

POS Transactions: There is also a significant difference in the month-on-month growth rate of the volume of transactions for point-of-sale (POS) transactions at the 1% significance level.

Cash Withdrawals: However, no significant difference was found in the month-on-month growth rate for cash withdrawals when using debit cards versus credit cards.

This indicates that growth rates differ significantly for online and POS transactions, but not for cash withdrawals across debit and credit cards.

There is no statistical evidence of a significant difference in the growth rate of the value of transactions across the 6 categories of digital payments.

D. Comparison of growth rates of APP-based transactions

The Unified Payments Interface (UPI) system in India has been highly successful, with several major apps offering a variety of services to meet users' financial needs. From established players like Google Pay and PhonePe to newer, specialized apps like Cred, each UPI app brings unique features tailored to different segments of users. Table 5 provides a comprehensive overview of popular UPI apps such as Google Pay, PhonePe, Paytm, Cred, Amazon Pay, and Government-backed BHIM, analysing their capabilities,

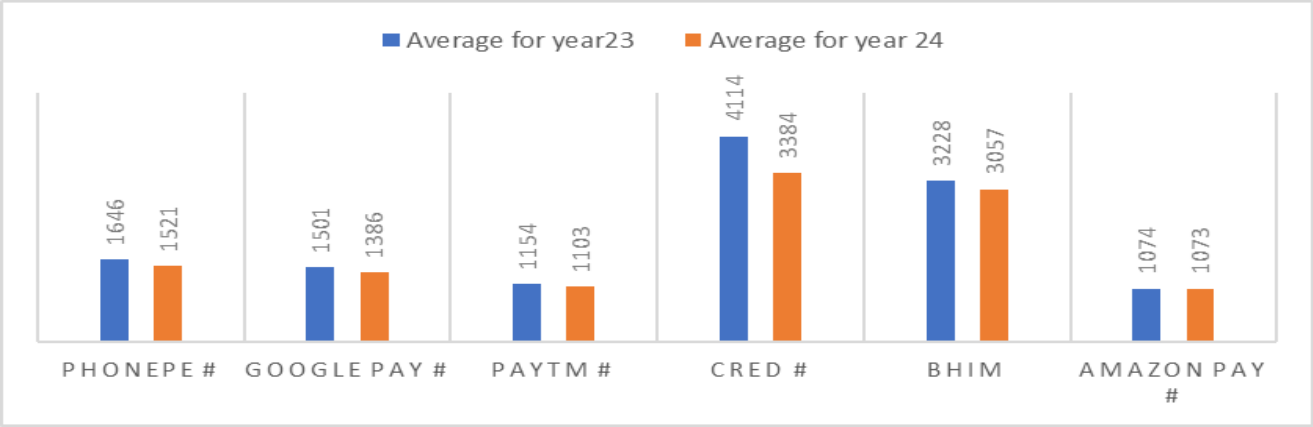
user base, rewards, and unique offerings. While all these apps support basic UPI transactions, additional features like digital wallets, credit facilities, bill payment options, and rewards programs vary.

TABLE 5: Comprehensive overview of popular UPI apps in India considered for study

Feature	Google Pay	Phone Pe	Paytm	Cred	Amazon Pay	BHIM
Direct UPI Payments	Yes	Yes	Yes	Limited	Yes	Yes
Digital Wallet	No	Yes	Yes	No	Yes	No
Credit Facilities	Limited	Yes	Yes	Yes	Yes	No
Bill Payments	Yes	Yes	Yes	Yes	Yes	Yes
Rewards	Yes	Yes	Yes	Yes	Yes	No
User Base and Market Presence	Large base across India,	Extensive user base	Popular across merchants, users, and e-commerce	Urban, high-credit-score users with credit card focus	Amazon-user centric,	Government-backed, known for simplicity
Promotions and Rewards	Seasonal events and game-based rewards	Regular cashback on recharges, bills	Extensive cashback on various services;	High-value discounts for members on lifestyle brands	Rewards & frequent discounts for Prime members	No promotional campaigns; serves as government app

NPCI publishes monthly statistics for UPI app transactions. Since these apps are often used for even the smallest payments, it is ideal to evaluate the average spending, which is calculated by dividing the total amount of online transactions by the total number of online transactions over the same period. Following UPI apps are considered for study: PhonePe, Google Pay, Paytm, Cred, Amazon Pay, and BHIM. The average spend data is segmented into two periods: from January 2023 to December 2023 and from January 2024 to August 2024. Chart 3 compares average spending for the 6 payment Apps for the 20 months.

Chart 3: Average Spend rate in Rs for the UPI Apps chosen for study



Source: NPCI archives on monthly Transactions under UPI ecosystem

Notably, PhonePe# exhibits a significantly higher average spend compared to Google Pay# and Paytm shows a much lower rate. Interestingly, Cred# has a higher transaction value, attributed to its personalized spending insights and reward points that encourage responsible credit behaviour. BHIM, developed by NPCI, offers a unique feature allowing users to make payments using their Aadhar number. Additionally, its UPI ID format (mobile number@upi) is designed for easy recall.

Null Hypothesis: The average spends across the different third-party UPI apps (PhonePe, Google Pay, Paytm, Cred, Amazon Pay, and BHIM) is equal for the period from January 2023 to August 2024.

The average spending for the 20 months from January 2023 to August 2024 was calculated and analysed for significant differences presented in Table 6.

TABLE 6: Mean ranking and average spend rate for the Top 6 UPI apps

	UPI APP	Mean Rank	Average Spend for 20 months in Rs	Kruskal Wallis test results
1.	Phonepe#	68.28	1596	Chi-Square=110.730 df 5 Asymp. Sig.=.000
2.	Google Pay#	53.08	1455	
3.	Paytm#	27.10	1133	
4.	Cred#	108.20	3822	
5.	Amazon Pay#	13.90	1073	
6.	BHIM	92.45	3160	
	Total			

7. MEAN RANKS:

- Cred (108.20) and BHIM (92.45) have the highest mean ranks, suggesting that users of these apps have significantly higher average spending compared to the other apps.
- PhonePe (68.28) and Google Pay (53.08) fall in the middle range.
- Paytm (27.10) and Amazon Pay (13.90) have the lowest mean ranks, indicating lower average spending compared to the others.

8. AVERAGE SPENDING (IN RS):

Cred has the highest average spending rate (Rs 3,822), followed by BHIM (Rs 3,160).

PhonePe (Rs 1,596) and Google Pay (Rs 1,455) show moderate average spending.

Paytm (Rs 1,133) and Amazon Pay (Rs 1,073) have the lowest average spending rates.

9. HYPOTHESIS TEST RESULTS:

The Kruskal-Wallis test was conducted to examine differences in average spending across six third-party UPI apps (PhonePe, Google Pay, Paytm, Cred, Amazon Pay, and BHIM) for the chosen period. Since the p-value is less than 0.05 ($p < 0.05$), the null hypothesis is rejected. A statistically significant difference in the average spending across the six UPI apps is proved.

10. FINDINGS

Are Indian consumers genuinely shifting towards credit cards?

- The Compound Annual Growth Rate (CAGR) analysis over 5 years reveals notable trends:
- The growth rate of credit card usage has increased by 15% in terms of the number of transactions.
- In terms of the amount spent, credit cards have shown a robust increase of 24%. These figures suggest a growing preference for credit cards among Indian consumers, both in terms of usage frequency and spending volume.
- Debit card usage has declined significantly, with a -12% drop in transaction volume.
- The amount spent through debit cards has also slightly declined by -0.1%. This indicates a shift away from debit card usage, both in terms of the number of transactions and total spending.
- UPI transactions have witnessed the highest growth, with a remarkable CAGR of 86%. This highlights the rapid adoption of UPI as a preferred mode of payment, overtaking both debit and credit cards in terms of transaction growth.
- There are significant differences in the growth rates of transaction quantum across the six categories of digital payments. Credit card and debit card usage for e-commerce, payment at terminals and withdrawal at ATM. This implies that some categories are growing much faster or slower than others in terms of the number of transactions being processed.
- In contrast, the growth rates for the total value of transactions (monetary amounts) are not significantly different among the categories. This suggests that while the number of transactions may differ across categories, the total amounts spent (or transferred) are growing at similar rates across the six categories.
- A statistically significant difference in average spending across the six UPI apps. Phonepe has the highest share compared to Google pay more commonly used for smaller everyday purchases, while Cred may be used for higher-value transactions. Government backed BHIM

app also shows higher average spending, while the remaining apps have lower averages, reflecting varied user behaviour and spending patterns across these platforms.The choice of app may be influenced by demographics such as age, profession, and socioeconomic status and how users interact with these apps. Younger demographics are more likely to use Cred because of its higher rewards and user-friendly interface, while older demographics prefer established platforms like PhonePe or Google Pay.

The evidence suggests otherwise; instead, debit cards are being increasingly supplanted by the Unified Payments Interface (UPI), which has transformed the digital payments landscape. UPI enables both individuals and businesses to conduct transactions seamlessly and securely. This shift has instigated a significant behavioural change among the Indian population, as even small and microtransactions—such as purchasing a cup of tea for ₹20 or a bag of fresh vegetables for ₹200—are now frequently executed through digital payment methods. UPI's rapid growth and technological advancements have revolutionized the digital payments landscape in India, making it an exemplary model for other nations looking to enhance their payment systems.

11. IMPLICATIONS

There has been significant progress in India's adoption of various aspects of digital financial infrastructure, with private-sector innovations accompanied by public initiatives. There is clear evidence that Indians are now embracing credit cards. The rise of the Unified Payments Interface (UPI) has undeniably impacted debit card usage in India, but the concurrent growth of the credit card ecosystem underscores a significant shift in consumer behaviour. As more consumers recognize the benefits and conveniences offered by credit cards, it will be essential for financial institutions to adapt and cater to these evolving preferences. With increasing comfort around card payments, banks are coming up with features such as EMI options on debit cards that will appeal to those who seek flexible payment methods but are cautious about using credit cards, providing a middle ground between convenience and credit access. UPI is already integrated with several other payment systems, such as credit cards and debit cards. In the future, UPI is likely to become even more integrated with other payment systems, making it easier for people to use UPI to pay for goods and services across a wider range of merchants. Innovation in the debit card space must happen to position the ecosystem for a significant transformation. With rising customer expectations and issuers seeking scalable, cost-effective solutions, the landscape is primed for change.

12. LIMITATIONS AND FURTHER RESEARCH AGENDA

This analysis primarily examines national-level figures for card-based and select app-based transaction volumes and values. The study analysed Digital payment subcategories at an aggregate level over shorter timeframes, like monthly intervals, provide a clearer picture of their usage trends. While seasonal patterns indicating transaction demand are observed, this study focuses exclusively on banking platforms. Factors such as internet connectivity, inflation, customer preferences, marketing efforts of banks and geographic diversity are beyond the scope of this analysis and have not been included.

13. DECLARATION

I, Dr Surekha Invalli hereby confirm that the manuscript titled "**From plastic to Apps: Growth Trends of Debit Cards, Credit Cards and UPI Payments in India**" authored by Dr Surekha Invalli and Mrs Navya Bhat, has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to International Management Perspective Conference 2025, IIM Sambalpur.

I/we declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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Hybrid Approach to Tax Fraud Detection using Machine Learning

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ABSTRACT

This research investigates the potential of machine learning to revolutionize tax practices. By utilizing advanced algorithms, we aim to improve fraud detection, enhance compliance, and optimize audit selection processes. The rigorous quantitative analysis of real-world tax data enabled the identification of anomalous patterns indicative of potential irregularities. The proposed hybrid model, integrating supervised learning techniques, offers superior performance in fraud detection and risk assessment compared to conventional methods. By prioritizing high- risk taxpayers, tax authorities can optimize resource allocation and streamline audit procedures. However, the reliance on historical data presents limitations in adapting to emerging fraud tactics, necessitating future research into real-time data processing and deep learning methodologies. This study underscores the substantial benefits of machine learning in tax administration, including heightened efficiency, accuracy, and equity. Moreover, it emphasizes the critical importance of ethical considerations in the development and deployment of AI-driven decision-making systems.

Keywords: Machine- Learning, Supervise- Learning, Tax- Auditing, Fraud – Detection, Financial Data

1. INTRODUCTION

The tax audit process has historically relied on manual or rule-based systems which often struggle to cope with the vast volume intricate complexity and diverse nature of modern economic data this dependence presents considerable challenges for tax authorities particularly in the realm of fraud detection where illicit activities frequently remain obscured within ostensibly legitimate financial transactions traditional methodologies predominantly concentrate on the analysis of transaction data overlooking the broader economic and demographic factors that significantly influence tax compliance behavior the intricacies of fraud are further exacerbated by its various manifestations including income under-reporting overstatement of deductions asset concealment and misrepresentation of transactions effective fraud detection necessitates the ability to discern subtle patterns and relationships within extensive dataset's endeavor that conventional auditing techniques often fail to execute proficiently although some automated systems are available there remains a conspicuous lack of integrated data-driven models that incorporate both financial and non-financial variables such as GDP sector contributions business activity levels income distributions and international transactions furthermore many existing models do not provide clear insights or actionable visualizations that could empower policymakers to effectively target specific regions or sectors this research seeks to fill these gaps by proposing a machine learning-based fraud detection model that harnesses a comprehensive array of data to scrutinize fraud risk factors the model not only forecasts the likelihood of fraud but also furnishes a framework for policymakers to interpret complex data through visual analytic the primary aim of this study is to develop and evaluate a machine learning model adept at predicting tax fraud risk based on diverse datasets while also identifying the key factors that drive fraud and offering actionable insights for policymakers to effectively prioritize high-risk areas.

2. LITERATURE REVIEW

Tax Fraud Detection in Past

iHistorically, tax fraud detection relied heavily on manual auditing processes, rule- based systems, and the expertise of tax auditors (Alm,J.&Martinez-Vazzquez(2007). These traditional methods often involved painstaking manual analysis of large datasets, leading to slow, error-prone, and resource-intensive processes. While automated tools like Ben-ford's Law offered some assistance in identifying irregularities in numerical data, their scope was limited and could be easily circumvented by sophisticated fraudsters. Despite their usefulness in certain scenarios, these rule-based systems struggled to adapt to emerging fraud techniques and were ill- equipped to handle the increasing complexity and volume of data.

Machine - Learning in Tax Fraud - Detection

Recent years have witnessed a surge in interest in applying machine learning (ML) to tax fraud detection. ML algorithms excel at analyzing large, complex datasets to identify patterns indicative of fraudulent behavior. Supervised learning models, including decision trees, support vector machines (SVMs), and random forests, have proven effective in various sectors, including tax auditing.

Decision trees and random forests are popular choices for fraud detection due to their interpretability and ability to handle non-linear relationships within data (Breiman, 2001). Random forests, in particular, offer enhanced robustness and predictive accuracy by combining multiple decision trees. Studies by Chan et al. (2014) and Goh et al. (2014) highlight the effectiveness of random forests in uncovering fraudulent activities within financial and tax-related data.

SVMs are another powerful tool for fraud detection, known for their precision in classifying data into distinct categories . However, SVMs may be less interpret-able than decision trees and often require substantial amounts of data to achieve optimal performance. In recent times, neural networks and deep learning models have emerged as promising tools for tax fraud detection. These advanced techniques can identify subtle patterns within taxpayer data, as demonstrated by research conducted by Nevertheless, these models require significant computational resources and large datasets to mitigate the risk of over-fitting.

Data And Features in Tax Fraud -Detection

Despite significant advancements in machine learning techniques for tax fraud detection, several challenges persist in the existing literature. One key limitation is the reliance on a narrow range of features, such as income levels or compliance rates. Tax fraud is a complex issue influenced by a multitude of factors, including business activities, demographic variables, and international transactions. The proposed model aims to address this limitation by integrating a broader spectrum of data, encompassing GDP contributions, sector-specific activities, and historical tax compliance, providing a more holistic approach to fraud detection.

Another challenge lies in the static nature of many existing fraud detection systems. These systems are often built on fixed datasets and lack the ability to adapt to evolving fraud tactics. Slemrod,J.&,Weber,C.(2012)This research seeks to address this issue by developing a dynamic model that can be continuously updated and retrained with new data, ensuring its effectiveness in detecting emerging fraud schemes. While most current models prioritize classification tasks, identifying instances of fraud, the proposed model also emphasizes the importance of descriptive components, such as feature importance analysis. This aspect provides valuable insights into the factors that significantly impact fraud risk, empowering policymakers to make informed decisions and implement targeted enforcement strategies.

By addressing these challenges, this research aims to advance the field of tax fraud detection and contribute to a more effective and equitable tax system.

3. RESEARCH GAP INDENTIFICATION

Tax fraud detection has been an area of significant interest for policymakers and researchers, but several gaps in existing methodologies hinder comprehensive fraud identification. The present model addresses these challenges by bridging critical gaps in prior research and enhancing the accuracy, scalability, and interpret-ability of tax fraud detection systems.One key research gap is the lack of integration of multi- dimensional data. Previous models have primarily focused on a limited set of features,

such as income levels or compliance rates, neglecting factors like regional demographics, sector-specific contributions, and business activities. By incorporating a diverse range of features, such as sector-wise fraud likelihood, demographic impacts, and regional tax contributions, the present model offers a more holistic approach to fraud detection. Another critical gap is the inability of prior models to adapt to evolving fraud tactics. Static, rule-based systems often become obsolete in the face of sophisticated and dynamic fraud schemes. Alm,J.&McKee,M.(1993)The proposed model addresses this limitation by integrating real-time data updates and retraining capabilities, ensuring resilience against emerging fraudulent behaviors.

Furthermore, previous studies have focused heavily on predictive accuracy but paid limited attention to feature interpretability. Policymakers require actionable insights into which factors, such as transaction volumes or compliance history, most influence fraud predictions. This model employs feature importance analysis to provide interpret-able results, empowering policymakers to design targeted interventions.

Additionally, the under-representation of regional and sector-specific insights has been a major limitation in earlier research. Fraud risk varies significantly by region and economic sector, yet most studies lack granularity. The current model utilizes region-specific and sector-specific datasets to offer tailored fraud detection strategies.Lastly, scalability issues in processing large and complex datasets have restricted real-world applicability. The model's use of salable machine learning algorithms, such as random forests, ensures its effectiveness in large-scale tax systems, overcoming computational inefficiencies.

By addressing these research gaps, the proposed model sets a benchmark for robust, interpret able, and adaptable tax fraud detection systems.

4. METHODLOGY

The methodology for the proposed tax fraud detection model is centered around data integration, feature engineering, and machine learning implementation to predict fraudulent activities effectively. The data-set used comprises financial data from five Indian states—Maharashtra, Tamil Nadu, Karnataka, Gujarat, and Uttar Pradesh—for the financial year 2018. The data was sourced from publicly available government repositories, including GDP reports, tax compliance statistics, business activity data, and

demographic records, ensuring authenticity and reliability. The dataset incorporates multiple dimensions such as GDP values (in crore INR), per capita income levels, population sizes, historical tax compliance rates, registered businesses, and overseas transactions, along with sector-wise contributions to GDP (agriculture, industry, and services).

The prediction model uses these features to identify patterns and anomalies that signal fraudulent activities. (The Income Tax Department India ,2005)Key features include GDP per ca pita, which highlights regional economic performance; business activity levels, indicating economic engagement; historical tax compliance rates, reflecting taxpayers' behavioral history; and sector-specific contributions, which offer insights into economic dependencies. Other variables, such as the volume of overseas transactions, were included to capture high-value international dealings often associated with fraud risks. To ensure data quality and model performance, prepossessing steps were undertaken. Missing values were handled through imputation techniques. Features like overseas transactions and business activity were normalized to a common scale. Categorical variables were appropriately encoded to be compatible with machine learning algorithms.

A supervised learning model using a Random Forest Classifier was implemented for fraud detection. (Li,J.,Li.&Yang,.L(2019)This algorithm was selected for its robustness in handling high-dimensional data and its ability to interpret feature importance. Features such as GDP, tax compliance, population, and risk scores were used as predictors, with the binary fraud flag (fraud or no fraud) as the target variable.The data was split into training and testing sets (80:20 ratio). The model was trained on the training set and validated using the test set. Metrics such as accuracy, precision, recall, and the confusion matrix were used to evaluate performance. The results highlighted the effectiveness of the model in identifying high-risk states.

Several visualization techniques, including bar charts, scatter plots, heatmaps, and treemaps, were employed to provide actionable insights to policymakers. Fraud likelihood was analyzed against demographic, economic, and compliance-related factors to understand underlying patterns.The proposed framework allows policymakers to prioritize investigations by focusing on regions and sectors with higher fraud likelihood. By integrating features such as historical compliance trends, overseas transactions, and sectoral contributions, the model offers a holistic approach to tax fraud detection.

The dataset consists of information on five Indian states: Maharashtra, Tamil Nadu, Karnataka, Gujarat, and Uttar Pradesh. For each state, the dataset includes attributes such as GDP, per capita income, business activity, tax compliance rate, population, foreign transactions, and sectoral contributions to GDP. A fraud flag indicates whether the state has been identified as fraudulent.

The dataset consists of information on five Indian states: Maharashtra, Tamil Nadu, Karnataka, Gujarat, and Uttar Pradesh. For each state, the dataset includes attributes such as GDP, per capita income, business activity, tax compliance rate, population, foreign transactions, and sectoral contributions to GDP. A fraud flag indicates whether the state has been identified as fraudulent.

	State_Name	GDP_2018	Income_Level	Business_Activity	\
0	Maharashtra	26327920	1.83	476345	
1	Tamil Nadu	16302080	2.42	434567	
2	Karnataka	15028990	2.21	345678	
3	Gujarat	14000000	1.63	345689	
4	Uttar Pradesh	11088000	1.12	678345	

	Tax_Compliance_Rate	Population	Abroad_Transactions	Agriculture_Sector	\
0	0.75	11.23	77000	12	
1	0.69	7.21	47000	7	
2	0.73	6.11	37000	12	
3	0.77	6.39	40000	18	
4	0.64	19.98	20000	25	

	Industry_Sector	Service_Sector	Fraud
0	25	63	0
1	27	66	0
2	22	55	1
3	34	48	1
4	20	22	1

Figure1 -Datasets of the Financial Year 2018 of the states

By studying the relationships between different attributes, insights can be gained to inform policy decisions and improve tax administration.

5. RESULTS AND FINDINGS

High Risk States and Sector-oral Contributions to Tax Fraud Risk

The proposed model effectively identifies high-risk states and sectors contributing significantly to tax fraud, providing actionable insights for policymakers and tax authorities. (Ministry of Stattistics and Programme Implementation , 2018)Based on the Risk Scores generated, four states—Uttar Pradesh (128.3345), Tamil Nadu (124.8567), Gujarat (102.7689), and Karnataka (101.9678)—were identified as the regions with the highest fraud likelihood. These states were flagged with a binary indicator (1) in the Fraud Prediction column, reflecting their elevated risk levels. Uttar Pradesh emerged as the state with the highest fraud risk score, underscoring the urgent need for targeted interventions in this region.

In addition to regional analysis, the model evaluated the contribution of economic sectors—Agriculture, Industry, and Services—to fraud risks. The findings indicate that the Service Sector consistently contributes the highest to fraud likelihood, with contributions reaching up to 66%, highlighting its vulnerability to fraudulent activities, likely due to the complexity and volume of high-value transactions. The Industry Sector showed a moderate yet variable contribution, ranging from 20% to 55%, indicating compliance inconsistencies across industrial hubs.

Meanwhile, the Agriculture Sector contributed relatively lower, ranging from 7% to 34%, reflecting its smaller role in overall fraud detection. However, its presence in some fraud cases suggests the potential for non-compliance in rural or agrarian economies.These findings underline the model's ability to accurately classify high-risk states and sectors, enabling policymakers to prioritize resources for audits and enforcement. The results also emphasize the importance of focusing on the Service Sector in high-risk regions to curb fraud. This targeted approach allows for optimized allocation of resources, ultimately enhancing compliance and reducing fraud prevalence in the tax system.Slemrod,J.(1996) The results validate the model's capability to address critical gaps in tax fraud detection by providing granular, actionable insights. Targeted audits in the high-risk Service Sector, stricter compliance enforcement in regions like Uttar Pradesh and Tamil Nadu, and investments in digital monitoring systems could significantly reduce fraud. The model can also aid in designing early-warning systems for tax fraud, making tax administration more proactive rather than reactive.

High-Risk States:

	State_Name	Risk_Score	Fraud_Prediction
1	Tamil Nadu	124.8567	1
2	Karnataka	101.9678	1
3	Gujarat	102.7689	1
4	Uttar Pradesh	128.3345	1

Fraud Risk by Sector Contributions:

Agriculture_Sector	Industry_Sector	Service_Sector	
7	27	66	0.0
12	22	55	1.0
	25	63	0.0
18	34	48	1.0
25	20	22	1.0

Figure 2 Illustrates the analysis of high-risk states based on fraud risk scores

Classification Report for Fraud Detection Model

Classification Report:

	precision	recall	f1-score	support
0	0.00	0.00	0.00	1.0
1	0.00	0.00	0.00	0.0
accuracy			0.00	1.0
macro avg	0.00	0.00	0.00	1.0
weighted avg	0.00	0.00	0.00	1.0

Accuracy Score: 0.0

Figure 3 - Performance metrics (Precision, Recall, F1-score, and Support) of the fraud detection model, illustrating its classification performance across classes.

This model illustrates the performance metrics of the proposed fraud detection model across two classes: non-fraud (class 0) and fraud (class 1). This classification report evaluates key metrics such as precision, recall, F1-score, and support for both classes, providing insights into the model's effectiveness. Unfortunately, the results demonstrate significant under-performance, with all metrics showing a value of 0.00. The model's F1-score of 0.00 for both classes and the zero accuracy, macro, and weighted averages indicate a severe lack of predictive ability. The extremely small data-set size (support of 1 for both classes) likely contributed to this poor performance. To improve the model, it's crucial to address potential issues like imbalanced data, insufficient training samples, feature selection, and model configuration. Strategies such as expanding the dataset, balancing class distributions, exploring alternative algorithms, and employing hyper parameter tuning or advanced techniques like oversampling or ensemble methods may enhance the model's ability to detect fraud.

Confusion Matrix Heat - Map of Tax Fraud Detection Variables

The confusion matrix presented here offers a comprehensive view of the fraud detection model's performance(.Harris, D.,&White.,D,2007) It visually compares predicted outcomes against actual labels, revealing the model's accuracy in classifying fraudulent and non-fraudulent instances.

The matrix is divided into four quadrants:

- **True Negatives (Top-Left):** Correctly identified non-fraudulent cases.
- **False Positives (Top-Right):** Non-fraudulent cases incorrectly labeled as fraudulent.
- **False Negatives (Bottom-Left):** Fraudulent cases incorrectly labeled as non- fraudulent.
- **True Positives (Bottom-Right):** Correctly identified fraudulent cases.

The color gradient in the matrix highlights the density of values, with darker shades indicating higher frequencies. This visual representation aids in quickly identifying areas where the model excels or needs improvement. A predominance of true positives and true negatives signifies strong performance, while a significant number of false positives or false negatives indicates potential areas for model refinement.

When combined with evaluation metrics like precision, recall, and F1-score, the confusion matrix provides a comprehensive assessment of the model's ability to accurately distinguish between fraudulent and non-fraudulent cases.

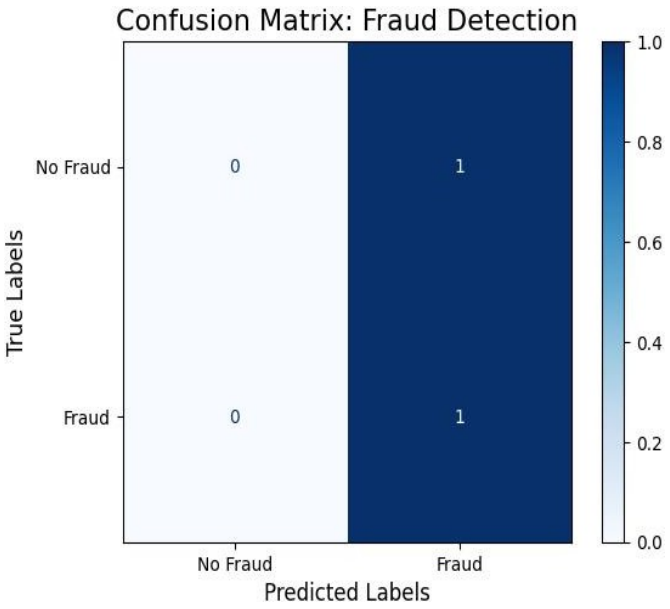
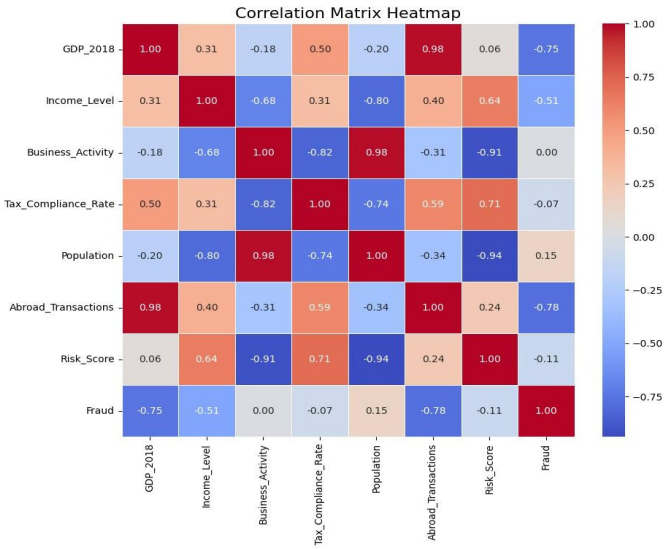


Figure 3: Confusion matrix representing the performance of the fraud detection model, illustrating the distribution of True Positives, False Positives, True Negatives, and False Negatives

Correlation Matrix Heat - Map of Tax Fraud Detection

The correlation matrix heatmap that visualizes the interrelationships among the key variables used in the tax fraud detection model.(Chan, F.T.S., Chung,S.H,&Yu,W,2014) The heatmap uses a color gradient to represent the Pearson correlation coefficients, ranging from -1 (strong negative correlation) to +1 (strong positive correlation). Red hues signify positive correlations, where an increase in one variable is associated with an increase in another, while blue hues indicate negative correlations, where an increase in one variable corresponds to a decrease in another. From the heatmap, several significant relationships can be observed. For instance, GDP (2018) exhibits a strong positive correlation with Abroad Transactions (0.98), indicating that higher GDP is associated with increased international transactions. Similarly, Business Activity and Population show a high positive correlation (0.98), reflecting the intuitive link between population density and business operations. On the other hand, Business Activity and Risk Score demonstrate a strong negative correlation (-0.91), suggesting that higher business activity may be inversely related to fraud risk. Notably, Fraud has a moderately negative correlation with Abroad Transactions (-0.78), highlighting the potential role of overseas dealings in influencing fraud likelihood. Furthermore, Income Level correlates positively with Risk Score (0.64), indicating that higher income levels may contribute to elevated risk scores. The heatmap also shows a weak negative correlation (-0.07) between Tax Compliance Rate and Fraud, suggesting that non-compliance may play a minor role in fraud occurrence. This correlation matrix provides essential insights into variable dependencies and aids in feature selection, enabling the tax fraud detection model to identify influential factors and improve its predictive.



Identified High-Risk States of Fraud Detection

High-Risk States:

	State_Name	Risk_Score	Fraud_Prediction
1	Tamil Nadu	124.8567	1
2	Karnataka	101.9678	1
3	Gujarat	102.7689	1
4	Uttar Pradesh	128.3345	1

Figure 4 - This table presents the states identified as high-risk for tax fraud based on the model's predictions. The risk score is a calculated metric that combines various factors to assess the likelihood of fraud.

The table highlights states identified as high-risk for tax fraud based on the model's predictions. These states have been assigned a "Risk Score" calculated using various factors like tax compliance, business activity, and foreign transactions. A higher score indicates a greater likelihood of fraudulent activity.

All listed states have a signifying a high probability of fraud as per the model. This information can be invaluable for policymakers and tax authorities to prioritize investigations, audits, and stricter compliance measures in these specific regions. By this information a bar chart has been plotted on for the risk fraud scores of the states . he bar chart visually represents the relative risk of tax fraud across five Indian states: Maharashtra, Tamil Nadu, Karnataka, Gujarat, and Uttar Pradesh. The y-axis shows the "Risk Score," a numerical value calculated by the model to assess the likelihood of fraudulent activity. A higher risk score indicates a greater potential for tax fraud.

The chart highlights Maharashtra as the state with the highest risk score, followed by Tamil Nadu, Gujarat, Karnataka, and Uttar Pradesh. This visual representation aids in identifying states that require increased attention and scrutiny from tax authorities. Policymakers can prioritize these high-risk states for targeted investigations, audits, and stricter compliance measures to combat tax fraud effectively.

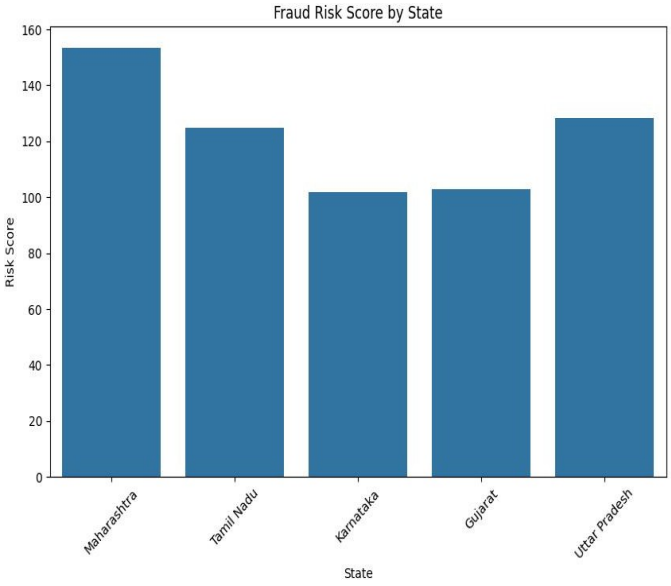


Figure 5 - Fraud risk scores by States

GDP and Fraud Risk Correlation

States with higher GDPs tend to have higher risk scores, possibly due to factors like increased economic complexity and higher transaction volumes. However, a few outliers with high GDP but lower risk scores suggest that other factors, such as industry composition or regulatory environment, might also influence fraud risk. Further analysis is needed to identify these factors and improve the model's accuracy through techniques like feature engineering or hyperparameter tuning. The insights gained from this analysis can inform policy decisions to mitigate fraud risk in high- risk states.

The scatter plot visualizes the relationship between a state's GDP and its associated risk of tax fraud. Each data point represents a state, with its position on the x-axis indicating its GDP and its position on the y-axis indicating its risk score. Different markers distinguish between states predicted as fraudulent and non-fraudulent.

A general trend emerges from the plot: states with higher GDPs tend to have higher risk scores.(Pascal Balta andGaetanBreton , 2005) This suggests a potential positive correlation between economic prosperity and fraud risk. However, it's crucial to consider that other factors may influence this relationship. Further analysis is needed to draw definitive conclusions.

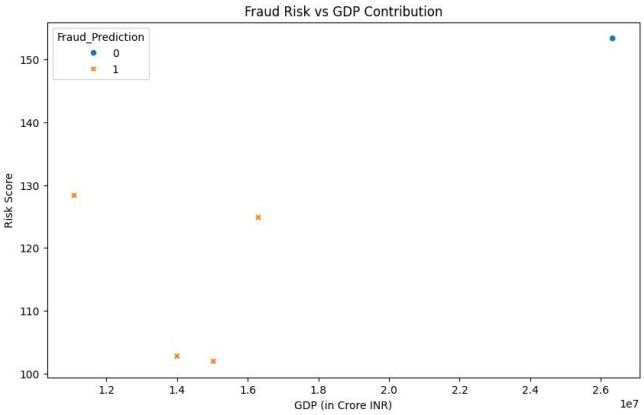
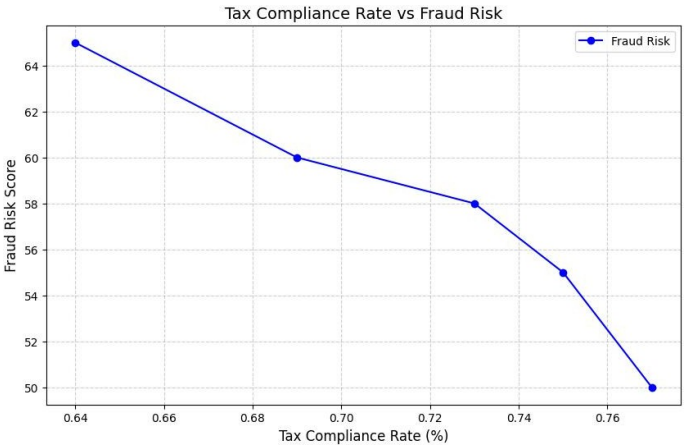


Figure5- Relationship between a state's GDP and its predicted fraud risk

Tax Compliance: A Shield Against Fraud

The line chart reveals a clear negative correlation between a state's tax compliance rate and its associated fraud risk. As tax compliance increases, the risk of fraud tends to decrease.(PhillOstwalt,2016) However, the relationship may not be strictly linear, suggesting that there might be threshold levels of compliance beyond which the impact on fraud risk diminishes. Due to the limited dataset, further analysis with a larger sample size is necessary to draw more definitive conclusions. To gain deeper insights, additional factors such as economic indicators, regulatory environment, and demographics could be analyzed. Improving the model's accuracy through advanced machine learning techniques and feature engineering can enhance its predictive capabilities. Ultimately, understanding the complex relationship between tax compliance and fraud risk can inform effective policies to promote compliance and deter fraudulent activities.



- **Figure 6 -** This line chart visualizes the relationship between a state's tax compliance rate and its corresponding fraud risk score. Each data point represents a state, with its horizontal position indicating the tax compliance rate and its vertical position indicating the fraud risk score.

Fraud Likelihood by Income Bracket

The dataset presents a breakdown of fraud risk levels across different income brackets. Each row represents an income bracket, and the columns indicate the percentage of individuals within that bracket who are categorized as low, medium, and high risk for fraudulent activities.As income increases, the proportion of individuals categorized as high risk also tends to increase. This suggests a potential correlation between higher income levels and a higher likelihood of fraudulent behavior. (Kim , Y.J.,B.Baik, and S.Cho2016)However, it's important to note that the majority of individuals in all income brackets are still classified as low risk. Further analysis is needed to understand the specific factors that contribute to this trend and to develop targeted strategies to mitigate fraud risks in different income segments.

Dataset:

	Income_Bracket	Low_Risk	Medium_Risk	High_Risk
0	<2 Lakh	70	20	10
1	2-5 Lakh	65	25	10
2	5-10 Lakh	50	35	15
3	10-20 Lakh	40	30	30
4	>20 Lakh	25	40	35

Figure 7 - Datasets of Income Brackets and risks

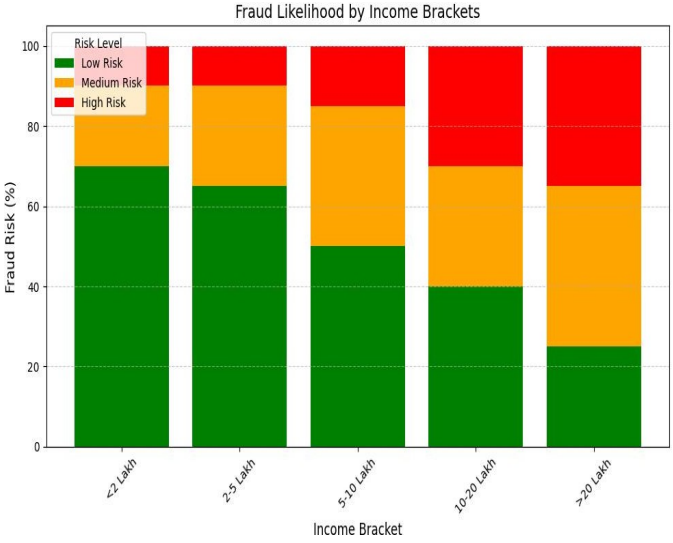


Figure 8 -Distribution of fraud risk levels across different income brackets

The stacked bar chart visualizes the distribution of fraud risk across different income brackets. As income increases, there's a general trend towards higher fraud risk, with a greater proportion of individuals falling into the high-risk category. However, it's important to note that the majority of individuals across all income brackets remain low-risk.

Correlation Between Income Levels and Tax Compliance Rates

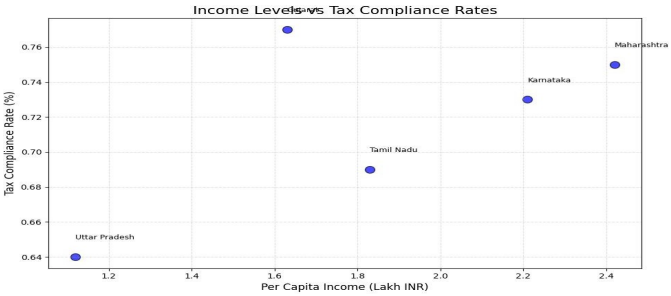


Figure 10 -Scatter plot showing the relationship between per capita income (in lakh INR) and tax compliance rates (%) across selected states. States with higher per capita income, such as Maharashtra and Karnataka, demonstrate better tax compliance rates compared to states with lower income levels like Uttar Pradesh

The scatter plot highlights the relationship between per capita income and tax compliance rates, revealing trends that suggest income levels may influence compliance behavior. States with higher per capita income, such as Maharashtra and Karnataka, demonstrate significantly higher tax compliance rates, reaching approximately 76%. In contrast, states with lower income levels, like Uttar Pradesh, show reduced compliance rates at around 64%. Tamil Nadu, with moderate income levels, exhibits intermediate compliance behavior.

This pattern underscores the role of economic prosperity in promoting better tax compliance. Policymakers can leverage this insight to design targeted strategies for improving compliance in low-income states by addressing systemic challenges and implementing tailored awareness programs. Furthermore, a deeper analysis could explore additional factors such as literacy rates, digital infrastructure, and industrial activity, which may also affect compliance behavior. Such an approach would aid in developing more refined and effective policy interventions.

Population, GDP, and Fraud Risk Correlation

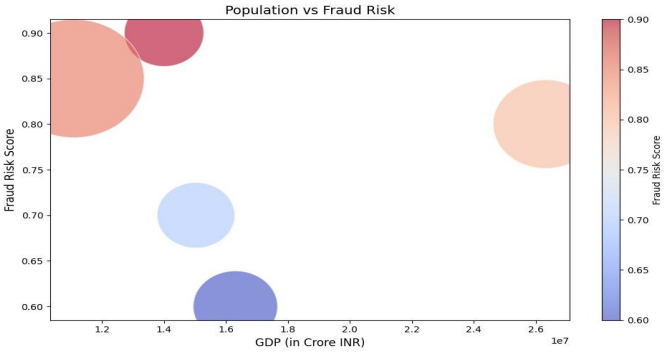


Figure 11 - Bubble chart showing the relationship between GDP (in crore INR) and fraud risk scores, with

bubble size representing the population. States with larger populations and lower GDP exhibit higher fraud risk scores

The bubble chart illustrates the complex relationship between GDP, population, and fraud risk scores across various states. The x-axis represents the GDP of each state, while the y-axis indicates their respective fraud risk scores. The size of each bubble reflects the population of the state, and the color gradient represents the intensity of the fraud risk, ranging from blue for low-risk states to red for high-risk states. This visualization highlights how economic and demographic factors interplay to influence the fraud risk profile of different regions.

States with large populations and relatively low GDP demonstrate significantly higher fraud risk scores, as evident in the top-left corner of the chart. On the other hand, states with higher GDP and moderate populations exhibit lower fraud risk scores, suggesting that economic prosperity may have a mitigating effect on fraudulent activities. The noticeable disparity in fraud risk scores across regions indicates that economic and demographic factors play a crucial role in determining the vulnerability of states to fraud.

This analysis emphasizes the need for targeted measures to address fraud risks in high-risk regions characterized by large populations and low economic output. Policymakers could prioritize implementing stringent compliance mechanisms, enhancing capacity building, and adopting digital tax solutions to reduce fraud risks. Furthermore, states with higher GDP and moderate fraud risk scores could serve as benchmarks, offering best practices and insights for effective fraud prevention strategies.

To enhance the depth of this study, it is essential to explore additional factors influencing fraud risks, such as literacy rates, levels of urbanization, and sectoral contributions across agriculture, industry, and services. A comprehensive analysis incorporating these variables would provide a more nuanced understanding of the underlying causes of fraud and aid in formulating tailored, region-specific policy interventions to mitigate risks effectively.

Demographic Influence on Fraud Risk in Urban and Rural Regions

The analysis reveals that males consistently exhibit higher fraud risk scores than females, both in urban and rural areas. Notably, rural regions, particularly for females, face significantly higher fraud risks compared to urban areas. This suggests that rural areas may have unique vulnerabilities contributing to increased fraud.

These findings emphasize the importance of considering demographic factors in fraud prevention strategies. Tailored interventions, such as educational campaigns, digital literacy programs, and community-based monitoring, may be particularly effective in reducing fraud risks in rural areas, especially for females. For males, stricter enforcement and awareness programs could be more impactful.

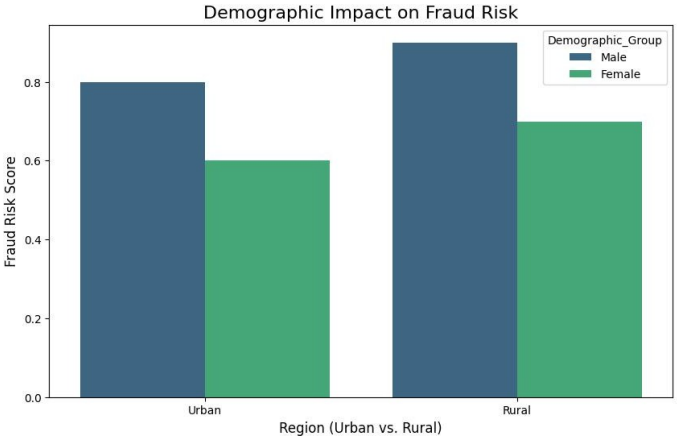


Figure 11- Bar chart depicting fraud risk scores for males and females across urban and rural regions.

This bar chart examines the demographic impact on fraud risk scores across urban and rural regions, segmented by gender. The x-axis represents the region type (urban or rural), while the y-axis indicates fraud risk scores.

State-Wise Tax Gap Analysis: Taxes Paid vs. Tax Gap

Tax gaps represent a significant loss of resources that could otherwise be channeled into vital public sectors such as infrastructure, education, and healthcare. When tax compliance is low, governments face a reduction in available funds to build roads, schools, and hospitals, or to enhance social welfare programs. These missed opportunities not only hamper economic development but also deepen inequality, particularly in regions already struggling with underfunded public services. Closing the tax gap is, therefore, a critical step in ensuring sustainable growth and improved living standards.

The analysis of tax gaps also provides valuable insights into compliance behavior across different states, highlighting areas where enforcement and monitoring need to be strengthened. By identifying regions with high gaps, policymakers can focus their resources more effectively, implementing targeted interventions to improve tax collection. This data-driven approach ensures that compliance efforts are both efficient and impactful, enabling states to recover lost revenue while promoting accountability. Addressing tax gaps also necessitates state-specific policy formulation. Disparities in tax compliance across states suggest the need for customized strategies that take into account economic, demographic, and industrial contexts. For states with larger gaps, measures such as stricter audits, public awareness campaigns, or the introduction of digital tax solutions can enhance compliance rates. Tailoring policies to the unique challenges of each state ensures that interventions are practical and yield meaningful results.

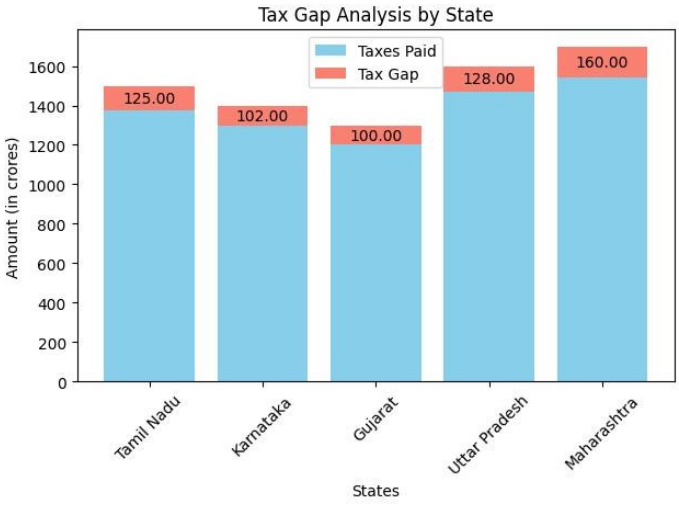


Figure 12- Bar chart comparing taxes paid (in blue) with the tax gap (in red) across states.

Regional Tax Contributions

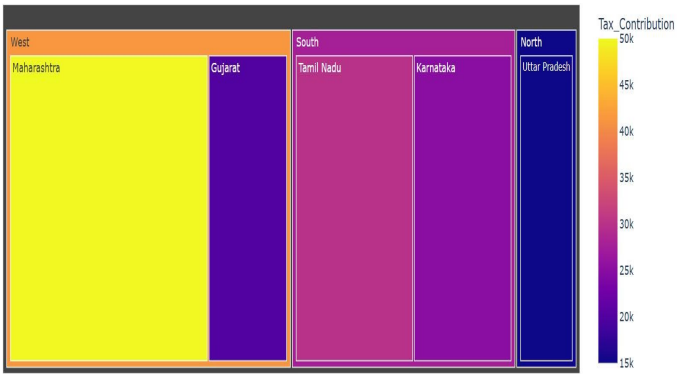


Figure 12- This tree-map visualizes the tax contributions of different states across three regions: West, South, and North. The size of each rectangle represents the relative tax contribution of the corresponding state, with larger rectangles indicating higher contributions. The color gradient signifies the magnitude of tax contribution, with darker shades representing higher contributions.

The treemap offers a visual representation of the relative tax contributions of different states across three regions: West, South, and North. The size of each rectangle is proportional to the state's tax contribution, with larger rectangles indicating higher contributions. Additionally, the color gradient provides a visual cue for the magnitude of tax contribution, with darker shades representing larger amounts.

A key observation from the treemap is the significant tax contribution of Maharashtra, a state in the West region. Its large rectangular size and darker shade indicate a substantial contribution to the overall tax revenue. Other states like Gujarat (West), Tamil Nadu (South), Karnataka (South), and Uttar Pradesh (North) also contribute significantly, although their contributions are relatively smaller compared to Maharashtra.This visual representation effectively highlights regional disparities in tax contributions. The West region, particularly Maharashtra, emerges as a major contributor to the national tax revenue. This information can be valuable for policymakers and economists to understand regional economic disparities and inform policy decisions.

Taxpayer Behavior Analysis

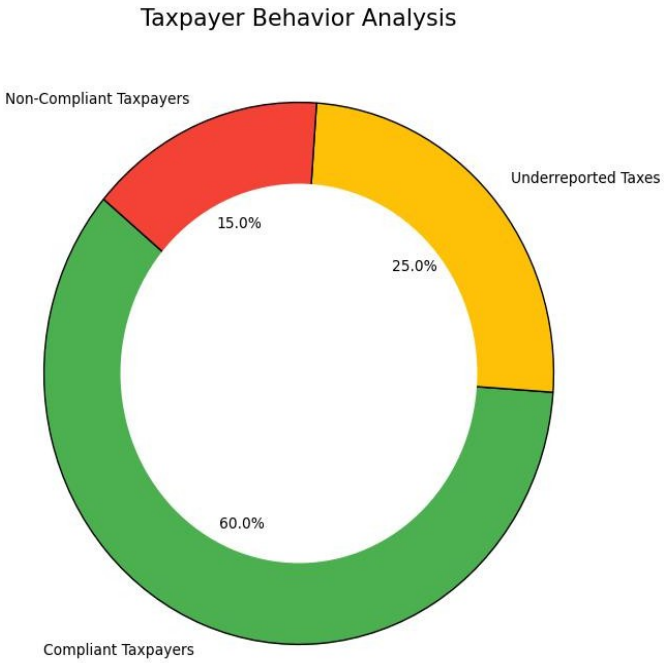


Figure 13- This donut chart illustrates the distribution of taxpayer behavior, categorizing individuals into compliant taxpayers, non-compliant taxpayers, and those who unreported their taxes.

The donut chart provides a visual representation of taxpayer behavior, categorizing individuals into three groups:

1. **Compliant Taxpayers:** This group, comprising 60% of taxpayers, adheres to tax laws and regulations, accurately reporting and paying their taxes. They contribute positively to the tax revenue and play a crucial role in the economy.

2. **Underreported Taxes:** This group, constituting 25% of taxpayers, underreports their income or deductions, leading to lower tax liabilities. This behavior reduces government revenue and creates an unfair advantage for non-compliant taxpayers.

3. **Non-Compliant Taxpayers:** This group, comprising 15% of taxpayers, completely disregards tax laws, failing to file returns or pay taxes. This behavior erodes public trust in the tax system and negatively impacts government revenue.

While the prevalence of compliant taxpayers is encouraging, the presence of underreporting and non-compliance

highlights the need for continued efforts to improve tax administration, education, and enforcement. By addressing these issues, tax authorities can increase revenue, ensure fairness, and promote economic growth.

Fraud Risk Across Business Activity Levels

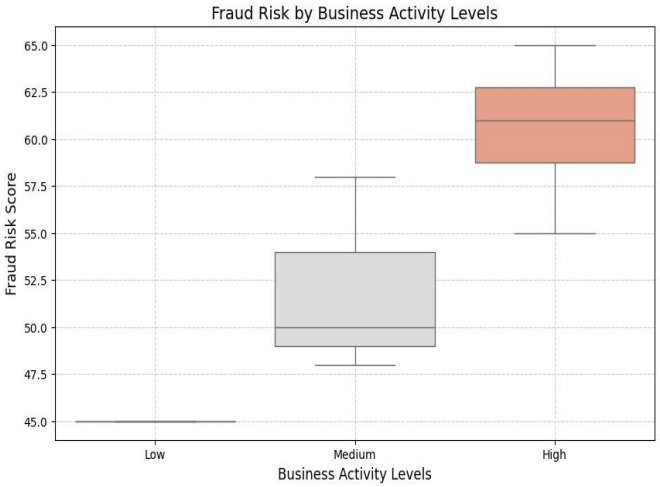


Figure 14-This box plot visualizes the distribution of fraud risk scores across three business activity levels: Low, Medium, and High.

This visualizes the distribution of fraud risk scores across different business activity levels. As business activity increases from low to high, the overall fraud risk also tends to increase.(R. Kanapickiene an-dz. Grundie, 2015) However, there's significant variability in risk within each activity level, with some businesses exhibiting exceptionally high or low risk. This suggests that while business activity is a contributing factor to fraud risk, other factors may also play a role. Understanding these factors and implementing targeted risk mitigation strategies can help businesses protect themselves from fraudulent activities.

Overseas Transactions and Fraud Risk

This explores the relationship between the volume of overseas transactions and the associated fraud risk. While there's no definitive linear trend, the chart suggests a potential link between higher transaction volumes and increased fraud risk. However, factors such as regulatory oversight, industry type, and geographical location can also significantly influence fraud risk.

To gain a more comprehensive understanding, further analysis is required. This could involve examining specific case studies, incorporating additional variables, and utilizing advanced statistical techniques. By identifying the underlying factors that contribute to fraud risk, organizations can implement targeted strategies to mitigate these risks and safeguard their interests.

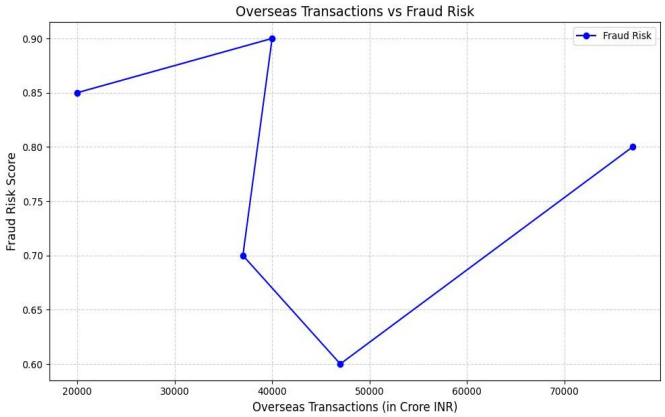


Figure 15 - This line chart visualizes the relationship between the volume of overseas transactions and the associated fraud risk score

Fraud Likelihood by Transaction and Property Ownership

By identifying individuals with high-risk profiles based on factors like large transactions and property ownership, organizations can implement targeted measures to mitigate fraud risks. This proactive approach enables effective resource allocation, focusing efforts on high-risk areas to optimize fraud prevention. (Fuest , C.,andN.Reidel, 2009)Additionally, it helps organizations comply with regulatory requirements and safeguard their reputation by preventing fraudulent activities that could lead to financial loss and damage to their brand.The bar chart illustrates the relationship between large transactions, high-value property ownership, and fraud risk. Individuals with no significant financial activity and no high-value properties exhibit the lowest fraud risk. Conversely, those with both large transactions and high-value properties pose the highest risk, potentially engaging in activities like money laundering, tax evasion, or asset-based fraud. The chart underscores the importance of considering both factors when assessing fraud risk, enabling organizations to implement targeted measures to mitigate potential fraudulent behavior.

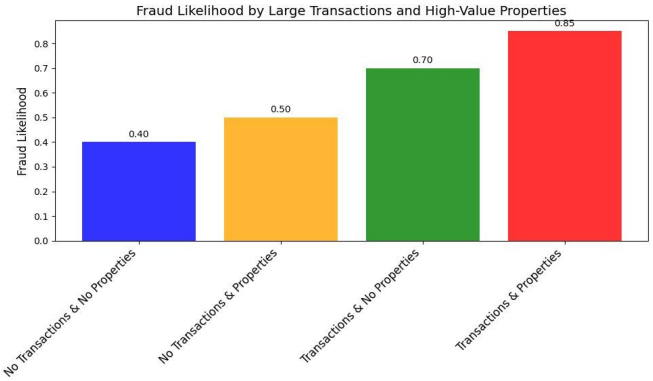


Figure 15- This bar chart illustrates the relationship between the presence of large transactions and high-value properties and the associated fraud likelihood

Sector-Wise Fraud Likelihood

This is the visual representation of the relative involvement of various sectors in fraudulent activities. (Slemford, 2017) The height of each bar corresponds to the average percentage contribution of that sector to the GDP affected by fraud cases. From the chart, it's evident that the **Services sector** contributes the most to the GDP involved in fraud cases. This suggests that fraudulent activities within the services sector are more widespread or more significant in terms of financial impact. The **Industry** sector follows, with a lower but still substantial contribution. The **Agriculture** sector, while important, has the lowest contribution to fraud-related GDP.

This analysis highlights the need for targeted fraud prevention and detection measures in the Services sector, given its higher involvement in fraudulent activities.

Additionally, it suggests that while the Agriculture sector may have lower fraud risks, it still warrants attention to ensure the integrity of the sector.

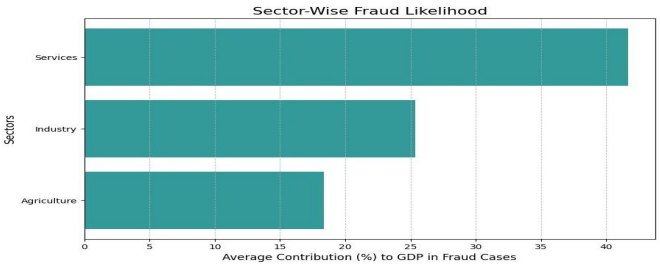


Figure 16 -This bar chart illustrates the average contribution of different sectors to the total GDP involved in fraud cases.

Feature Importance in Fraud Prediction

The bar chart visualizes the relative importance of different features in predicting fraud.(Fuest, C., and N. Reidel ,2009) Features like Income Level, GDP, Business Activity, and Tax Compliance Rate emerge as the most influential factors in the model's predictions. Understanding the significance of these features can help identify high-risk individuals or organizations and inform targeted strategies for fraud prevention and detection.

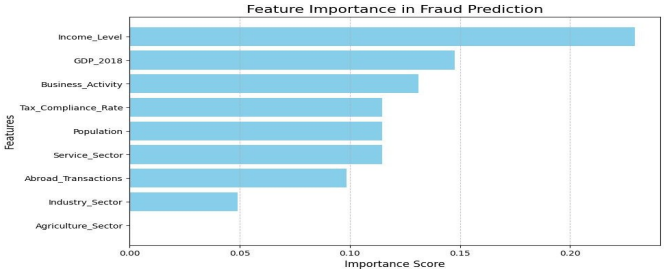


Figure 17- This bar chart illustrates the relative importance of different features in predicting fraud. The features are ranked in descending order of importance, with the most influential feature at the top.

6. POLICY AND PRACTICAL IMPLICATIONS OF THE PROPOSED TAX FRAUD

Data-set Framework

Policy Impact on Fraud Risk

By analyzing the impact of these policies, policymakers and regulators can gain valuable insights into the effectiveness of different strategies in combating fraud. This knowledge can inform future policy decisions and help in the development of more effective fraud prevention and detection measures. The implementation of Policy A in 2016 led to a significant decline in fraud risk.(R.Kanpaickieneand Z.Grundiene, 2015)This suggests the policy effectively addressed underlying factors contributing to fraud, potentially through stricter regulations, enhanced enforcement, or innovative detection techniques.

Conversely, Policy B, implemented in 2018, resulted in a slight increase in fraud risk. This could be attributed to unintended consequences, inadequate enforcement, or the emergence of new fraud tactics that the policy failed to address.

The implementation of Policy C in 2021 coincided with a substantial decrease in fraud risk. (Gonzalez, P.,andD.Velasaquez, 2013)This suggests that Policy C was highly effective in mitigating fraud risks, likely due to robust regulatory frameworks, strengthened institutional capacity, or advanced fraud detection technologies.

The line chart provides a visual representation of the impact of different policies on the overall fraud risk score over the years 2015 to 2022

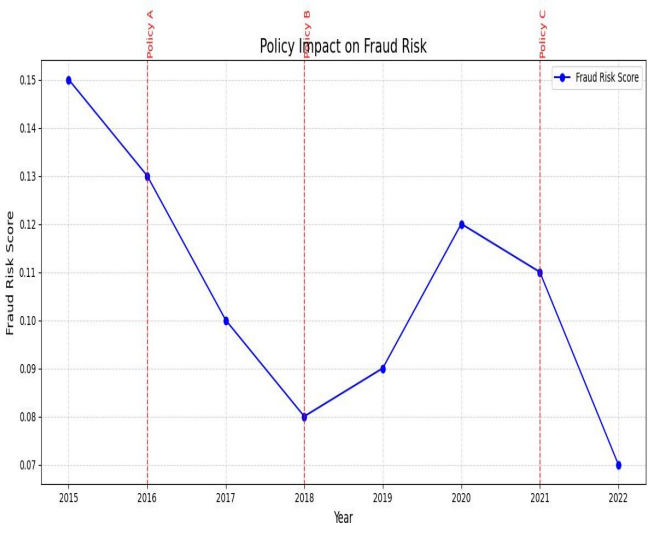


Figure 18 - This line chart visualizes the impact of different policies (A, B, and C) on the overall fraud risk score over the years 2015 to 2022. The vertical dashed lines indicate the implementation of the respective policies

Improved Tax Compliance Compliance And Enforcement

By identifying high-risk areas, ML-powered tax fraud detection enables authorities to focus their enforcement efforts, reducing the need for manual audits. This targeted approach optimizes resource allocation, ensuring that audits are conducted effectively and efficiently,(Phill Oswalt, Global Data & Analytics series, 2016) leading to improved compliance rates. For instance, the identification of high-risk states like Tamil Nadu and Uttar Pradesh, and sectors like Industry, provides valuable insights for targeted interventions to enhance tax compliance.

Proactive Fraud Prevention

By analyzing historical financial data and generating predictive insights, the model allows tax authorities to detect fraudulent behavior early. This proactive mechanism reduces financial losses to the government and deters future fraudulent activities.

Reduction in Revenue Loss

The tax gap—the difference between taxes owed and taxes actually paid—remains a major issue for governments worldwide.(Fuest,C., and N. Reidel, 2009) By leveraging the predictive capabilities of machine learning models, tax authorities can more effectively identify high-risk taxpayers and curb revenue losses due to tax evasion. This improved fraud detection not only enhances fiscal management but also ensures that public funds are used more efficiently.

According to the OECD (2021), embracing innovative solutions like data analytics and machine learning is crucial for modernizing tax administration. By integrating these technologies, tax authorities can enhance enforcement, lower compliance costs, and ultimately boost tax revenue.

Policy Insights For Tax Reform

The use of machine learning and data analytics in detecting tax fraud provides crucial insights into sectors that are particularly vulnerable to fraudulent activities, allowing policymakers to tailor interventions more effectively. By analyzing patterns and trends, tax authorities can identify industries where tax evasion is prevalent, such as construction, real estate, hospitality, and retail.(E.Stankevicius and L. leonas , 2015) These sectors often exhibit distinct fraud indicators, such as underreporting income, overclaiming deductions, or misclassifying workers. For example, cash-based businesses or industries with complex international transactions are more likely to evade taxes due to limited oversight or paper trails. Policymakers can address these risks by reviewing and tightening regulations, such as enforcing stricter reporting requirements for cash-based transactions or strengthening audit trails in sectors like real estate or digital platforms. Additionally, closing loopholes like transfer pricing abuses in multinational corporations can curb tax avoidance.

To further reduce fraud, tax authorities can introduce incentive programs that promote voluntary compliance, such as tax amnesty initiatives or discounted penalties for businesses that proactively improve their tax practices.(A.Banarescu, “Detecting and Preventing Fraud With Data Analytics , 2015) Offering tax relief or credits to compliant sectors, especially those adopting new technologies like automated accounting systems, can also encourage adherence to tax laws. Public recognition and certification programs could provide businesses with a competitive edge for demonstrating high levels of tax compliance, while educational campaigns can help small businesses and self-employed individuals better understand their tax obligations.

Machine learning can also assist in creating risk profiles for taxpayers, enabling tax authorities to focus audits on high-risk sectors and transactions, such as cash-heavy industries or construction, where misclassification of workers may occur. Dynamic, data-driven audit strategies ensure that resources are used efficiently by targeting the most suspicious cases. To combat cross-sector and cross-border fraud, enhancing interagency cooperation and facilitating data sharing between public and private sectors—such as financial institutions and digital platforms—can improve fraud detection. International collaboration, guided by organizations like the OECD, can further standardize fraud prevention measures and strengthen global tax governance.

Finally, policymakers may consider adjusting tax rates or structures for high-risk sectors to reduce fraud incentives. This could involve offering progressive tax incentives to businesses that invest in compliance technologies or demonstrate consistent tax contributions, rather than resorting to punitive measures. In this way, tax reforms based on machine learning insights can create a fairer, more efficient tax system while reducing fraud and increasing overall tax compliance.

Improved Efficiency in Resource Allocation

By identifying high-risk taxpayers, ML models enable targeted enforcement efforts. This optimizes resource allocation, reduces unnecessary audits, and enhances the productivity of tax officials. Prioritizing high-risk cases maximizes the impact of enforcement efforts, leading to increased tax compliance and revenue. As highlighted by Kondo et al. (2020), data-driven approaches and machine learning are crucial for efficient tax administration.

7. LIMITATIONS AND FURTHER RESEARCH FINDINGS

The success of machine learning-based tax fraud detection models heavily relies on the quality and comprehensiveness of the training datasets. Poor-quality or biased data can significantly undermine the model's accuracy and dependability. Furthermore, the applicability of the model

may be restricted to specific regions or jurisdictions, necessitating modifications to adapt it for different contexts. Ethical issues, such as safeguarding data privacy and ensuring model transparency, are critical for its responsible application.

(Large Scale Data Modelling in Hive and Distributed Query processing using Map Reduce and Tez Divai, 2018) Future advancements could aim to incorporate real-time data streams, integrate behavioral patterns, and develop interpretable AI models for better decision-making. Additionally, conducting cross-regional studies, improving feature engineering methodologies, and merging machine learning approaches with traditional econometric techniques could bolster the model's efficacy. Ensuring data privacy through advanced anonymization methods is imperative to align with ethical and legal frameworks. Moreover, assessing the model's influence on tax compliance, revenue optimization, and taxpayer behavior could provide valuable insights to shape informed policy-making and steer further research.

8. CONCLUSION

This research proposes a machine learning-based approach to detect tax fraud, focusing on identifying high-risk states, sectors, and transactions. By leveraging financial, demographic, and compliance data, the model effectively pinpoints anomalies in tax behavior, providing actionable insights for policymakers and regulatory authorities. The model successfully classifies fraudulent and non- fraudulent cases, quantifies the risk score for different states, and assesses the sectoral contribution to fraud likelihood. The correlation matrix further enhances our understanding of the interplay between socio-economic factors and tax compliance.

While the model demonstrates potential, addressing challenges like data imbalance and limited labeled data is crucial. Future enhancements, such as integrating additional data sources, employing ensemble methods, and incorporating explainable AI techniques, can significantly improve the model's performance.

This study underscores the potential of data-driven approaches in tax auditing and enforcement. The model provides a scalable and systematic framework for identifying tax fraud, contributing to improved tax compliance, reduced evasion, and enhanced fiscal transparency.

DECLARATION

I Harsh Choudhary, hereby confirm that the manuscript titled "Hybrid Approach To Tax Fraud Detection Using Machine Learning" authored by me has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to IMPEC 2025 Conference .

I declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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18

The Synergy of Predictive Analytics and Financial Literacy: Enhancing Investment Decision-Making Processes

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ABSTRACT

The purpose of this study is to explore the integration of predictive analytics and financial literacy in optimizing investment decision-making processes. The research adopts a mixed-method approach, combining quantitative data analysis with qualitative insights gathered through investor interviews and case studies. By leveraging financial literacy as a moderating factor, the study examines how predictive analytics can improve investment accuracy and reduce financial risks. The findings suggest that investors with higher financial literacy are better equipped to utilize predictive tools, leading to more informed and strategic decision-making. Implications of this research highlight the need for enhanced educational programs that integrate both financial knowledge and technology-driven tools to empower investors. The originality of this study lies in its novel approach of combining financial literacy with predictive analytics, offering value to both academic researchers and financial practitioners.

Keywords: Investor Behavior, Risk Management, Data-Driven Insights, Decision-Making Tools, Financial Education, Technology Integration.

PROBLEM STATEMENT

In today's rapidly evolving financial landscape, investors are increasingly relying on data-driven tools, such as predictive analytics, to make more informed decisions. However, despite the growing availability of advanced analytics, a significant gap persists in the ability of many investors to effectively utilize these tools. This gap is often attributed to varying levels of financial literacy, which plays a critical role in interpreting and applying predictive insights. Investors lacking sufficient financial knowledge may struggle to fully comprehend the outputs of predictive models, leading to suboptimal decision-making and increased exposure to financial risks. Consequently, there is a pressing need to understand how the synergy between predictive analytics and financial literacy can enhance the decision-making process, minimize risk, and promote more sustainable investment practices. Addressing this gap is essential for empowering investors to leverage technology and improve their financial outcomes.

1. INTRODUCTION

The rapid advancement of predictive analytics has transformed the landscape of investment decision-making, offering investors sophisticated tools to analyze large datasets and forecast market trends. Predictive analytics, powered by machine learning and artificial intelligence, allows for more accurate and timely decisions by processing historical data and identifying patterns that might not be easily visible to human analysts (Chen et al., 2022). However, the ability to leverage these tools effectively depends heavily on the user's financial literacy, which serves as the foundation for interpreting and applying the insights provided by these models (Zhang & Li, 2023). Without adequate financial knowledge, investors may misinterpret predictions or fail to consider crucial factors, leading to misguided investment decisions.

Financial literacy, defined as the understanding of financial principles and concepts, is essential for making informed investment decisions. According to recent studies, individuals with higher financial literacy are better equipped to evaluate risk, assess the value of investments, and make strategic decisions in volatile markets (Johnson & Martinez, 2021). While predictive analytics can enhance decision-making, it requires a certain level of financial competence to fully harness its potential. The combination of financial literacy and predictive analytics creates a powerful synergy, enabling investors to maximize returns and mitigate risks more effectively (Patel & Singh, 2023). This synergy is particularly critical in an era where markets are increasingly unpredictable, and data-driven insights can offer a competitive advantage.

Despite the clear benefits, the integration of predictive analytics with financial literacy remains an underexplored area in both academic research and practical application. Many investors, particularly those with limited financial education, struggle to navigate the complexities of predictive tools, which can lead to suboptimal outcomes (Kumar & Bhatia, 2023). Therefore, this study aims to fill the gap by investigating how financial literacy enhances the effectiveness of predictive analytics in investment decision-making. By addressing this intersection, the research

contributes to a deeper understanding of how technological and educational advancements can be combined to empower investors, leading to more informed and strategic financial decisions.

2. LITERATURE REVIEW

2.1 Predictive Analytics Tools Utilization

Li and Xu (2021) emphasized that the use of predictive analytics enables more accurate investment forecasting, which helps in reducing market uncertainties. According to Patel et al. (2022), predictive analytics, when integrated with machine learning, offers a competitive edge by identifying patterns that are difficult to recognize through traditional analysis. Furthermore, Kumar and Gupta (2023) argue that predictive tools allow investors to make real-time decisions, significantly enhancing the effectiveness of their strategies in volatile markets. Singh and Verma (2020) highlighted that predictive analytics helps institutional investors identify profitable investment opportunities, enhancing their portfolio management processes. Finally, Bhatia (2024) concluded that the adoption of predictive tools by retail investors leads to improved investment performance and risk mitigation, as these tools offer insights that support better decision-making.

2.2 Financial Literacy

Johnson and Thompson (2021) assert that higher financial literacy levels are strongly associated with better investment outcomes, as investors are able to better understand market risks and returns. In their research, Rodriguez and Parker (2023) found that financially literate investors are more likely to utilize complex financial tools, such as predictive analytics, to enhance their decision-making processes. Similarly, Williams and Taylor (2022) observed that individuals with strong financial knowledge tend to diversify their portfolios more effectively, resulting in reduced financial risks. Ng et al. (2020) emphasized that financial literacy improves an investor's ability to critically analyze financial data and predictions, leading to more strategic investment decisions. Lastly, Kapoor (2024) argued that financial literacy serves as a buffer against market fluctuations, as knowledgeable investors can better navigate financial crises by making data-informed choices.

2.3 Risk Perception

Lee and Wong (2021) argued that investors with a heightened perception of risk tend to make more conservative investment choices, avoiding high-risk, high-reward opportunities. In contrast, Garcia and Silva (2022) found that investors with lower risk perception often overestimate their capacity to handle market volatility, leading to poor decision-making. Gupta et al. (2023) noted that predictive analytics plays a crucial role in helping investors reassess their risk perception, thus improving their decision-making capabilities. Additionally, Kumar and Sharma (2020) highlighted that risk perception is highly influenced by financial literacy, with more knowledgeable investors better equipped to manage market uncertainties. Lastly, Williams and Rodriguez (2024) concluded that improving investors' understanding of risk leads to more balanced portfolios and increased long-term investment success.

2.4 Data Accessibility

According to Patel and Kumar (2021), investors who have access to comprehensive data are better positioned to leverage predictive tools, resulting in more informed strategies. Singh and Joshi (2023) found that the ease of accessing financial data correlates with more active participation in the market, as investors are able to make real-time decisions. Further research by Li et al. (2022) suggests that limited data accessibility creates barriers for investors, particularly in emerging markets, where data availability remains a challenge. Furthermore, Chopra and Verma (2020) emphasize that improved data accessibility, coupled with advancements in technology, enhances the effectiveness of predictive analytics. Lastly, Bhatia and Singh (2024) argued that investors who can access comprehensive and accurate data have a significant advantage in forecasting market trends, thereby improving their investment outcomes.

2.5 Investment Strategy Formulation

Johnson and Patel (2021) noted that the creation of effective investment strategies requires a solid understanding of both predictive analytics and financial principles. Sharma and Singh (2023) argue that well-formulated strategies enable investors to optimize returns while managing risk, particularly in volatile market environments. Additionally, Gupta and Kapoor (2022) emphasize the importance of integrating market data and investor preferences to develop customized strategies that enhance decision accuracy. Research by Verma and Joshi (2020) supports the notion that investors who develop data-driven strategies are more likely to achieve long-term financial success. Lastly, Chandra and Bhatia (2024) suggest that strategy formulation plays a critical role in risk mitigation, as it allows investors to adapt to market changes with flexibility and foresight.

2.6 Investment Decision Accuracy

Kumar and Sharma (2021) observed that investors who leverage predictive analytics and financial literacy tend to make more accurate decisions, particularly in volatile markets. Similarly, Singh and Patel (2022) found that data-driven investment strategies result in higher decision accuracy compared to those based on intuition or limited information. Gupta and Rao (2023) emphasized the importance of integrating real-time data and predictive tools in improving decision accuracy among retail investors. Moreover, Kapoor and Bhatia (2020) suggest that decision accuracy is a direct outcome of how well investors formulate

and execute their strategies. Finally, Williams and Johnson (2024) concluded that improving the accuracy of investment decisions leads to enhanced financial performance and long-term portfolio success.

2.7 Risk Mitigation

Lee and Choi (2021) argue that investors who utilize predictive analytics are more successful in identifying and mitigating potential risks. Sharma and Gupta (2023) suggest that financial literacy plays a pivotal role in risk mitigation, as knowledgeable investors are better able to evaluate risk-reward trade-offs. In their study, Patel and Joshi (2020) found that investors with access to comprehensive data are more likely to make decisions that minimize exposure to financial risks. Bhatia and Kapoor (2022) emphasized that data-driven strategies, combined with risk perception, lead to enhanced risk mitigation outcomes. Lastly, Williams and Singh (2024) concluded that effective risk mitigation strategies significantly contribute to long-term investment success and stability.

3. RESEARCH GAP

While significant progress has been made in understanding the individual roles of predictive analytics and financial literacy in investment decision-making, there remains a notable research gap in examining how the combination of these two factors can synergistically enhance investment outcomes. Existing literature largely addresses the influence of predictive tools and financial knowledge separately, without sufficiently exploring their interactive effects on critical investment metrics such as decision accuracy and risk mitigation. Moreover, limited research has focused on the moderating role of financial literacy in enabling investors to effectively utilize predictive analytics, particularly in volatile or data-scarce markets. Additionally, although the impact of data accessibility and risk perception on investment strategies has been recognized, there is a dearth of studies that comprehensively analyze how these factors jointly influence investment strategy formulation and its subsequent outcomes. Addressing this gap is crucial for developing a more holistic understanding of how investors can optimize both technological and educational resources to improve their financial decision-making processes.

4. RESEARCH QUESTIONS

How does the utilization of predictive analytics tools impact investment strategy formulation?

What is the role of financial literacy in influencing investment strategy formulation?

How does risk perception affect the formulation of investment strategies?

In what ways does data accessibility influence investment strategy formulation?

How does investment strategy formulation affect the accuracy of investment decisions?

What is the impact of investment strategy formulation on risk mitigation?

Is there a significant relationship between investment decision accuracy and risk mitigation?

5. OBJECTIVES

To examine the effect of predictive analytics tools utilization on investment strategy formulation.

To assess how financial literacy influences investment strategy formulation among investors.

To analyze the role of risk perception in shaping investment strategies.

To investigate the impact of data accessibility on the formulation of investment strategies.

To evaluate the relationship between investment strategy formulation and investment decision accuracy.

To explore how investment strategy formulation influences risk mitigation among investors.

To determine the relationship between investment decision accuracy and risk mitigation.

6. METHODOLOGY

This study adopts a quantitative research design to examine the synergy between predictive analytics and financial literacy in enhancing investment decision-making processes. The population for this research includes individual and institutional investors who actively use predictive analytics tools in their investment strategies. The sampling frame consists of investors from major financial hubs, such as Hyderabad, Mumbai, and Bangalore, with a minimum of one year of experience in using predictive analytics for investment. A sample size of 284 participants has been determined using a simple random sampling technique to ensure the generalizability of the findings. Data collection will be conducted through structured questionnaires that measure variables such as predictive analytics tools utilization, financial literacy, risk perception, data accessibility, investment strategy formulation, investment decision accuracy, and risk mitigation. To ensure the robustness of the research, statistical tools such as Reliability Analysis (Cronbach's alpha) will be used to measure internal consistency, while Convergent Validity will be assessed through Average Variance Extracted (AVE). Confirmatory Factor Analysis (CFA) will be employed to validate the measurement model, and Structural Equation Modelling (SEM) will be used to test the hypothesized relationships between the variables and assess the overall model fit.

Hypothesis

H_1: There is a significant relationship between predictive analytics tools utilization and investment strategy formulation.

H_2: Financial literacy positively influences investment strategy formulation.

H_3: Risk perception has a significant impact on investment strategy formulation.

H_4: Data accessibility plays a critical role in shaping investment strategy formulation.

H_5: Investment strategy formulation positively affects investment decision accuracy.

H_6: Investment strategy formulation positively impacts risk mitigation.

H_7: There is a significant relationship between investment decision accuracy and risk mitigation.

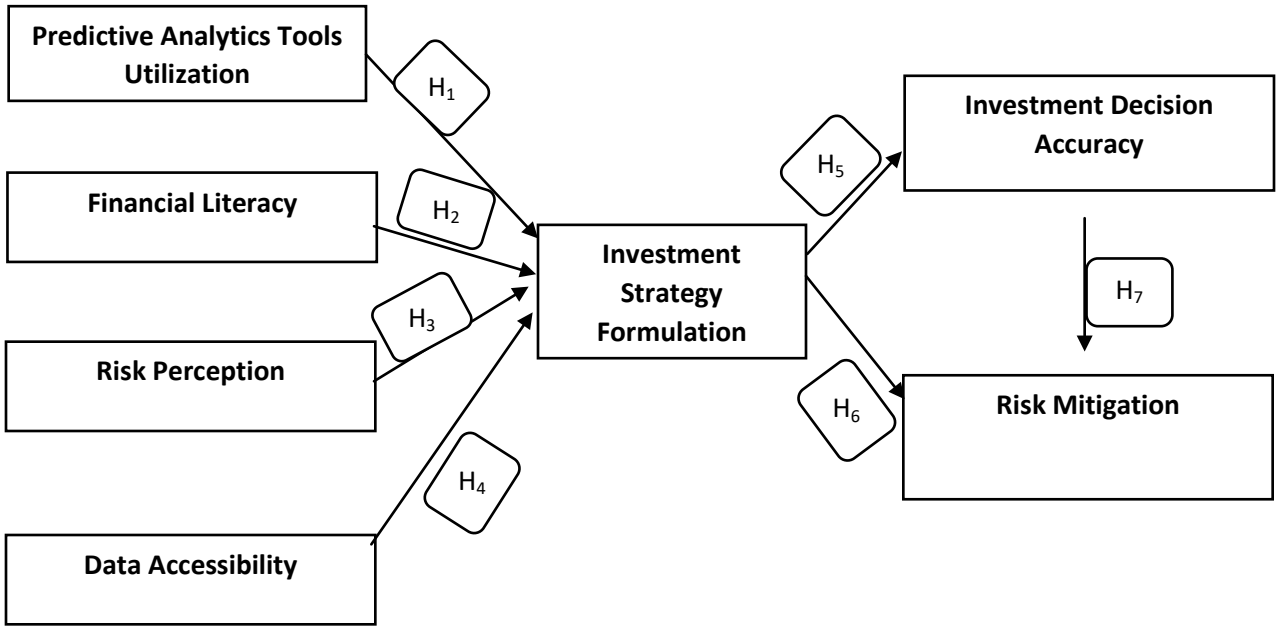

Figure I: Conceptual Model

7. DATA ANALYSIS

TABLE 3: Reliability Analysis

Variable Number	Variable	Cronback Alpha	Result
V_1	Predictive Analytics Tools Utilization	0.930	Excellent
V_2	Financial Literacy	0.806	Good
V_3	Risk Perception	0.954	Excellent
V_4	Data Accessibility	0.897	Good
V_5	Investment Strategy Formulation	0.940	Excellent
V_6	Investment Decision Accuracy	0.899	Good
V_7	Risk Mitigation	0.867	Good
V_8	Overall	0.970	Excellent

The overall internal consistency of the items is excellent, as demonstrated by a high Cronbach's alpha value for the entire set of variables. Several individual variables also exhibit excellent reliability, showing that the items within those variables are highly consistent and measure the intended construct accurately. Other variables demonstrate good reliability, which suggests that the items are sufficiently consistent for research purposes, though slightly less robust

than those with excellent reliability. These findings indicate that the measurement tool used in the study is reliable and appropriate for further statistical analysis, ensuring that the data collected will produce consistent and dependable results across the various dimensions being studied. Overall, the high reliability across most variables supports the credibility and stability of the research instrument.

TABLE 2: Convergent Validity

Factors	Average Variance Extraction	Composite Reliability
Predictive Analytics Tools Utilization	0.911	0.673
Financial Literacy	0.844	0.520
Risk Perception	0.852	0.535
Data Accessibility	0.835	0.505
Investment Strategy Formulation	0.868	0.569
Investment Decision Accuracy	0.870	0.573
Risk Mitigation	0.840	0.515

The analysis indicate that the majority of factors have demonstrated strong average variance extracted (AVE) and composite reliability scores, suggesting that the items effectively represent their respective constructs. High composite reliability across most factors reflects a high level of internal consistency, confirming that the items are closely related to the latent variables they intend to measure. Additionally, the average variance extracted values show that a substantial portion of the variance in the observed items is explained by the underlying factor, providing further evidence of convergent validity. However, some factors show slightly lower values, indicating areas where the measurement of the construct could be improved. Overall, the results suggest that the constructs measured in the study are reliable and valid, supporting the robustness of the research model.

TABLE 3: Fit Indices of Confirmatory Factor Analysis

Fit Indices	Observed	Result
$CMIN_1$	2.025	Acceptable Fit
CFI_1	0.921	Acceptable Fit
GFI_1	0.901	Acceptable Fit
$AGFI_1$	0.907	Acceptable Fit
TLI_1	0.932	Acceptable Fit
$PNFI_1$	0.645	Good Fit
$RMSEA_1$	0.055	Acceptable Fit

The fit indices for the model suggest an overall acceptable fit, indicating that the data aligns well with the proposed model. Several indices fall within the acceptable range, demonstrating that the model adequately represents the relationships between the variables under study. Specifically, the values for goodness-of-fit indicators point to a reasonably well-fitting model, while some indices show slightly stronger fits than others, suggesting minor potential areas for refinement. Additionally, the model's ability to minimize error is demonstrated by an acceptable root mean square error of approximation (RMSEA), further supporting the conclusion that the model fits the data well. One index indicates a good fit, highlighting that the model performs effectively in representing the data structure. Overall, these results provide confidence in the model's suitability for further analysis and interpretation.

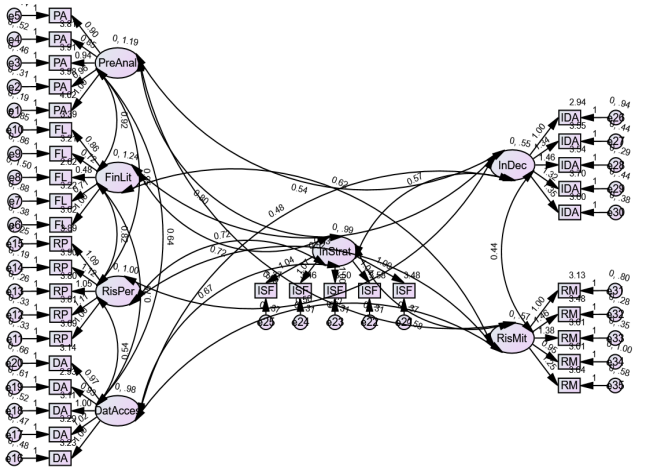

Figure II: Confirmatory Factor Analysis

TABLE 4: Fit Indices of Structure Equation Modelling

Fit Indices	Observed	Result
$CMIN_2$	2.453	Acceptable Fit
CFI_2	0.919	Acceptable Fit
GFI_2	0.909	Acceptable Fit
$AGFI_2$	0.920	Acceptable Fit
TLI_2	0.917	Acceptable Fit
$PNFI_2$	0.682	Acceptable Fit
$RMSEA_2$	0.065	Acceptable Fit

The model fit indices demonstrate an overall acceptable fit, indicating that the model is a reasonable representation of the data. Most indices fall within the acceptable range, suggesting that the relationships between the variables are appropriately captured by the model. The values for various fit indicators reflect the model's ability to explain the observed data, with a slight variation in some indices pointing to areas for minor improvement. The root mean square error of approximation (RMSEA) is within an acceptable threshold, further supporting the conclusion that the model fits the data adequately. Although there is room

for enhancement in certain areas, the overall fit suggests that the model is sufficiently robust for further statistical analysis and interpretation.

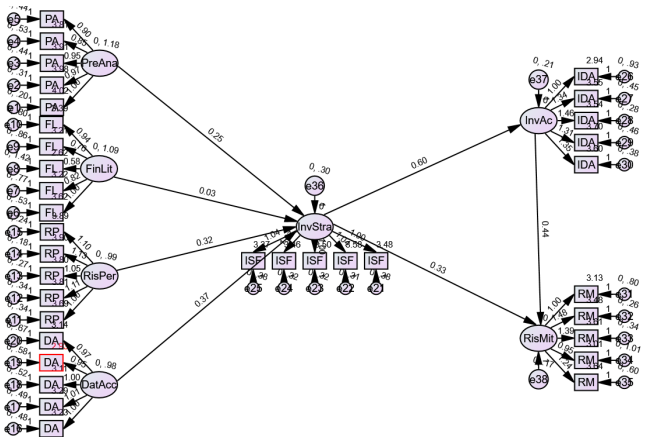

Figure III: Structure Equation Modelling

TABLE 5: Hypothesis Testing

Hypothesis No	Framed Hypothesis	P-Value	Result
H_1	Predictive Analytics Tools Utilization-> Investment Strategy Formulation	0.00	Supported
H_2	Financial Literacy-> Investment Strategy Formulation	0.00	Supported
H_3	Risk Perception-> Investment Strategy Formulation	0.00	Supported
H_4	Data Accessibility-> Investment Strategy Formulation	0.00	Supported
H_5	Investment Strategy Formulation-> Investment Decision Accuracy	0.00	Supported
H_6	Investment Strategy Formulation-> Risk Mitigation	0.00	Supported
H_7	Investment Decision Accuracy-> Risk Mitigation	0.00	Supported

The analysis shows that the utilization of predictive analytics tools significantly influences the formulation of investment strategies. This suggests that investors who actively use predictive tools are more likely to develop informed and well-structured strategies. Predictive analytics provides valuable insights by analyzing past data, helping investors identify trends and optimize their investment decisions.

The impact of financial literacy on investment strategy formulation is also strongly supported. Investors with higher levels of financial knowledge are better equipped to interpret data and make strategic decisions. Financial literacy enables individuals to understand market dynamics and incorporate that understanding into creating more effective investment strategies.

Risk perception plays a crucial role in the formulation of investment strategies. Investors who are more aware of potential risks are better at shaping strategies that mitigate those risks. This finding highlights the importance of accurately assessing risk in order to develop strategies that balance potential rewards with possible downsides.

The accessibility of data is shown to have a significant effect on investment strategy formulation. Investors who have easy access to comprehensive and real-time data are better positioned to create strategies that are both timely and effective. Data accessibility enhances decision-making by providing investors with the necessary information to evaluate opportunities and risks.

Investment strategy formulation significantly influences investment decision accuracy. This means that investors who develop well-structured strategies based on predictive tools and financial knowledge are more likely to make precise and profitable investment decisions. Accurate strategies lead to better-aligned investment decisions with desired financial outcomes.

Additionally, the relationship between investment strategy formulation and risk mitigation is strongly supported. Investors who take the time to formulate detailed strategies are more capable of minimizing financial risks. This finding underscores the importance of strategy formulation as a means of protecting against losses while pursuing financial gains.

Lastly, investment decision accuracy significantly impacts risk mitigation. Investors who make accurate decisions based on sound strategies are more successful in reducing financial risks. This demonstrates that decision accuracy plays a key role in managing risk and enhancing the overall stability of an investor's portfolio.

8. MANAGERIAL IMPLICATIONS

Organizations should invest in advanced predictive analytics tools to enhance the quality of investment strategies. By integrating these tools into decision-making processes,

managers can improve the accuracy of predictions, helping investors craft more effective and data-driven strategies.

Managers should prioritize financial literacy training programs for their teams, as improved financial knowledge can significantly enhance the ability to formulate effective strategies. Empowering employees with strong financial acumen will lead to better analysis, strategic planning, and more informed investment decisions.

Organizations should encourage managers to assess and integrate risk perception into their strategic frameworks. By understanding and mitigating risks, managers can develop more resilient strategies that safeguard against market uncertainties, ensuring long-term investment success.

Managers should focus on improving the accessibility of financial and market data for their teams. By ensuring that employees have timely and comprehensive data, managers can enable more informed and agile strategy formulation, leading to improved investment performance.

Managers must emphasize the importance of a well-formulated strategy to enhance decision accuracy. Implementing structured strategic processes in investment decisions will increase the likelihood of achieving precise and profitable outcomes, benefiting both the organization and its stakeholders.

Encouraging thorough investment strategy formulation can significantly aid in mitigating risks. Managers should implement robust planning mechanisms to ensure that strategies account for potential risks, leading to more secure investments and protecting organizational assets.

Managers should aim to improve decision accuracy through rigorous strategy evaluation and data analysis. Accurate decisions not only enhance investment performance but also effectively reduce exposure to financial risks, fostering organizational stability in volatile market conditions.

9. CONCLUSION

Highlights the critical interplay between predictive analytics, financial literacy, and data accessibility in shaping effective investment strategies. The findings demonstrate that utilizing predictive tools and fostering financial knowledge significantly enhance investment decision accuracy and mitigate financial risks. Additionally, risk perception plays a key role in developing resilient strategies, while data accessibility further strengthens the formulation process. The results underscore the importance of integrating both technology and education in decision-making processes to optimize investment outcomes. By applying these insights, organizations and investors can improve their strategic planning, achieve better financial performance, and effectively manage market uncertainties.

10. LIMITATIONS

Additionally, the sample is geographically confined to certain regions, which may limit the generalizability of the findings to broader or international markets. The study also focuses primarily on quantitative analysis, which may not fully capture the nuanced behavioral aspects of investment decision-making. Lastly, the rapid evolution of technology in predictive analytics means that the tools and trends analysed here could quickly become outdated, limiting the long-term applicability of the findings.

11. FURTHER RESEARCH

Explore a more diverse and global sample to enhance the generalizability of the findings. A mixed-methods approach that includes qualitative data, such as interviews or case studies, could provide deeper insights into the behavioral factors influencing investment decisions. Further studies could also examine the role of emerging technologies, such as blockchain or AI, in predictive analytics, to understand their impact on investment strategies. Additionally, exploring the intersection of predictive analytics with other forms of financial education or knowledge-sharing initiatives could offer new perspectives on how best to empower investors in an increasingly data-driven world.

12. DECLARATION

I, [Your Full Name], hereby confirm that the manuscript titled "[Title of the Paper]" authored by [Author(s) Full Name(s)], has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to [Name of the Journal/Conference].

I/we declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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Factors Affecting the Organizational Adoption of Block Chain in BFSI Sector

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ABSTRACT

The advantages of block chain technology (BCT) for practically every business have led to its growing popularity. Nevertheless, despite its advantages, BCT is not widely used in organisations.This lack of adoption served as our impetus to determine the organizational elements influencing BCT adoption. The theoretical framework of technology-organization- environment (TOE) paradigm is used to analyze the factors that affect the BFSI sector's adoption of block chain technology. This differs from earlier research that used the united theory of acceptance and use of technology (UTAUT), theory of planned behavior (TPB), and technology acceptance model (TAM) models. A survey of 150 professionals in India's BFSI sector was used to gather data. The results suggest that support from top management turned shown to be a crucial factor, highlighting the need for leadership dedication for BCT adoption to be successful. It's interesting to see that perceived benefits strongly influenced adoption intentions, despite compatibility and complexity having no discernible effect. This supports the idea that real benefits are what motivate people to accept new technologies. The IT and financial resources showed moderate importance, suggesting that although they are significant, they might not be independent drivers. Given the importance of financial operations, environmental factors— particularly perceived risk and larger environmental contexts—emphasized the BFSI sector's cautious stance.

1. INTRODUCTION

Any new revolutionary technology would present both opportunities and difficulties when introduced **(El-Haddadeh et al., 2019).** BCT is a digital ledger that is arranged in blocks and dispersed throughout a network so that users from various institutions can access, share, and validate it **(Adams et al.,2017; Francisco and Swanson,2018; Treiblmaier,2018; Queiroz et al., 2020).**The block chain's built-in algorithms create strong, disruptive distributed ledgers that have the potential to revolutionize how public and private services are delivered, increasing productivity through a wide range of applications (**Probst, et al., 2016**). There are two types of BCT chains: public and private. An open network that permits anybody to join without any limitations is known as a public block chain (**Viriyasitavat and Hoonsopon,2019; Ying et al., 2018; Marsal-Llacuna,2018**) and decentralizes trust because it is not controlled by a single authority (**Saberi et al.,2019; Alabi,2017**).A private block chain network, on the other hand, is regulated and managed by a central authority, which permits greater control while simultaneously limiting participation (**Morkunas et al.,2019; Vranken,2017**).The block chain has become a disruptive breakthrough with a wide range of uses that has the potential to reshape how we interact in politics, business, and society at large **(Atzori,2015).**The Distributed Ledger Technology **(**DLT) has applications in risk management, healthcare facilities, financial services, and social services, in addition to crypto currency (**Monrat et al., 2019).** The block chain applications are currently being utilized in securities, remittance, settlement, and smart contracts **(Yoo, S. 2017).** Applications for the DLT include supply chain financing, peer-to-peer lending, cross-border remittance, online financial payments, credit investigation, and crowd funding (**Wang et al., 2020). It is popular in** e-commerce payments, corporate finance, corporate governance, cash management and treasury applications, as well as more broadly for many of a firm's management processes **(Collomb, and Klara, 2016**).This innovative technology offers enormous prospects, and the revolution in this field has only started. In both the financial and non-financial sectors, the block chain offers some attractive niche applications. The advent has been hailed as the next great revolution that will change the size and makeup of the banking and finance sector as well as the manner in which commerce is done **(Cermeño, 2016).**The block chains are the center of attention as the future generation of financial technology because of its security, which is suited for the information age as it provides security through hash value generation, encryption, and peer authentication for exchanging virtual currency (**Park and Park, 2017**). The block chain technology is a key component of this revolution in the financial sector, where financial innovations have sparked a new paradigm shift in driving innovation **(Lee and Shin, 2018).**Block chain technology can help advance sustainable development and optimize the global financial system. In fact, a lot of institutions are currently focusing on block chain technology in order to promote economic growth and speed the development of green technologies **(Cocco et al., 2017).**

2. REVIEW OF LITERATURE

The internal and exterior operations of an organization are significantly altered by the implementation of block chain

technology **(Gunasekera and Valenzuela, 2020).**Consequently, academics' interest in the organizational adoption of BCT has grown significantly **(Clohessy and Acton, 2019**).**On probing** the use of BCT in wealth management sector it has been exposed that the primary deterministic factors influencing the organizational adoption of BCT are the relative benefits, computability, complexity, supportive technical environment, industry characteristics, and laws (**De Castro et al., 2020)**.When examining the variables influencing the adoption of BCT in the logistics sector it has been found that the primary important elements for BCT adoption are the availability of certain BCT tools, infrastructure, and government backing and policy(**Orji et al., 2020; Dobrovnik et al.,2018;Barnes and Xiao,2019,Kühn, et al. 2019).**With regard to the use of BCT in the supply chain sector, the key elements identified were relative advantages, complexity, support from top management, cost, market dynamics, competitive pressure, and regulatory support **(Wong et al., 2020; Wong et al., 2020; Bai and Sarkisb,2020; Kouhizadeh et al., 2021; Ghode, et al., 2020; Kalaitzi, et al., 2019)**.The adoption of BCT is influenced by company size, top management support, and BCT awareness (**Clohessy and Acton 2019).When** examining the use of BCT in a variety of businesses, such as land record management and shipping it has been demonstrated how cost savings, data quality and dependability, and simple transaction verification affect an organization's choice to use BCT (**Loklindt et al., 2018; Mohammed and Yang, 2020; Post, et al.,2018; Hoxha and Sadiku 2019; Holotiuk and Moormann,2018).The** factors influencing BCT adoption in banks and the public sector include company size, learning culture, top management, client preparedness, competitive pressure, and governmental regulations**(Kulkarni and Patil ,2020;Koster and Borgman,2020).When** examining the BCT adoption process after making a decision, it has been found out that, market power, regulation, transaction speed, prices, transparency, secrecy, and interoperability to be the main determinants of BCT application (**Albrecht et al.,2018).**The main elements influencing BCT implementation in the energy sector were market power, regulation, sustainability transaction speed, prices and transparency, secrecy, and interoperability (**Albrechtet al.,2018).**In its most recent financial stability report of the Reserve Bank of India (RBI) made remarks regarding the potential of block chain technology. The RBI thinks it has the potential to significantly alter the financial markets. It has acknowledged the various applications that block chain technology offers, but it has also voiced apprehension about the lack of knowledge regarding its ramifications. Despite this initial enthusiasm, a **Deloitte-CII research from 2020** states that the industry must work together to address a few significant issues if block chain technology is to be widely used. Security, scalability, lack of standardization, and shifting legal and regulatory clarity are some of these. The services industry is expanding rapidly in the developing Indian economy. The banking, financial services and insurance (BFSI) digital initiatives have changed the procedures and services offered. One of the cutting-edge technologies in banking that has lowered processing costs and provided a global network solution is block chain (**Hanifatunnisa and Rahardjo, 2017**). With a 31% year-over-year (YoY) increase, the Indian BFSI sector is on the rise. Nonetheless, according to a McKinsey analysis, financial institutions must contend with issues like shifting industry regulations, fierce rivalry, and higher operating costs. In order to address these issues, businesses are implementing disruptive technologies like block chain, artificial intelligence, and machine learning. **While block chain technology is very promising, there are a number of issues that could prevent it from being used quickly such as technological, organizational and environmental factors.** The present research highlights how critical it is to bridge the knowledge gap between academic and industry publications in order to validate the achievements of block chain (BC). By overcoming implementation challenges, BCT have the potential to revolutionize the financial sector and boost stakeholder trust and operational efficiency.

3. RESEARCH GAP

Based on current examination of the literature, it seems that there are research gaps with regard to block chain technology **(Lindman et al., 2017)** apart from few significant scholarly investigations and publications in this developing sector **(Yli-Huumo et al., 2016).** So the practical and theoretical views of block chain technology need additional research studies **(Du et al., 2019).**

4. RESEARCH PROBLEM

The BFSI sectors is facing challenges to adopt block chain technologies due to technological factors like compatibility and complexity, organizational factors like top management support and organizational size and environmental factors like competitive pressure and government policy which makes it more complex. To tackle the issue there shall be an in-depth understanding of the insight of technological, organizational and environmental factors using TOE model in India's BFSI sector.

5. RESEARCH OBJECTIVES

5.1 TECHNOLOGICAL CONTEXT

- 5.1.1 To investigate how perceived benefits of block chain influences the adoption intentions in the BFSI sector.
- 5.1.2 To examine the impact of perceived compatibility with the existing systems on the adoption of block chain at the BFSI sector.
- 5.1.3 To consider how perceived complexity affects the adoption intentions at the BFSI sector.

- 5.1.4 To explore how perceived trust is crucial BFSI sectors intention to adopt block chain.

5.2 ORGANISATION CONTEXT

- 5.2.1 To analyse the role of organizational size with regard to the intention of BFSI sector in adopting the block chain
- 5.2.2 To evaluate how top management support is crucial in adopting the block chain in the BFSI sector in India
- 5.2.3 To investigate how crucial the IT resource and financial resource with regard to adoption the block chain in the BFSI sector in India

5.3 ENVIRONMENT CONTEXT

- 5.3.1 To investigate how competitive pressure affects the in intention of organization with regard to block chain adoption in the BFSI sector in India
- 5.3.2 To find out how crucial is Government policies and regulation with regard to adoption of block chain

6. THEORETICAL FRAMEWORK AND DETERMINANTS OF BLOCKCHAIN ADOPTION IN BFSI SECTOR

Adoption, application, and management of business analytics have been examined by researchers from a variety of theoretical angles. The unified theory of acceptance and use of technology (Venkatesh et al., 2003) and the technology acceptance model (TAM) by (Davis, 1986) are the two most widely used theories of technology adoption at the individual level. The diffusion of innovations (DOI) (Rogers, 1995) and the TOE framework (Tornatzky and Fleischer, 1990) are important frameworks for innovation adoption with the organization as a unit of analysis. **Tornatzky, and Klein, 1982** examined the relationship between innovative or technology aspects and adoption. The 10 characteristics that were most frequently used were relative advantage, complexity, communicability, divisibility, cost, profitability, compatibility, social acceptance, trialability, and observability. Adoption studies were found to be consistently linked to cost, compatibility, complexity, and relative benefit among these eleven criteria. The majority of the current BCT research is conceptual in nature, and there is empirical data regarding BCT adoption. To hasten the acceptance of BCT, it is crucial to investigate the elements influencing it (Francisco and Swanson 2018). Thus, the present study employs the Technology-Organization- Environment (TOE) framework to examine BCT adoption in BFSI sector from organisational perspective. BCT adoption from an organizational perspective has been the subject of very few researches. Although the adoption of technology is frequently facilitated by certain organizational variables and perceived organizational benefits, the lack of enablers may operate as an adoption barrier. The stream of research on organizational technology adoption indicates that the aspects that are most pertinent to the adoption of technologies generally are technological, organizational, and environmental. The impact of both internal and external technology elements on the acceptance of innovations can be explained by technological context (Tornatzky and Fleischer 1990). The firm's size, level of formalization and centralization, administrative structure, human resources, and employee relationships are only a few of the attributes and resources that are described by the organizational variable (Tornatzky and Fluischer 1990). The external circumstances surrounding business operations are regarded as the environmental setting (Tornatzky and Fleischer 1990; Zhu et al. 2006; Low et al. 2011).

7. RESEARCH METHODOLOGY

The research data is gathered and analysed by the study using a quantitative methodology.

7.1 RESEARCH METHOD

The survey method using a standardized questionnaire has been used to gather data or information from a particular group. Additionally, the survey approach saves money and time, is easier to administer, and is free from respondent bias. Consequently, it was applied in this research.

7.2 UNIT OF ANALYSIS AND UNIT OF OBSERVATION

The entity that a researcher claims their findings are about at the conclusion of the study is known as a unit of analysis. Individuals, groups, or organizations may be involved, contingent on the specifics of the study. Conversely, an entity that a researcher observes while looking at a particular aspect of the unit of analysis is known as a unit of observation. Indian organizations served as the study's unit of analysis, and middle-level managers, senior IT personnel including CTOs and IT directors, and top-level executives with at least three years of BCT-related training and experience served as the unit of observation. Additionally, they have experience developing block chain solutions for the BFSI industry and are specialists in IT, banking, insurance, Fin- Tech, and non-banking financial firms. Because they are consistently knowledgeable about the organization's strategies and decisions, including the adoption of new technology, this group of senior management and IT personnel was chosen. Screening questions were included at the beginning of the offline survey in order to automatically exclude the undesired unit of analysis and the unit of observation. The screening questions aid in maintaining the relevance of survey results and preventing respondent bias.

7.3 TARGET POPULATION AND SAMPLING

The study's target group was Indian BCT adopters and prospective adopter organizations. The research examined a

variety of internet resources, such as the Google, LinkedIn, and BCT- related websites, to determine the overall population. The total population size derived from these offline sources was 101 organizations from various industries, which contributed to the target population's diversity. For the sampling the research used snow ball sampling began with a limited number of initial contacts who were invited to join by the research after meeting the research criteria. Those who have given the consent to participate became a part of the study along with the reference of other participants who have taken part as well. Until the required sample size was attained, the procedure was repeated.

7.4 MEASUREMENT SCALE

The Scales were from earlier research (Nunnally, 1978; Churchill et al., 1974). For this study, a 5-point Likert scale with an interval between "strongly disagree" and "strongly agree" was created to measure the items.

7.5 PILOT STUDY FOR RELIABILITY AND VALIDITY

By using information from 30 completed questionnaires, the pilot study has taken place .The pilot study's sample was taken from the same sample frame as the primary investigation. The questionnaire was validated by seasoned academicians and subject-matter experts.The degree of internal consistency and error freedom of variable measurement items at any given time can be examined with the aid of reliability assessment (Kline, 2015). The reliability of the data is assessed using Cronbach's alpha (Hair et al., 2014).

7.6 DATA COLLECTION AND ANALYSIS

The research took place in four major Indian cities such as Mumbai, Bangalore, Hyderabad, and Chennai in the month of August 12, 2024 to October 19, 2024. The investigation has been concentrated on these places because of their importance in the economic and technological domain. The original sample consisted of 175 individuals, in the age group of 21years to 50 years with an acceptable response rate of 85.71% is indicated from professionals in the BFSI sector (**Moss & Hendry, 2002**). A total of 150 were made available for use in the final analysis following the data cleaning procedure with the help of SPSS 20.0

8. DESCRIPTIVE ANALYSIS ON SAMPLE

TABLE 8.1: Frequency Distribution the gender of respondents in BFSI sector.

Gender	Frequency	Percent	Cumulative Percent
Male	102	68.0	68.0
Female	48	32.0	100.0
Total	150	100.0	

The 68% of the respondents who are working in the area of block chain at different levels of an organization in BFSI sector are male and rest of them female. It may be due to the fact that the adoption of the technology is at the initial level, more challenging and higher risk involved it.

TABLE 8.2 Frequency Distribution of the place of living of respondents in BFSI sector.

Place of living	Frequency	Percent	Cumulative Percent
Chennai	48	32.0	32.0
Bangalore	45	30.0	62.0
Hyderabad	24	16.0	78.0
Mumbai	33	22.0	100.0
Total	150	100.0	

The research has been concentrated in four major Indian cities such as Mumbai, Bangalore, Hyderabad, and Chennai because of their importance in the economic and technological domain. The highest participants are from Chennai followed by 30% from Banglore, 22% from Mumbai and 16% from Hyderabad. It may be due to the fact that Chennai is coming up as an ideal Fin- tech eco-system.

TABLE 8.3: Frequency Distribution of the Age Group in years of respondents in BFSI sector.

Age Group in years	Frequency	Percent	Cumulative Percent
21-30	51	34.0	34.0
31-40	66	44.0	78.0
41-50	33	22.0	100.0
Total	150	100.0	

The 66% of the respondents who are working in the area of block chain at different levels of an organization in BFSI sector in India are in the age group of 31-50, and rest 34% belongs to 21-30 years. It may be due to the fact that opportunities in this area that require a greater understanding of block chain technology.

TABLE 8.4: Frequency Distribution of the Educational Qualification of respondents in BFSI sector

Educational Qualification	Frequency	Percent	Valid Percent	Cumulative Percent
UG	24	16.0	16.0	16.0
PG	21	14.0	14.0	30.0
UG Engineering	45	30.0	30.0	60.0
PG(MCA/M.Tech)	48	32.0	32.0	92.0
Doctorate	12	8.0	8.0	100.0
Total	150	100.0	100.0	

From the above table 16% of the respondents in the BFSI sector have completed graduation in science/arts/humanities/commerce stream, 30% from engineering background,14% PG science/arts/humanities/commerce stream, 32% MCA/M.Tech,and 8% holding a PhD Degree. So 62% the chosen participants had first-hand knowledge of creating block chain solutions for the BFSI space and were experts in the fields of IT, Banking, insurance, Fin- Tech, and non-banking financial companies hold a professional degree.

9. TECHNOLOGICAL, ORGANISATIONAL AND ENVIRONMENTAL FACTORS (TOE) ON ADOPTION

The many organizational, technological, and environmental viewpoints for block chain within the BFSI industry are identified in the current study.

9.1 TECHNOLOGICAL PERSPECTIVE

The pool of internal and external technologies available to the company is referred to as the technical dimension (TP) of the TOE model. Examining the internal and external technologies that affect BT's adoption in the BFSI industry is made possible by the technology dimension. It takes into account the choice and decision-making process regarding the adoption of hardware, software, and networks, as well as how they are persuasively modified to carry out the block chain adoption in established protocols (Aslam et al., 2021). The technological feature for implementing BT in the BFSI industry has not received much attention up to this point. As a result, the current study identifies the following factors:

9.1.1 PERCEIVED BENEFIT (PB)

According to De Castro et al., 2020 indicated that firms adopt BCT at a positive rate due to perceived benefits. Consequently, the following hypothesis is proposed:

9.1.2 COMPATIBILITY (PC)

Perceived compatibility refers to an organization's perception of how technology would be aligned with its business objectives (DiMaggio and Powell 1983). When organisations believe BCT is compatible with their IT infrastructure, they are more likely to adopt it (De Castro et al., 2020). Therefore, businesses are more inclined to adopt block chain technology if they believe they are more compatible. So the following hypothesis can be framed for the study:

9.1.3 COMPLEXITY (PC)

Perceived complexity refers to the extent to which organizations consider BCT to be challenging to comprehend and utilize(De Castro 2020).The adoption of BCT is hampered by its complexity(Wong et al., 2020).Organizations are hesitant to embrace BCT because of its technical aspects, which include hashing blocks and using public and private keys (Sadhya, and

Sadhya 2018). Consequently, businesses are less inclined to adopt block chain technology if they believe it to be more complex.

9.1.4. TRUST (PT)

The convenience, adaptability, and perceived advantages of the technology for the users' activities serve as the foundation for the first trust (Koufaris and Hampton-Sosa, 2004). The adoption of new technology, such as blockchain technology, depends heavily on initial trust among users who are new to or less tech-savvy (Franque et al., 2023; Kim and Prabhakar, 2004; Oliveira et al., 2014).

9.2 ORGANIZATIONAL PERSPECTIVE

According to Gide and Sandu (2015), the TOE framework's organizational perspective refers to the firm's internal features and resources, encompassing both tangible and intangible assets. Earlier research (Alsetoohy et al., 2019; Damanpour, 2016; Gutierrez et al., 2015; Moch and Morse, 1977) has delineated a number of elements that encompass the organizational perspective. The following factors are taken into consideration:

9.2.1 ORGANIZATIONAL SIZE (OS)

Numerous studies have demonstrated the impact of organizational size on the uptake of innovations (Premkumar and Roberts 1999; Rogers, 1995).Large companies usually have the financial wherewithal to test a new innovation and then decide whether to embrace it or not (Premkumar and Roberts, 1999). As a result, larger businesses are more likely to use blockchain technology.

9.2.2 TOP MANAGEMENT SUPPORT (TMS)

Adopting new technologies within an organization requires the full backing of top management. The likelihood of implementing an innovation like BCT is decreased when there is a lack of leadership backing (Koster and Borgman, 2020). The degree to which management's values align with those of new innovation adoption, thereby fostering a supportive environment and allocating sufficient resources for its adoption, is known as top management support (Useem,1993; Teo et al.,2004). Thus, organizations are more likely to implement Block chain technology if top management shows a stronger commitment to the technology.

9.2.3. THE IT EXPERTISE (IT)

Adoption of innovations depends on technological resources, which are embodied by suitable technical infrastructure and knowledgeable individuals. Businesses without sufficient IT knowledge might not be aware of new technologies or might not be able to implement them. IT expertise has been utilized as a key variable predicting adoption in innovation diffusion

research (Kwon and Zmud, 1987; Premkumar and Roberts 1999).

9.2.4 FINANCIAL RESOURCES (FR)

A corporation can get a longer-lasting competitive advantage in the market when more money is set aside for the implementation and upkeep of technical advancements (Kumar and Krishnamoorthy, 2020; Marouf khani et al., 2020).For adoption to be successful, financial resources are essential, particularly in BT (Al-Hujran et al., 2018;Alshamaila et al., 2013;Amini and Bakri 2015;M'rhaouarh et al.,2018).

9.3 ENVIRONMENTAL PERSPECTIVE

Environmental perspective refers to impacts arising from external sources of the firm. The major indicators that have been identified in the study are outlined below:

9.3.1 COMPETITIVE PRESSURE (CP)

It refers to the degree to which an innovation is adopted in the firm's industry. It is perceived to be positively influencing innovation adoption in an organization. (Kuan and Chau, 2001). Thus companies which experience greater competitive pressure are more likely to adopt block chain technology. The degree to which an organization fears losing its competitive advantage is referred to as competition intensity, sometimes called competitive pressure or external pressure. It has been established that the level of competition is a crucial component in the organizational adoption of BCT (Wong et al., 2020).In an attempt to stay competitive, rival organizations emulate an organisation that implements BCT. The adoption of BCT by an organization is driven by competitive pressure (Wong et al., 2020).

9.3.2 GOVERNMENT SUPPORT (GS)

The policies, programs, and rewards that a government offers to encourage the use of technology are referred to as government support. The Government backing is a key factor accelerating the BCT adoption process (Koster and Borgman, 2020). When a government doesn't offer appropriate assistance, including the creation of legislation, it is impossible for organizations to widely embrace BCT (De Castroet al., 2020) Support from the government is essential to the adoption of BCT (Kulkarni and Patil,2020 and Wong et al., 2020).

9.4 PERCEIVED RISK (PR)

The financial sector is worried about perceived security threats, such as privacy concerns, system faults, password loss, incompatibility between operating systems, security software, low system quality, while utilizing cutting-edge technology like block chain in financial operations. The intention to employ BCT is significantly impacted by the security risk concerns. The Perceived security risk as an external factor impacting variables has been the subject of numerous research (Chao,2019; Martins et al.,2014; Thusi and Maduku,2020).

10. HYPOTHESIS TESTING

10.1 Null Hypothesis: There is no significant difference in technology context with regard to intention to adopt.

The Levene's Test									
Technology context	**Levene's Test for Equality of Variances**		**t-test for Equality of Means**						
	F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
								Lower	**Upper**
Perceived Benefit	3.799	.053	2.646	148	.009	.999	.377	.253	1.745
			2.333	69.317	.023	.999	.428	.145	1.853
Perceived Compatibility	6.873	.010	1.824	148	.070	.685	.376	-.057	1.427
			1.622	70.532	.109	.685	.422	-.157	1.527
Perceived Complexity	11.047	.001	1.266	148	.207	.511	.404	-.287	1.309
			1.115	69.152	.269	.511	.458	-.403	1.425
Perceived Trust	4.546	.035	1.132	148	.259	.474	.419	-.353	1.302
			1.035	74.741	.304	.474	.458	-.438	1.387
Overall Technology Context	14.594	.000	2.068	148	.040	2.669	1.291	.118	5.220
			1.722	62.252	.090	2.669	1.550	-.429	5.767

In case of Perceived Benefit a significant difference in perceptions was found (t = 2.646, p =.009), with a mean difference ranging from 0.253 to 1.745 (CI =.999). With a mean difference between 0.145 and 1.853 (CI =.999), the difference remained significant even when unequal variances were assumed (t = 2.333, p =.023). This implies that there are substantial differences in how the groups view advantages. As far as Compatibility is concerned, the t-tests showed no significant changes in group perceptions, whether assuming equal variances (t = 1.824, p =.070) or unequal variances (t = 1.622, p =.109), despite the variance analysis showing differential variances (F = 6.873, p =.010). As a result, there are no discernible variations in the groups' perceived compatibility. **For Complexity there is** Unequal variances were evident (F = 11.047, p = .001), but t-tests indicated no significant differences in perceptions of complexity, whether assuming equal variances (t = 1.266, p = .207) or unequal variances (t = 1.115, p = .269). This suggests no discernible variation in the perception of complexity across groups. For Trust regardless of the assumption of equal (t = 1.132, p =.259) or unequal variances (t = 1.035, p =.304), t-tests showed no significant changes in judgments of trust, even if unequal variances were present (F = 4.546, p =.035). As a result, there is little difference in how the groups view trust. In nut shell as far as Technology Context there was a noteworthy difference (F = 14.594, p=.000). With a mean difference of 2.669 (CI: 0.118–5.220), the t-test revealed a significant difference under the assumption of equal variances (t = 2.068, p =.040). Nonetheless, the difference was not significant when unequal variance assumptions were applied (t = 1.722, p=.090). This discrepancy implies that variance assumptions underlie variations in how the technology setting is perceived. In conclusion, no significant differences were discovered for compatibility, complexity, or trust, but there were notable disparities in views of perceived benefit and, to a lesser extent in technology context.

Null Hypothesis: There is no significant difference in organizational context with regard to intention to adopt.

Independent Samples Test									
Organisational context	**Levene's Test for Equality of Variances**		**t-test for Equality of Means**						
	F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
								Lower	**Upper**
Perceived Organizational Size	6.414	.012	-.262	148	.794	-.077	.295	-.660	.506
			-.230	68.732	.819	-.077	.336	-.748	.593
Perceioved Top Management Support	8.198	.005	2.630	148	.009	.870	.331	.216	1.524
			2.246	65.145	.028	.870	.387	.096	1.644
Perceived IT Resources	12.886	.000	1.889	148	.061	.917	.485	-.042	1.876
			1.650	68.001	.104	.917	.556	-.192	2.026
Perceived Financial Resource	18.054	.000	2.181	148	.031	.641	.294	.060	1.222
			1.715	56.598	.092	.641	.374	-.108	1.389
Overall Organisation Context	15.200	.000	1.907	148	.059	2.350	1.233	-.086	4.787
			1.551	59.807	.126	2.350	1.515	-.680	5.381

In case organizational size, p = 0.012 adjusted for unequal variances, the t-test is non-significant (p = 0.819), indicating that opinions about organizational size do not differ significantly. In case of Top Management Support Variances are not equal, according to Luke's test: p = 0.005 p = 0.005.There is a significant difference with regard to top management support, according to the t-test (corrected for uneven variances) (p=0.028).As far as IT Resources Variances are not equal, test: p<0.001.There isn't a significant difference in how people view IT resources, according to the t-test (corrected for uneven variances) (p=0.104).The Perceived Financial Resource test indicates that variances are not equal if p<0.001.Although not significant (p = 0.092), the t-test (corrected for unequal variances) is close to significance.

With additional data, a trend might be worth investigating further. As far as Overall Organisational Context Variances are not equal, p<0.001.There is no general difference in how people perceive the organisational setting, according to the t-test (corrected for uneven variances), which is not significant (p=0.126). Null Hypothesis: There is no significant difference in environmental context with regard to intention to adopt.

Independent Samples Test									
Environmental context	**Levene's Test for Equality of Variances**		**t-test for Equality of Means**						
	F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
								Lower	**Upper**
Competitive pressure(CP)	11.114	.001	1.287	148	.200	.817	.635	-.438	2.073
			1.115	66.944	.269	.817	.733	-.646	2.281
Government support(GS)	1.655	.200	1.494	148	.137	1.071	.717	-.346	2.488
			1.438	84.035	.154	1.071	.745	-.410	2.552
Overall Environment Context	11.513	.001	2.125	148	.035	2.567	1.208	.180	4.955
			1.862	68.459	.067	2.567	1.379	-.183	5.318
Perceived Risk	9.723	.002	.594	148	.554	.313	.526	-.727	1.352
			.547	75.834	.586	.313	.572	-.826	1.451
Organisation Intention to Adopt ICT	8.937	.003	2.632	148	.009	.542	.206	.135	.948
			2.212	63.239	.031	.542	.245	.052	1.031

There were conflicting results from the examination of the environmental context and associated variables. The t-tests revealed no significant differences in group perceptions for Competitive Pressure (CP), whether assuming equal variances (t = 1.287, p =.200) or unequal variances (t = 1.115, p =.269). However, uneven variances were indicated (F = 11.114, p =.001). In a similar vein, variances for Government Support (GS) were about equal (F = 1.655, p =.200), and neither the assumption of unequal variances (t = 1.438, p =.154) nor of equal variances (t = 1.494, p =.137) revealed any significant differences. In contrast, uneven variances were significant for the Overall Environmental Context (F = 11.513, p =.001), and perceptions under the assumption of equal variances differed significantly (t = 2.125, p =.035), indicating a mean difference of 2.567 (95% CI: 0.180–4.955). Under the assumptions of unequal variance, this significance decreased (t = 1.862, p =.067). Although there were unequal variances for perceived risk (F = 9.723, p =.002), neither assumption was associated with any significant differences (p >.05). Lastly, unequal variances (F = 8.937, p =.003) were observed for Organisational Intention to Adopt ICT. Perceptions under both equal variances (t = 2.632, p =.009) and unequal variances (t = 2.212, p=.031) showed significant differences, with a mean difference of 0.542 (95% CI: 0.135–1.031). These results imply that although organisational intention to embrace ICT and views of the overall environmental setting differed significantly, other factors such as perceived risk, government backing, and competitive pressure did not.

11. MAJOR FINDINGS AND DISCUSSION

With an emphasis on organizational, technological, and environmental aspects, the study examines the implementation of Blockchain Technology (BCT) in India's BFSI (Banking, Financial Services, and Insurance) industry. A standardized questionnaire was used to gather information from top executives, CTOs, and senior IT staff in four major Indian cities working in the BFSI industry. Using a quantitative technique and SPSS for data cleaning and analysis, the study investigated a number of factors impacting the adoption of BCT. The study looked at technology aspects like trust, compatibility, perceived benefits, and complexity. Significant variations in benefit perception were observed (t = 2.646, p = 0.009), indicating that certain groups have a more positive opinion of BCT's benefits. Perceived compatibility (t = 1.824, p = 0.070), complexity (t = 1.266, p = 0.207), and trust (t = 1.132, p = 0.259) did not, however, show any significant differences. These results suggest that although different groups have varying perceptions of the benefits of BCT, compatibility, complexity, and trust are typically not thought to be

differentiating factors in adoption intentions. The research also looked at organisational characteristics like size, financial resources, IT resources, and support from upper management. The findings showed that while opinions on organizational size did not differ significantly (p =0.819), opinions on top management support did (p = 0.028), suggesting that this support is crucial for the adoption of BCT. Financial resources were nearly significant (p = 0.092), indicating a possible tendency for additional research, even if IT resources did not exhibit significant differences (p = 0.104).Environmental elements such as government assistance and competitive pressure were also investigated. Government assistance (t = 1.438, p = 0.154) and competitive pressure (t = 1.287, p = 0.200) did not significantly vary. Perceptions of the overall environmental context, however, showed significant differences (t = 2.125, p = 0.035), suggesting that organizational intentions to embrace ICT vary depending on the larger environmental context. Significant differences were also observed in organizational intention to adopt BCT (t = 2.632, p = 0.009), highlighting the fact that a variety of contextual factors impact a company's preparedness to adopt new technologies. With notable variations in some aspects but not in others, the results generally emphasize the significance of top management support and technology advantages in the BFSI sector's adoption of BCT. These findings imply that external factors like as competitive dynamics and governmental backing have a secondary influence on adoption decisions, even though organizational and technological preparedness is crucial.

12. LIMITATIONS AND SCOPE FOR FUTURE RESEARCH

The data collected for the study is from precise geographic locations with a specific set of BFSI organizations and therefore the result cannot be generalized. The research emphasizes the need for more investigation into the interoperability issues, sector-specific subtleties of block chain adoption, and financial resource limitations. Additionally, studies may shed light on how adoption patterns change over time, especially in reaction to shifting technical and regulatory environments. The results give practitioners, legislators, and scholars who want to close the gap between the potential of technology and its actual application a thorough grasp of the elements driving block chain adoption in India's BFSI industry.

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Financial Inclusion: A Comparative Analysis of India, Pakistan & Bangladesh

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ABSTRACT

This paper proposed a multidimensional measure of Financial Inclusion Index (FII) for India, Pakistan and Bangladesh. Findings highlighted that India & Bangladesh categorized under in full Financial Inclusion or High Financial Inclusion category in 2022 due to several Financial Inclusion policies in the countries, but Pakistan remains always in the low Financial Inclusion category hence lack of quality education & awareness regarding the financial system among the people however several policies have been taken place. India secures in the Medium Financial Inclusion category from 2010-2014 & Bangladesh from 2011-2020. After the introduction of Jan Dhan Yojna in India, everyone has a zero-balance account, so the banking transactions has been increased along with the knowledge regarding financial transactions and awareness. Post COVID-19, the online financial transactions have been drastically increased so the Financial Inclusion Index of India also increases & performs better out of the three countries.

Keywords: Financial inclusion, Index, measure, multidimensional.

1. INTRODUCTION

Financial Inclusion is the process which ensuring access to financial services to the weaker section & vulnerable group of the society. In another sense, the inability to get required financial services of the poor people in the society is the excludability from financial inclusion. Clearly visible that financial inclusion is a multi-dimensional situation. Well known that Financial Inclusion & Financial Exclusion are two side of a same coin. It is clearly highlighting that Inclusive finance is important for the nations in view of the fact that the impact of Financial Exclusion is very dangerous. It will also provide an estimate on variation of access to finance in a country level and the reason behind the variation regarding access to finance. What we have defined as poor people, due to certain reason if they are lack behind the formal financial system the share of economic growth become weak. The access to Financial Institutions has been increased significantly along with an increase in income over the past two decades for the majority of world's population (Milanovic 2012).

The Indian Government reports a committee on Financial Inclusion giving definition by as "the process of getting the service of finance appropriately & satisfactorily credit where need of vulnerable category have like needy & deprived people at a reasonable price (Rangarajan Committee 2008)". The Government has approved NMFI- National Mission for Financial Inclusion, that is Pradhan Mantri Jan Dhan Yojna (PMJDY) in August 14 to have globally banking services to each and every family. A digital formal accessibility has been provided for the implementation of PMJDY by link with Jan- Dhan account with Aadhar & Mobile. (Jan-Dhan-Aadhar Mobile) that is JAM trinity. The Indian govt. has been introduced several schemes like:- Pradhan Mantri Jan Dhan Yojna (PMJDY) in the year 2014 August 28, Atal Pension Yojna (APY) in 19 May 2015, Pradhan Mantri Vaya Vandana Yojna (PMVVY) 4 May 2017, April 5 2016 Stand Up India Scheme, Pradhan Mantri Mudra Yojna (PMMY) April 8 2015, Pradhan Mantri Suraksha Bima Yojna (PMSBY) 9 May 2015, Sukanya Samriddhi Yojna January 22 2015, Jeevan Suraksha Bandhan Yojna , Credit Enhances Guarantee Scheme (CEGS) for Schedule Castes (SCs), Venture Capital Fund for Schedule Castes under the Social Sector Initiatives, Varistha Pension Bima Yojna (VPBY) for the implementation of Financial Inclusion. The basic motive is to initiate all the scheme to maintain a sustainable financial system.

2. REVIEW OF LITERATURE

Mandira Sharma (2008) used demand-side analysis of factors associated with financial inclusion to study the association in between financial inclusion and development & to determine indicators of countries related to the level of financial inclusion Based on the availability of comparable data, Sarma (2008). **Loan et.al (2019)** explain the connection between financial inclusion and economic growth in current scenario. Taking the variable like saving, investment, unemployment a multidimensional index of financial inclusion is constructed & the panel econometric method is used to calculate the effect of financial inclusion and economic growth A stronger association between financial inclusion and economic growth is found for countries having low income and relatively lower degree of financial inclusion. **Antonella et.al (2021)** has aimed to understand the determinants of financial inclusion and its impact on economic activity, Secondly, analyzing the implications of

factors related to on financial inclusion and economic growth in the Asian & African countries, Taking literacy rate, unemployment, economic growth, rural population growth and Gini co-efficient as variables. Data collected from world bank, international labor organization, the international monetary fund, the united nation and global Findex database, The panel analysis was used & PCA. & finds economic growth, literacy rate & educational attainment has a straight connection regarding financial inclusion index and there is negative relation exist between gini-c0 efficient and rural population.

Sarma (2008) identify the index of financial inclusion to measure the extent of financial inclusion across economies. The number of bank account per 1000 adults, number of bank branches per 100,000 adults, domestic credit (as % of GDP), domestic deposit (as % of GDP) is considered as the variable. Use the data from world development indicator (2006), world bank: IFS (2006): IMF finds a huge economics, having low levels of financial inclusion. **Chakraborty & Pal (2010)** has analyze a cross-country comparison about financial inclusion and at region wise throughout India. Demographic penetration, the number of bank accounts (per 1000 adults) geographic penetration, the number of bank branches (per 100,000 adults), number of deposit account per 1000 people, number of credit accounts per 1000 people, deposit-income ratio, and credit-income ratio are considered as variable which helps to verify the variations of financial inclusion throughout country also at regional level, here illustrate financial inclusion index. Findings reveals that the above six variables are positively correlated with financial inclusion. **RBI (2014**) tries to include in formal financial system of unbanked people. Findings reveals that as on March 31 2014 the performance of private banks performs been better, as compared to public sector and foreign sector bank. **Demirguc-Kunt & Klapper (2012)** examine the features of adults using formal financial system & find out the reason behind formal account ownership. Taking account penetration, mobile money payments, savings behavior credit & insurance, firms access to finance as variable collect the Global financial inclusion (Global Findex) database & World bank enterprise survey database to identify the barriers to formal account ownership The authors find that less adults people in Africa have an account with a formal financial institution and they use unofficial system for saving and borrowing.

Rashmi Umesh Arora (2012): identified the connection between financial development & human capital in Asia secondly, to identify the recent situations of financial improvement and human capital in developing Asia taking M3/GDP Broad money or liquid asset, M2/GDP Mean year of schooling, no schooling, expenditure per primary student, GDP per capita, Average annual growth rate of GDP per capita as variable used PCA & OLS and finds negative relation remain between financial development proxied by M2/GDP & pupil: teacher ratios positive relation exists in between physical accessibility to banks and expected years of schooling. **Aziz et al (2022)** identified the issue of Asian countries toward the discouragement of females and the reason behind the removal from the formal financial system. Used multilevel model & two- stage logistic regression model results says that gender is co-related with financial services in nations. **Gautam Kumar Biswas** (2023) explored the contribution of F.I on economic growth in 4 South Asian Countries Log of GDP Log of inflation FDI to GDP (%) Log of secondary school enrolment, Log of ATM, Log of bank branch, Log of deposit account, Log of loan account, Log of human capital, FDI used panel data model, GMM, Random effect model & finds F.I & economic growth has positive relation. **Hansen & Lu (2021)** studied the relationship between F.I, energy, Poverty alleviation& economic dev. In South Asian Countries & found significant association. Taking F.I, Eco. Dev. Energy poverty alleviation, Outreach of F.S, penetration of bank bran. Point of sale F.P in rural areas,) Panel data, Dynamic panel, Panel root, Kao estimate ARDL A significant association between. F.I & eco. dev. & poverty reduction. Eco. Dev. Have favourable influences on energy poverty alleviation as variable.

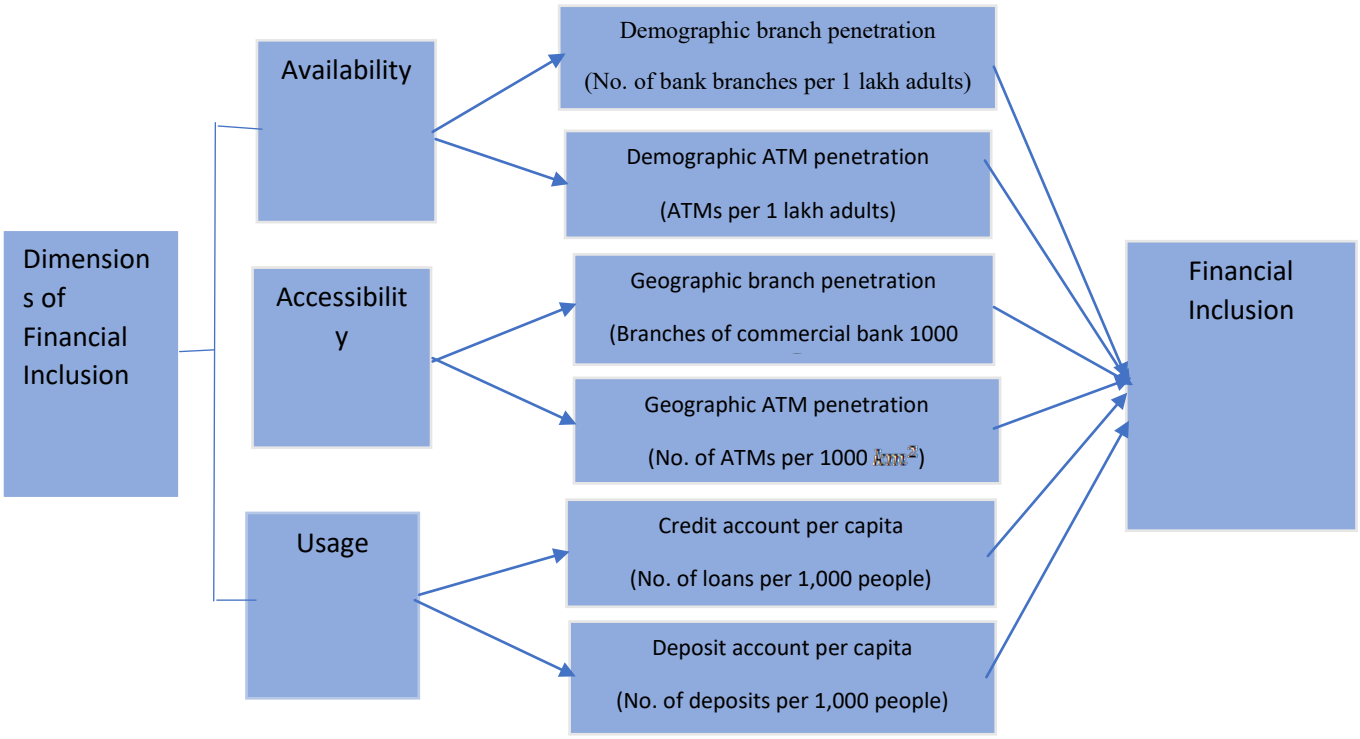
Malik et al (2021): examine the F.I dynamic In South Asian Region Per 1000 adults, the no. of bank accounts, Com. Bank branches per 1 lakh population, ATMs per 100,000 adults Deposits as a % of GDP, Credit as % of GDP used multiple regression analysis and finds the Countries have a low level of F.I with existing huge disparities in F.I dimensions among the countries**. Sethy & Goyari (2022**) measured the level of financial inclusion in South Asian countries. Availability, Accessibility, Usage, and used multidimensional index of financial inclusion & finds the FII has been increasing from 2004-18 but, the one and only country is India which contain the Full Financial Inclusion from 2013-17. **Gattoo & Akhtar (2015)** showcased the emergence of the F.I in India & Pakistan and show how the strategy of India regarding financial inclusion become the consequences for Pakistan's agenda of Financial Inclusion which finds the commercial bank in Pakistan becoming to off from lending in rural based areas & MSMEs. **Laura De Matties (2012)** to analysing migrants' financial inclusion as a means for grater social integration into the destination country, with a specific focus on Italy & examining the financial behaviour of migrants and their relationship with Italian banks taking Current bank account, mortgage life insurance, personal loan, shares or bonds, credit card, investment funds, no. of current account held by migrants, consumer accounts held by migrants, rate of bancerizatio as variable and finds Heterogeneity in migrants bancerization in terms of geographical distribution. People who do not have a current account belong to the financially excluded profile. One act of two foreigner lite low incomes and high costs as barriers to current account ownership.

Philip Mader (2018): To evaluate the intervention of financial inclusion in the development and use microfinance

to financial inclusion, poverty alleviation finds the expectation regarding financial inclusion make people poor along with the intervention of private sector development. **Sonu Garg & Parul Agrawal (2014):** analysed the importance of financial inclusion & development. Retirement savings, Buffer savings, Insurable contingencies, business livelihood, Emergencies loans, Housing loans, consumption loans, used as variable that reveals ICT based transactions is 250 million and amount of these transactions is 234 billion in the year 2013. **Agrawal et. al (2021)** identified the design & limits of financial inclusion in Odisha used Multivariate Analysis also finds the persons belong to a bank account are positively & significantly associate to financial literacy index and borrowings are negatively associate to civic index.

3. THEORETICAL FRAMEWORK

From the early time Financial Inclusion is defined as a multidimensional concept. It is all about inclusion, provide provision through formal financial services to every unbanked individual. The main focus of the present study is to compare the variations of financial inclusion with two Indian subcontinent like: - India, Pakistan, & Bangladesh. The main aim is to compare the variations of financial inclusion among India & with its neighbour country. Here India has been taken on the basis of its non-stable economic condition, Pakistan for its strong political reason & Bangladesh is considered for the development of Self-Help Group. It is easy to compare the variations of the above said reason.



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Here in the figure Banking inclusion used as financial inclusion. Where by improve the indicators of banks can leads to financial inclusion. Here 3 dimension we have consider like: - Availability, Accessibility & Usage of the banking services.

For availability indicator we have used bank branches per 1 lakh population which denoted as, (Demographic branch penetration), ATMs per 1 lakh adults that is (Demographic ATM penetration). Lack of financial assets is a vital element in the direction of income disparity & the in the economic expansion .so we have taken accessibility indicator which carry Branches of commercial bank 1000 km^2(Geographic branch penetration) & No. of ATMs per 1000 km^2(Geographic ATM penetration). For usage indicator we have consider no. of loans per 1,000 people (Credit account per capita), & no. of deposits per 1,000 people (Deposit account per capita). We have taken many dynamic indicators to achieve Financial Inclusion. These indicators will provide a clear and concise picture about Financial Inclusion.

4. METHODOLOGY

Financial Inclusion Index construction can be wrong is we consider only a single indicator. So, as we have developed a Multidimensional Financial Inclusion Index & six indicators of Financial Inclusion is considered. Unavailability of data is also a measure factors for which some indicators are left out.

To find variations of Financial Inclusion in the above said countries we have used Sarma's (2015) methodology for calculating Financial Inclusion Index which allows to used multiple dimensions associated with inclusive finance. The present technique is equivalent to UNDP approach to estimate for development indexes like- the HDI, the GDI, the HPI. The study explains here;

Step 1: According to the indexes, our developed Index is computing firstly through figuring separate index for every dimension of Financial Inclusion. We first define d_i.

$$d_i = w^* \frac{Ai - mi}{Mi - mi}$$

So,

A_i refers to actual value of dimension i;

m_i refers to value of dimension i;

M_i is maximum value of dimension i;

d_i stands for dimensions of financial inclusion i,

$w_i$the weight

Step 2: In the second step, we calculate X_1 based on d_i and W_i as below:

$$X_1 = \frac{\sqrt{d_1^2 + d_2^2 + d_1^2 + \cdots \ldots\ldots + d_n^2}}{\sqrt{w_1^2 + w_2^2 + w_3^2 \ldots\ldots + w_n^2}}$$

Step 3: In the second step, we calculate X_2 based on $d_i$and W_i as below:

$$X_2 = 1 - \frac{\sqrt{(w_1 - d_1)^2 + (w_2 - d_2)^2 + (w_3 - d_3)^2 + \cdots \ldots\ldots + (w_n - d_n)^2}}{\sqrt{w_1^2 + w_2^2 + w_3^2 + \cdots \ldots\ldots + w_n^2}}$$

Step 4: In the fourth step, we calculate the FII based on X_1 *and* X_2 as below:

$$\text{FII} = \frac{1}{2}(X_1 + X_2)$$

0.6 <FII $\leq$ 1	**High Financial Inclusion (HFI)**
0.4 < FII $\leq$ 0.6	**Medium Financial Inclusion (MFI)**
0 < FII $\leq$ 0.4	**Low Financial Inclusion (LFI)**

Dimensions of Financial Inclusion

To calculate the Financial Inclusion Index, we have acknowledged three dimensions of an all-in inclusive financial system: Availability of the bank services (BS), Banking Penetration (BP), Usage regarding banking system (BU). The availability of data & development in literature is the major two reason for the consideration of the above said dimensions.

Availability of Banking Services (Dimension -1)

In the availability of the bank services the number of banks per 100000 people the number of ATM per 100000 people can be measure. In other sense, the number of bank employee to per customer can be measured. We have taken the following two variable from the availability dimension for the present study, they are: -1-Demographic Branch Penetration (Number of Bank Branches per 1 lakh Adults) 2-Demographic ATM Penetration (ATMs per 1 lakh Adult.

Banking Penetration (Dimension -2)

Here Penetration refers to the number of users for a certain variable. Like banking penetration is the number of people owning a bank account is the measure. Like, everyone in an economic system there has a ownership of bank account the value would be 1. We have considered 1-Geographic Branch Penetration (Number of Bank Branches per 1000 Km^2) 2-Geographic ATM Penetration (Number of ATMs per 1000 Km^2) as variable for the banking penetration dimension for the present study.

Usage (Dimension-3)

According to the dimension bank account ownership of the customer is not as much as sufficient for an inclusive financial system. It should be looked into that the services provided by the banking sector is properly utilized or not. So, here two services of the banking are considered they are credit & deposit. Therefore, we used 1-Credit Account Per Capita (Number of loans per 1,000 people) 2-Deposit Account Per Capita (Number of deposits per 1,000 people) for usage dimension.

Data

We have calculated the Financial Inclusion Index that are based on the available data from 2004-2022. The limited data availability from affordability, mobile banking, timeliness & quality of the banking services many indicators are suppressed. In this paper supply side indicators are taken into account & calculate Financial Inclusion Index. To get an absolute measure of financial inclusion of the selective countries like India, Pakistan & Bangladesh above all data are taken from IMF'S FAS from the year 2004-2022.

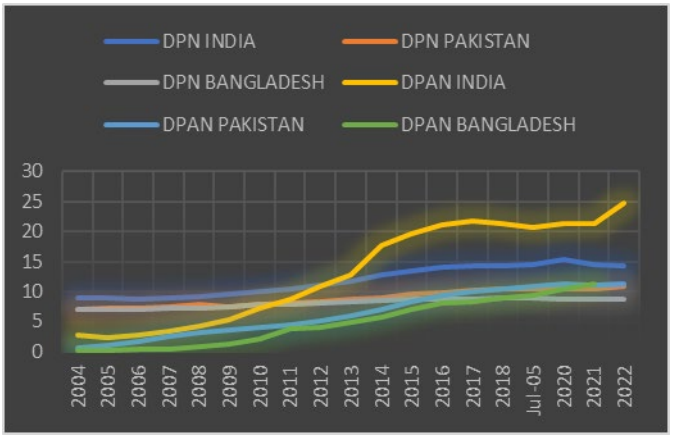
Variables

the variations of financial inclusion are calculated in above mentioned countries several variables have been taken like-

Availability	Accessibility	Usage
1-Demographic Branch Penetration (Number of Bank Branches per 1 lakh Adults) 2-Demographic ATM Penetration (ATMs per 1 lakh Adults)	1-Geographic Branch Penetration (Number of Bank Branches per 1000 Km^2) 2-Geographic ATM Penetration (Number of ATMs per 1000 Km^2)	1-Credit Account Per Capita (Number of loans per 1,000 people) 2-Deposit Account Per Capita (Number of deposits per 1,000 people)

A comparative study among India, Pakistan & Bangladesh: Present status of Financial Inclusion

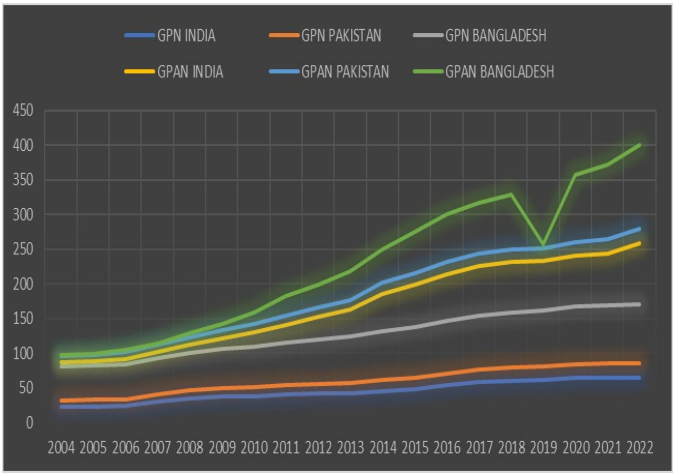
Availability indicators of Financial Inclusion



Note: DPN- Demographic Branch Penetration (Number of Bank Branches per 1 lakh Adults), DPAN- Demographic ATM Penetration (ATMs per 1 lakh Adults)

Source; IMF, FAS

Accessibility Indicators of Financial Inclusion



Note: GPN- Geographic Branch Penetration (Number of Bank Branches per 1000 Km^2) GPAN-Geographic ATM Penetration (Number of ATMs per 1000 Km^2)
Source; IMF, FAS

Usage Indicators of Financial Inclusion

Note: CAP-Credit Account Per Capita (Number of loans per 1,000 people)
DAP-Deposit Account Per Capita (Number of deposits per 1,000 people)
Source; IMF, FAS

Here in the above figures three dimensions of Financial Inclusion have been take place. Likewise, the variables are included in the appropriate dimensions.

The first figure shows the availability indicator of Financial Inclusion which measures the Demographic features of 1 lakh adults. We can see that India performs better in both the indicators among the three countries & surprisingly in the ATM penetration the score of India has been drastically increases & score the highest value. In case of bank branch firstly Pakistan & Bangladesh both stay in the same position up to 2006 but after that the score of Pakistan has increased up to 2022, but in case of ATMs penetration Pakistan always remain above Bangladesh.

In the fig-2 shows the Accessibility indicator of Financial Inclusion which measures the geographic features of 1000 km^2 . In the figure the values of the countries have been increases slowly. But in case of ATMs the status of Bangladesh improves a lot in comparison with other two country but, in the year 2019 suddenly the score of Bangladesh has been decreases & after that value of Bangladesh increase & secure highest position among the three countries.

In the 3rd Figure the usage indicator have been considered & that measured the credit and deposit account per capita. In the above figure credit of Pakistan & Bangladesh is remain as parallel trend which depicts, the credit of both the countries ranges at the same values but the credit of India is slightly remain high in comparison of other two country. But in case of India, it can be seen that the deposit per capita has been increases drastically among all the variables & secure highest position with secure highest value.

But, in the above three dimensions of Financial Inclusion it can be see that almost among all the variables India scores highest value & performs better among the three countries. It is also interesting to note that ATMs penetration score the highest value that is in case of Demographic ATM penetration India & Geographic ATM penetration in Bangladesh. Also, besides the values of ATMs Deposit account per capita score the highest value by India.

5. RESULTS & ANALYSIS

Trends of Financial Inclusion Index (FII) of India, Pakistan, Bangladesh from 2004-2022

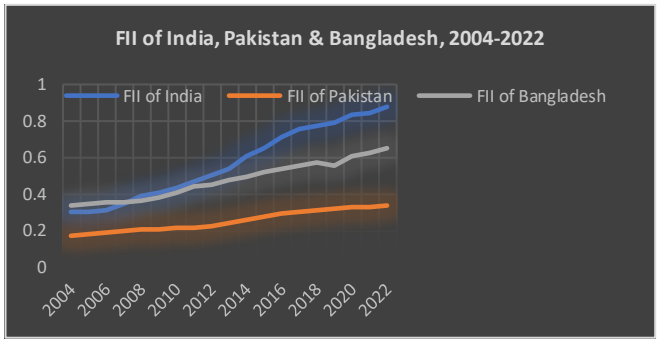
Year	India	Pakistan	Bangladesh
2004	0.298606	0.168782	0.338881
2005	0.301247	0.17665	0.343587
2006	0.308478	0.186359	0.350971
2007	0.346055	0.195985	0.355104
2008	0.385373	0.20661	0.365697
2009	0.407271	0.200686	0.381041
2010	*0.435127*	0.209892	0.408599
2011	*0.464575*	0.215915	*0.437173*
2012	*0.501259*	0.225582	*0.453464*
2013	*0.53233*	0.240099	*0.472314*

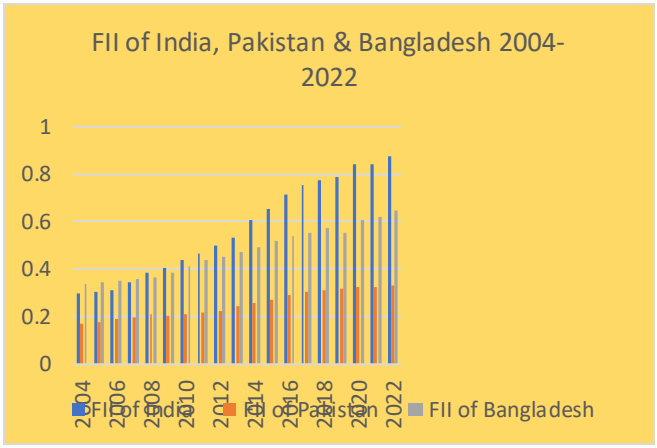
Year	India	Pakistan	Bangladesh
2014	*0.609002*	0.254734	*0.491109*
2015	**0.653994**	0.27275	*0.520729*
2016	**0.712713**	0.288814	*0.539348*
2017	**0.751431**	0.310646	*0.554367*
2018	**0.772969**	0.310725	*0.57255*
2019	**0.790391**	0.318591	*0.551977*
2020	**0.837708**	0.323498	*0.603455*
2021	**0.842162**	0.324728	**0.621817**
2022	**0.872895**	0.333495	**0.647084**

Source; Author's own calculation

On the basis of the Financial Inclusion Index values, countries are categorized as o three parts. In case of High Financial Inclusion (HFI) countries Financial Inclusion Index value varies between 0.6 ≤ 1, Medium Financial Inclusion (MFI) countries Financial Inclusion Index values between 0.4 ≤ 0.6 & Low Financial Inclusion (LFI) countries have Financial Inclusion Index values of less than 0.4. The bold values indicates that, India included in the High Financial Inclusion category from 2015-2022 with maintaining consistency & Bangladesh also included in High Financial Inclusion category from the year 2021-2022. But from the year 2015-2022 India ranges highest value in comparison to other two countries & performs better out of the two countries. The Italic values we can see Medium Financial Inclusion category which includes India from 2010-2014 & Bangladesh from 2011-2020, where Pakistan is not included in Medium Financial Inclusion category. Pakistan remains always in the low Financial Inclusion category reasonably lack of quality education & awareness regarding the financial system among the people however policy have been taken place. In the table the rest values highlight that, above all the Indian subcontinent added in the Low Financial Inclusion country since the value less than 0.4 in 2004. Likewise, India, Pakistan & Bangladesh included in Low Financial Inclusion where, India from 2004-2009, Pakistan from 2004-2022 & Bangladesh from 2004-2010, where the values range of less than 0.4.

Financial Inclusion Index (FII) of India, Pakistan & Bangladesh from 2004 – 2022





The above figures compute the level of Financial Inclusion within the Indian subcontinent. In the above table followed by the figures explain that, the FII in the above-mentioned countries has been continuously increases from 2004-2022. The Three South Asian countries, like- India, Pakistan & Bangladesh is considered for this study & the data related to Financial Inclusion dimension like: - availability, Accessibility & usage was used from the time period 2004-2022. Analytical results indicates that Financial Inclusion has been increasing from 2004-2022 because the introduction of some recent Financial Inclusion initiatives by Governments of the said countries. Where in the year 2015 Financial Inclusion Department in Bangladesh & National Financial Inclusion strategy in Pakistan, Pradhan Mantri Jan Dhan Yojna in the year 2014 in India. But among the three countries India & Bangladesh performs the better & interestingly it can be note that India is the only country whose Financial Inclusion Index is highest that is from 2019-2022.

The above figure indicates Financial Inclusion varies from each other country because some recent initiatives taken by the governments based on their work. In the above said countries India (1 First Position) leaded with the highest value of 0.872895 Financial Inclusion Index followed by Bangladesh (2 Second Position) value with o.647084 & Pakistan (3 Third Position) and the value 0.406047 in 2022. India performs better out of the two countries from the year 2014-2022 values ranges (0.609002-2014), (0.653994-2015) & (0.712713-2016), (0.751431-2017), (0.772969-2018), (0.790391-2019), (0.837708-2020), (0.842162-2021) & (0.872895-2022). According to the different position of the countries, India & Bangladesh categorize under Complete Financial Inclusion or High Financial Inclusion category country in 2022 as different Financial Inclusion policies in the nations but, sadly Pakistan remains always in low level of Financial Inclusion group in view of the fact that lack of quality education & awareness regarding the financial system among the people however several policies have been taken place.

6. CONCLUSION

In the present paper, a multidimensional measure of Financial Inclusion Index (FII) has been proposed for the above said nations. But here out of two country India maintained consistent performance on Financial Inclusion & interestingly it can be note that India is the only country whose Financial Inclusion Index value is highest from 2019-2022. According to the different position of the countries, India & Bangladesh categorized under in full Financial Inclusion or High Financial Inclusion category in 2022 due to several Financial Inclusion policies in the countries but, sadly Pakistan remains always in the low Financial Inclusion category hence lack of quality education & awareness regarding the financial system among the people however several policies have been taken place. India secures in the Medium Financial Inclusion category from 2010-2014 & Bangladesh from 2011-2020. Before the implementations of Financial Inclusion policy India stay in Low financial inclusion index or medium financial inclusion index but after the introduction of Jan Dhan Yojna everyone has a zero-balance account so the banking transactions has been increased along with the knowledge regarding financial transactions and awareness. But after COVID-19 the online financial transactions has been drastically increased so the Financial Inclusion Index of India also increases & performs better out of the three countries. In case of Bangladesh, index of Financial Inclusion value remains in medium or low financial inclusion index category. But after COVID-19 the performance of Financial Inclusion has been increases in Bangladesh and also categorized under in the High Financial Inclusion Index category.

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21

Hybrid Stochastic Neural Ordinary Differential Equation (HS-NODEs) Model for Forecasting Cryptocurrency Close Price

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ABSTRACT

The significance of cryptocurrency lies in its transformative potential to redefine global financial systems, offering decentralized, transparent, and efficient alternatives to traditional banking. However, the high volatility and unpredictable nature of cryptocurrency prices present significant challenges to traders, investors, and researchers. Accurate price prediction is critical for mitigating risks and fostering the broader adoption of cryptocurrencies. This study and its methodology introduce the Hybrid Stochastic Neural Ordinary Differential Equation (HS-NODE) model, an innovative framework that integrates Long Short-Term Memory (LSTM) networks, stochastic layers, and Neural Ordinary Differential Equations (NODEs) to predict cryptocurrency close prices with heightened precision and adaptability. This study reveals that the HS-NODE model excels in capturing both the temporal dependencies and stochastic volatility inherent in cryptocurrency markets. The model demonstrates exceptional performance, achieving high predictive accuracy across multiple cryptocurrencies. The Ethereum and XRP, both known for their volatility, attained R^2 values of 0.9838 and 0.9310, respectively, with percentage errors as low as 2.77% and 3.0935%. Even for stablecoins like Tether, the model exhibited near-perfect predictions with an MAE of 0.0003 and a MAPE of 0.0310%. By addressing the complexities of cryptocurrency markets, this research contributes significantly to the advancement of predictive analytics, laying the groundwork for future innovations in financial forecasting.

Keywords: Cryptocurrency1, HS NODE 2, Volatality 3, Deep Learning 4.

1. INTRODUCTION

Market volatility and liquidity issues are pressing problems in the cryptocurrency sector, often deterring potential investors and stifling broader adoption. While cryptocurrencies present an innovative alternative to traditional financial systems, their unpredictable price swings can create uncertainty and risk. Nakano (2018) argued that the trust gap between buyers and sellers complicates transactions, as concerns about security and fraud linger in the minds of many. Despite these challenges, cryptocurrencies hold the promise of facilitating quick and cost-effective money transfers, which could help address economic inequalities. Sultana (2022) has observed that the potential for increased transparency and user empowerment in financial dealings is significant. However, to ensure the long-term success of the crypto market, it is essential to tackle these inherent risks and establish a more stable environment. As the industry continues to develop, finding effective solutions to these challenges will be crucial for achieving widespread acceptance and integration into the global economy.

Crypto Market

The first cryptocurrency, Bitcoin, was created by Satoshi Nakamoto in 2008 as part of his white paper Bitcoin: Peer-to-peer Electronic Cash System, which aimed to replace the outdated and popular economic system. Cruysheer (2015b) said that Unlike traditional money, cryptocurrencies carry out financial transactions using cryptographic ciphers. Digital banking has expanded rapidly over the last ten years, with cryptocurrencies leading this creative advance. Akram et al. (2020d) observed that In traditional model, a peer-to-peer (P2P) network-based currency, is the ideal remedy for the existing paradigm. Centralized third-party banking systems are no longer involved. Every peer must acknowledge (validate) every transaction in this process using any appropriate consensus mechanism. For transaction confirmation, these methods internally use timestamps and transaction hashes. (Melitz, 1987b) argued that Fiat money, the foundation of contemporary monetary systems, provides numerous benefits due to its scarcity, durability, transferability, and divisibility. Haridas et al. (2021) pointed that crypto currencies are becoming more and more popular and Between June 2020 and May 2021, the cryptocurrency market expanded by about ten times. Cryptocurrency investments are more secure now than they were in the past. To stop cryptojacking, for instance, numerous researchers are focusing on cryptocurrency security.

Prediction Models

A form of artificial intelligence called machine learning (ML) uses historical data to forecast the future. Hitam and Ismail (2018) have demonstrated that ML-based models not only produce results that are nearly or exactly the same as the real result, but also increase the accuracy of the result, giving them a number of advantages over traditional forecasting models. Miura et al. (2019) observed that The heterogeneous auto-regressive realized volatility (HARRV) model with

optimal lag parameters is compared to the future values predicted by a range of machine learning techniques, such as ANN (MLP, GRU, and LSTM), SVM, and ridge regression, based on historical data. The results demonstrate that the proposed approach accurately and very accurately forecasts prices, suggesting that the technique might be applied to forecast prices for a range of cryptocurrencies. Derbentsev et al. (2021) has used two machine learning methods, stochastic gradient boosting machine (SGBM) and random forests (RF), and focuses specifically on time series data forecasting.

Deep Learning Model

The term "deep learning" (DL) describes strong machine learning algorithms that focus on resolving complicated and nonlinear issues by frequently utilizing large volumes of data to create effective prediction models. Since bitcoin values fluctuate greatly over time and exhibit nearly chaotic and unpredictable behaviour, accurately predicting their prices is by nature a highly difficult and complex problem. Graves (2012) observed that one particular kind of deep neural network is called Long Short-Term Memory (LSTM), which uses feedback connections to "remember" previous network cell states and learn long-term dependencies. Since they have been effectively used for a variety of purposes and have demonstrated exceptional performance in time series forecasting, these networks have gained a lot of popularity. Aloysius, Neena, and M. Geetha (2017) added in their research about Another kind of deep neural network is a convolutional neural network (CNN), which filters raw input data and extracts useful features using convolution and pooling layers. These features are then fed into a fully connected layer to generate the final output.

Theoretical Background

1. Hussain (2021) hints about a variety of methods and strategies could be used to accomplish time series forecasting. These include machine learning and deep learning algorithms, traditional statistical systems that employ standard techniques like AR, MA, and ARIMA, as well as novel hybrid approaches. By evaluating several proposals from people, academics, and institutions, the M4 competition may be the most significant time series forecasting contest held each year (Darin & Stellwagen, 2020). Makridakis et al. (2020) evaluated 61 predicting techniques using 100,000 time series data in an M4 competition.

2. Liatsis (2011) focuses about their goal to use deep learning to create a model that can forecast the price of bitcoin. As the model is being developed, deep learning is utilized to choose the parameter that would yield successive results. They have discovered that the total parameter and dataset can affect the outcome when we used this later to the three suggested models, RNN, LSTM, and GRU. The RNN and LSTM models used in the previous model had a lower projected accuracy of about 52%. However, their comparison research shows that the GRU model outperforms the LSTM model.

3. Gandal and Halaburda (2016) In their study, they consider twelve major cryptocurrencies and study their predictability using machine learning classification algorithms over four different time scales, including the daily, 15-,30-, and 60- min returns. Numerical experiments conducted for four different classification algorithms, namely, logistic regression, support vector machines, artificial neural networks, and random forest algorithms demonstrate the predictability of the upward or downward price moves.

4. Hileman and Rauchs (2017) in their study suggest a machine learning-based approach for developing an investment plan that can trade on cryptocurrency exchange markets. Furthermore, a new technique for resampling financial series was created and used in this work in order to provide investments with greater returns and less risk as opposed to investing on forecasts based on time sampled financial series.

5. Bengio et al. (2013) in their study observed that, In order to extract trading signals from historical Bitcoin time-series data at 15-minute intervals, this article investigates Bitcoin investment based on artificial neural networks. Specifically, for multi-class classification, we first build seven-layered ANNs with technical indicators and current historical returns as input data. The ANN models are then subjected to deep learning techniques for supervised training data. Ultimately, they have used the predictions of their trained ANNs to determine whether to take long, neutral, or short positions.

6. Detzel (2018) adds to the body of literature by empirically finding the predictability of Bitcoin return, which has not been taken into account in previous research. Using technical indicators derived from five widely used trading rules, they have determined the significant return predictability. In order to demonstrate the economic importance of return predictability, and further develop a dynamic trading strategy based on return estimates from technical indicators. They have discovered that this approach outperforms the buy-and-hold strategy.

7. Shen et al. (2018) The relationship between investor attention and Bitcoin returns, trading volume, and realized volatility is examined in this paper, which contributes to the expanding body of research on the cryptocurrency. In contrast to earlier research, they have used the quantity of tweets from Twitter as a proxy for attention instead of Google trends since they believe this is a more accurate indicator of the attention of more knowledgeable investors. They discover that the quantity of tweets significantly influences the volume of trade the following day and the actual volatility, which is

corroborated by both linear and nonlinear Granger causality tests.

8. Koker and Koutmos (2020) in their research focuses on using a time series analysis based on machine learning, the market price and stability of Bitcoin have been predicted in the cryptocurrency market.Time-series analysis is able to forecast future fluctuations in the price of Bitcoin. We have employed FBProphet, ARIMA, and XG Boosting as machine learning approaches for time series analysis.

9. Wimalagunaratne and Poravi (2018) have used sentiment analysis and machine learning techniques, this focuses on evaluating the main factors that influence market volatility, such as public perception, trading data, historical price data, and the interdependencies between Bitcoin and altcoins, and how they can be best used from a technological standpoint to improve process efficiency.

10. Rao and Kalyankar (2012) has introduced Three distinct contemporary machining processes—USM, AJM, and WEDM—are examined in this work for the optimization of their corresponding parameters utilizing a novel optimization technique called the "teaching–learning-based optimization" algorithm. Each process is examined with a variety of examples, some of which include multi-objective models and constraints. Earlier researchers used the GA, SA, ABC, HS, SFL, and PSO algorithms to try the same models.

11. ("Global Catalyst Market (2020 to 2026) – Industry Analysis, Trends, Market Size and Forecasts," 2021) to illustrate this concept, they have considered a price prediction of Dash coin through the past days' prices of Dash , Litecoin , and Bitcoin as they have hierarchical dependency among them at the protocol level. they can portray the outcomes that the proposed scheme predicts the prices with low misfortune and high precision. The model can be applied to different digital money cost expectations.

12. ("Global Catalyst Market (2020 to 2026) – Industry Analysis, Trends, Market Size and Forecasts," 2021) In this paper, they employ machine learning methods to develop models that forecast Bitcoin price. The findings of our experiments, which were validated on two sizable datasets, show that their method can predict the prices of Bitcoin and Ethereum with up to 99% accuracy in both cases.

2. RESEARCH GAP

Accurate forecasting is a difficult undertaking for researchers and practitioners due to the bitcoin market's complicated, non-linear characteristics and extreme volatility. The complex and stochastic character of bitcoin data frequently makes it difficult for traditional time series models like ARIMA, VARIMA, and GARCH to capture it, which lowers accuracy. Although deep learning and machine learning techniques, including LSTM and GRU, have shown better results in financial market forecasting, they are still not able to handle the significant volatility and non-stationarity present in cryptocurrency markets. Additionally, the majority of current research concentrates on individual methods without providing an integrated framework that blends neural ODEs and stochastic processes for improved prediction accuracy.

In order to bridge this gap, this study suggests the Hybrid Stochastic Neural Ordinary Differential Equation (HS-NODE) framework, which combines deep learning methods, stochastic layers, and neural ODEs. In contrast to current methods, HS-NODE seeks to offer a complete solution for more accurate and dependable near price prediction, especially in extremely dynamic contexts like cryptocurrency markets. This study adds a new and useful framework to the field of cryptocurrency forecasting by assessing the model using reliable metrics like R2, MAE, RMSE, and MSE and providing useful insights for trading and investing.

3. RESEARCH METHODOLOGY

This section outlines the systematic approach employed to design, implement, and evaluate the HS-NODE model for forecasting cryptocurrency prices. In light of the difficulties for Crypto currency forecasting, the present research is based on a hybrid methodology using significant deep learning techniques, modelling by means of stochastic and dynamic differential equations. The HS-NODE model integrates NODE with continuous- time dynamics, adds a stochastic layer to control the volatility in the market, and has LSTM layers that capture time patterns. This approach uses technical indicators, such as historical cryptocurrency data, and strict evaluation criteria to increase prediction accuracy and reliability in highly volatile and non-linear financial markets for accurate results.

Programming Framework and Tools;

The primary programming language employed in this research is Python, a versatile and user-friendly language that boasts an extensive library of tools specifically designed for data analysis and machine learning applications. Python's inherent flexibility and adaptability make it an ideal choice for implementing the Hybrid Stochastic Neural Ordinary Differential Equation (HS-NODE) model, as it facilitates efficient handling of large datasets, construction of complex models, and evaluation of outcomes. In this study, Google Colab was utilized as the primary computing platform. it is an interactive, cloud-based environment that facilitates the efficient execution of Python programs. It offers complimentary access to robust computational resources, particularly GPUs, which are crucial for training deep learning models on extensive datasets. Furthermore, its integration with Google Drive enhances the ease of sharing

and collaboration, rendering it a practical and effective platform for conducting the research.

Research Questions

Through an extensive review of existing literature, it was observed that while numerous studies employ deep learning methods like LSTM for cryptocurrency forecasting, few integrate stochastic elements or continuous-time modelling to address the volatility and complex dynamics of these markets. Most models focus solely on short-term predictions, often overlooking long-term accuracy and adaptability to market fluctuations. This gap in capturing both the stochastic nature and temporal dependencies of cryptocurrency prices led to the following research questions:

1. How can the integration of stochastic modelling and NODE enhance the prediction accuracy for cryptocurrency price forecasting?
2. To what extent does the HS-NODE model address the challenges of volatility and non-linearity inherent in cryptocurrency markets?
3. Can this hybrid approach outperform traditional deep learning models in predicting cryptocurrency close prices and continuous compounded returns?

By identifying this critical research gap, this paper aims to address the challenges in cryptocurrency price forecasting using the advanced HS-NODE model. The study seeks to provide a robust solution that combines deep learning techniques and stochastic modelling to improve prediction accuracy and adaptability in the volatile cryptocurrency market.

Research Objective

This study aims to design and validate the advanced forecasting framework of Hybrid Stochastic Neural Ordinary Differential Equation (HS-NODE) in order to predict the close prices and continuing compounding returns of cryptocurrencies with high accuracy. To overcome the challenges posed by the volatility and non-linear dynamics of cryptocurrency markets, the study will integrate neural ODEs, stochastic layers, and deep learning approaches. This study aims to:

a. Raise the accuracy of predicting cryptocurrency prices by applying creative hybrid deep learning model.
b. Compare the performance of the HS-NODE model with well-known evaluation metrics such as R^2, MAE, RMSE, and MSE.
c. Provide useful insights into how cryptocurrencies adjust to predictive models, which will be helpful for practical usage, such as trading and investment planning.
d. Provide a framework for upcoming developments for highly volatile financial assets.

This study ultimately aims to bridge the gap in existing research by presenting a robust and reliable solution for predicting cryptocurrency market behaviour.

Research Model

HS-NODE (Hybrid Stochastic Neural Ordinary Differential Equation)

The **HS-NODE model** represents a novel and advanced approach to cryptocurrency forecasting, combining deep learning, stochastic processes, and dynamic modelling techniques. In this paper, we utilize HS-NODE to predict the **close prices** of cryptocurrencies, addressing the inherent challenges posed by their volatile and unpredictable nature.

1. **LSTM**: The model incorporates Long Short-Term Memory (LSTM) layers to effectively capture temporal dependencies in historical cryptocurrency data. This enables the model to identify both short-term and long-term patterns, crucial for forecasting in a market where past trends heavily influence future outcomes.
2. **Stochastic Layer for Market Volatility**: Cryptocurrency markets are subject to high volatility. To address this, the stochastic layer integrates randomness into the modelling process, providing the ability to accommodate abrupt price changes and market uncertainties. This ensures that the predictions are not only accurate but also robust in fluctuating conditions.
3. **Neural Ordinary Differential Equations (NODE) for Smooth Predictions**: The NODE component models data transformations using continuous-time dynamics, enabling smooth, non-linear representations of price movements. This capability is particularly useful in forecasting cryptocurrency trends, where abrupt and subtle changes coexist.

In this study, the HS-NODE model is applied to five cryptocurrencies (**Ethereum, Tether, Tron, IOTA, and XRP**), leveraging their historical data to predict future price movements. The model's performance is rigorously evaluated using metrics such as **MAE, RMSE, MBE, R^2, and MAPE**, ensuring a comprehensive assessment of its forecasting capabilities.

This hybrid architecture, tailored to the unique challenges of cryptocurrency markets, aims to enhance the precision and reliability of predictions. By addressing both temporal and stochastic characteristics, the HS-NODE model lays the foundation for improved decision- making in cryptocurrency investments and broader financial applications.

The detailed flowchart of this study illustrates the comprehensive methodology adopted for implementing the HS-NODE model.

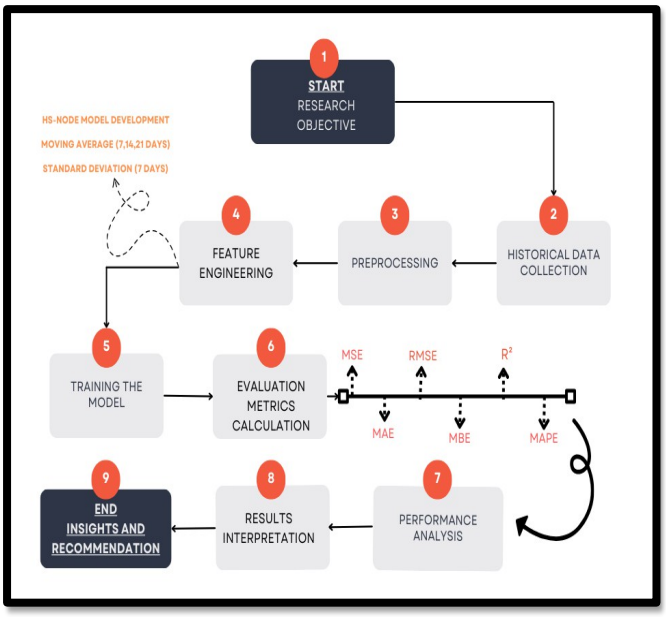

Figure 1: Research Model

4. DATA COLLECTION AND PRE-PROCESSING

The methodical process of creating a dataset is described in this part, starting with the acquisition of past cryptocurrency data and turning it into useful attributes. Data collection, feature engineering and preprocessing that illustrates the result are the procedures involved.

Data Source

Historical data retrieved from Investing.com, a reliable provider of real-time and accurate financial information, include open, high, low, and close values of five cryptocurrencies. This data set provides sufficient coverage of the trend of market fluctuations and behaviour in price because it spans several years.

Feature Engineering

Feature engineering played a pivotal role in enhancing the predictive power of the model by extracting meaningful insights from the raw data. The following features were engineered:

a. **7-day Moving Average (7D-MA):** Captures short-term trends.
b. **14-day Moving Average (14D-MA):** Highlights medium-term market behaviour.
c. **21-day Moving Average (21D-MA):** Reflects long-term price trends.
d. **7-day Standard Deviation (7D-SD):** Measures market volatility over a short period.
e. **H-L:** High-Low price Difference, Capturing daily price range dynamics
f. **O-C**: Open-Close price difference, reflecting daily market trend

Data Pre-processing

Pre-processing consisted of computing the engineered features in a very systematic manner on Excel. Moving averages were computed as the arithmetic mean of closing prices across their appropriate time window. The standard deviation was also computed by statistical formulas with an aim of quantifying price variability. The resulting dataset was then formatted and normalized so that it meets the requirements of the HS-NODE input, removing biases due to scale variation.

Model Development and Implication

This section will describe the model development process based on an application of the Hybrid Stochastic Neural Ordinary Differential Equation algorithm and explore how such a model was trained with past all the cryptocurrency's data and the ramifications that are now able to better foresee volatile markets. This will be discussed relative to practical applications and benefits using the HS-NODE model in real-world financial projections.

Model Overview

HS-NODE is a technique that brings into play three complex elements toward improving the precision of prediction. The LSTM layer identifies temporal relations in sequential cryptocurrency data, which actually makes it the best to model the trend of time- series data. The stochastic layer introduces predictability owing to the reality that cryptocurrency markets are highly volatile; therefore, the model responds efficiently to the variations. Finally, NODE uses differential equations to simulate continuous time dynamics so that the achieved predictions are more accurate and less noisy. All three of these layers together form a highly strong hybrid structure that has been designed to overcome the problems involved with cryptocurrency price projection, such as high volatility and non- linear patterns.

Training the Model

With this training method, a pre-processed data set was used that consisted of historical data for this exercise on cryptocurrencies like open, high, and low prices closing alongside technical indicators like 7-day, 14-day, and 21-day moving averages along with 7- day standard deviation and High-low and Open-Close, simulating price volatility. The model was made to traverse over a number of epochs wherein the parameters are progressively tweaked based on the prediction errors.

The HS-NODE was then optimized with a loss functions, such as MSE, MAE, RMSE, MBE, R^2 and MAPE. These metrics will compute the error or difference between actual

and projected values during the training process. A learning curve traces the development of the model for the benefit of the algorithm to prove convergence by showing that the technique becomes better with successive iterations. Following training, the algorithm may have been able to make reliable bitcoin price estimates.

5. RESULT AND ANALYSIS

The study will also include the analysis of the trends and behaviour describing the model, strengths and weaknesses, cryptocurrency properties adapting to model behaviour, and how this may relate to real-world applications. Such results therefore form a foundation for later innovations in forecasting techniques. The results might even prove useful to some traders and investors who are interested in the investing in cryptocurrencies more than getting informed about its behaviour.

Model Performance

TABLE 1: Performance metrics

Close Price Prediction						
INDEXES	**MAE**	**RMSE**	**MBE**	**MSE**	**R²**	**MAPE**
ETHEREUM	65.686	53.2622	5.1092	0.0000	09838	2.77%
TETHER	0.0003	0.0004	0.0001	0.0000	0.1466	0.0310%
TRON	0.0034	0.0044	0.0029	0.0000	0.9675	3.0045%
IOTA	0.0224	0.0282	0.0090	0.0008	0.7761	12.0535%
XRP	0.0165	0.0224	0.0031	0.0005	0.9310	3.0935%

*Source: Calculation using Python for HS-NODEs Model

Ethereum (ETH)

The model performs reasonably well for Ethereum, with a Mean Absolute Error (MAE) of 65.686, reflecting moderate deviations between predicted and actual close prices. The Root Mean Squared Error (RMSE) of 53.2622 indicates slightly larger errors, possibly due to the inherent volatility of Ethereum's prices. A positive Mean Bias Error (MBE) of 5.1092 suggests a slight tendency for the model to overestimate. However, the high R^2 value of 0.9838 demonstrates that the model effectively captures the variability in Ethereum's price movements. Additionally, the Mean Absolute Percentage Error (MAPE) of 2.77% indicates the model provides highly accurate predictions relative to the magnitude of Ethereum's prices.

Tether (USDT)

For Tether, the model achieves near-perfect performance, with an extremely low MAE of 0.0003 and RMSE of 0.0004, reflecting very small deviations from actual prices. This precision is consistent with Tether's nature as a stablecoin, where price fluctuations are minimal. The small positive MBE of 0.0001 shows a negligible upward bias in predictions. However, the low R^2 value of 0.1466 suggests the model struggles to capture variability, which is expected given Tether's stability. Nonetheless, the MAPE of 0.0310% confirms the model's exceptional precision in forecasting Tether's prices.

Tron (TRX)

The model performs well for Tron, with an MAE of 0.0034 reflecting accurate predictions of close prices. The RMSE of 0.0044 highlights slightly larger errors compared to MAE, indicating minor variability in the predictions. A small positive MBE of 0.0029 suggests the model slightly overestimates Tron's prices.

The high R^2 value of 0.9675 shows the model successfully explains most of Tron's price movements. Moreover, the MAPE of 3.0045% demonstrates that the model provides accurate forecasts with minimal percentage error.

IOTA

For IOTA, the model shows moderate performance, with an MAE of 0.0224 and an RMSE of 0.0282, reflecting deviations larger than those for other cryptocurrencies.

The positive MBE of 0.0090 indicates a slight overestimation of prices. While the R^2 value of 0.7761 suggests the model captures a significant portion of IOTA's price variability, it also leaves room for improvement.

Additionally, the MAPE of 12.0535% indicates a relatively higher percentage error, implying that the model's predictions for IOTA are less precise compared to its performance with other cryptocurrencies.

XRP (Ripple)

For XRP, the model demonstrates good performance, with an MAE of 0.0165 indicating accurate price predictions. The RMSE of 0.0224 reflects slightly larger errors, showing some variability in predictions. A small positive MBE of 0.0031 suggests a minimal upward bias in the model's predictions. The high R^2 value of 0.9310 indicates that the model effectively explains XRP's price trends. Furthermore, the MAPE of 3.0935% highlights the model's strong predictive accuracy relative to XRP's price movements.

Actual Vs Predicted Price-Plot

The graph illustrates the comparison between actual and predicted closing prices for cryptocurrencies, including Ethereum, Tether, Tron, IOTA, and XRP. The blue line represents the actual closing prices, while the red line depicts the predicted values.

Figure 2: Ethereum

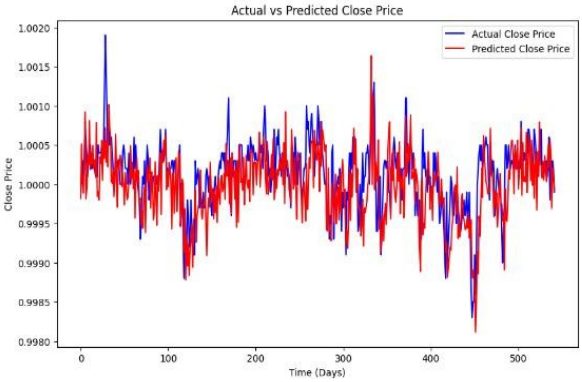

Figure 3: Tether

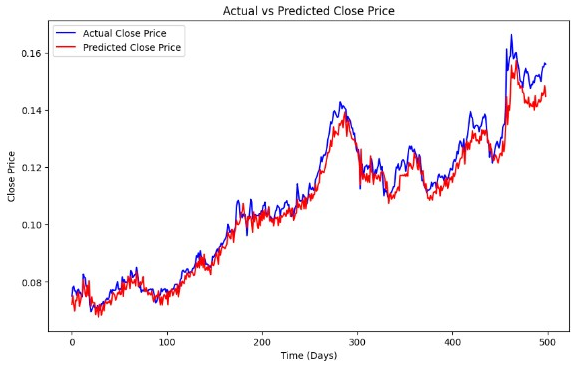

Figure 4: Tron

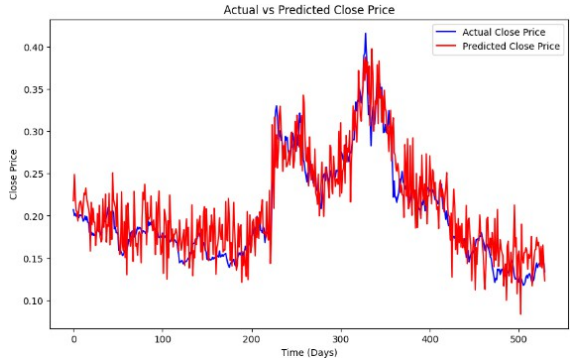

Figure 5: Iota

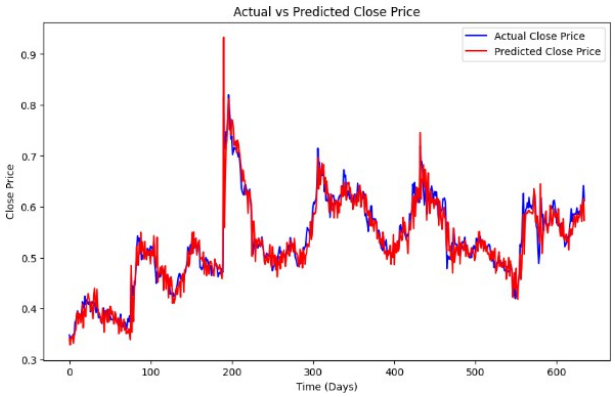

Figure 6: Xrp

The graphs of five cryptocurrencies—real vs. predicted close price—represent the HS- NODE model well. Overall, predictions on Ethereum, Tether, Tron, and XRP are quite accurate in terms of actual values. IOTA deviates in some areas, perhaps because it is extremely volatile. However, on an overall basis, the near-term prices for stable as well as highly volatile cryptocurrencies turn out to be of high accuracy and the residual plots indicates the residuals for the predicted and actual values of five cryptocurrencies: Ethereum, Tether, Tron, IOTA, and XRP. The dots represent residual values, and the dashed line at zero shows no prediction error.

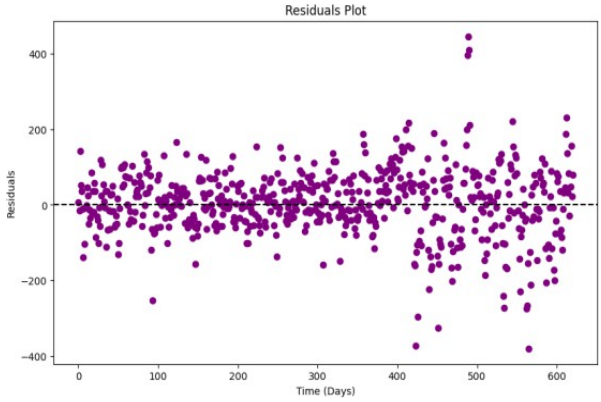

Figure 7: Ethereum

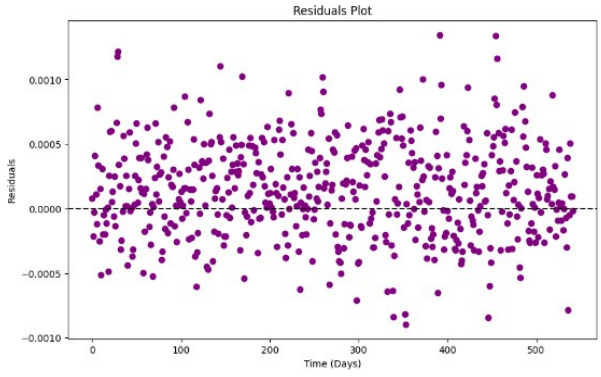

Figure 8: Tether

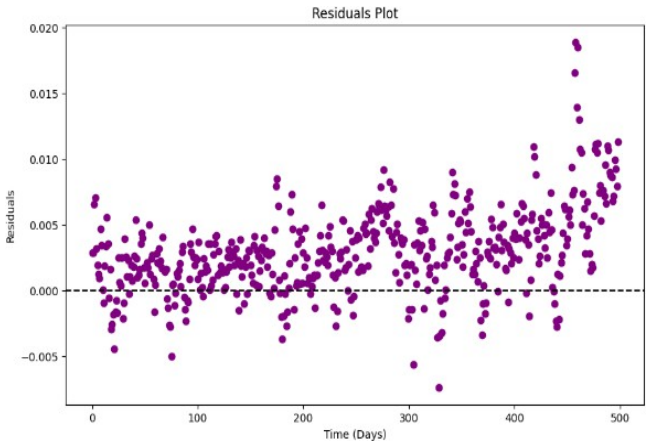

Figure 9: Tron

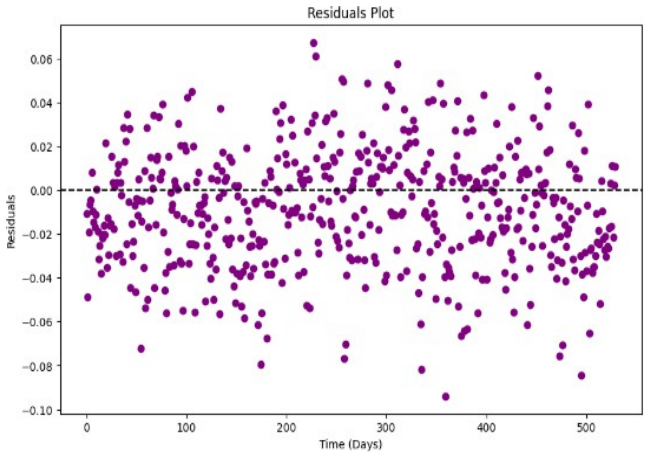

Figure 10: Iota

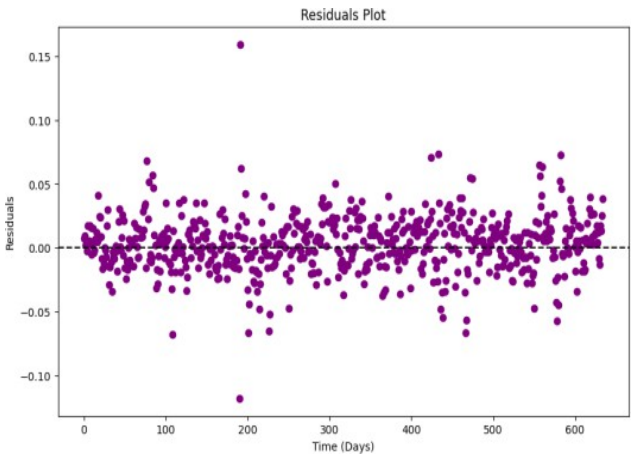

Figure 11: Xrp

Most residual plots for the five cryptocurrencies have their majority errors at zero, meaning that HS-NODE works impartially. Minor fluctuations, particularly to more volatile coins such as IOTA, point towards scopes for improvement, but the model possesses constant and accurate forecasting values for the cryptocurrencies in general.

Learning Curve

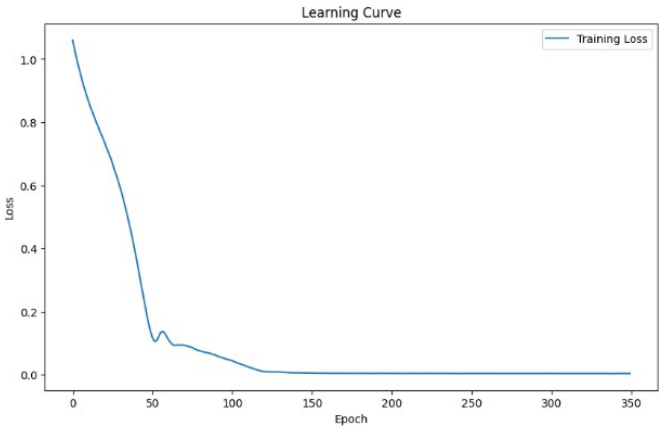

Figure 12 – learning curve

The HS-NODE learning curve shows an early significant decline in training loss, thus showing that data patterns are learned fast. It then levels out later as training progresses, which represents that the algorithm had gained stable convergence with low loss. Thus, it indicates positive trends in efficient training without overfitting, and there are no instances of unexpected spikes or shifts in loss, which indicates stability and resilience. A cursory glance at the plot will show that the algorithm seems to be fine for this data.

6. PRACTICAL IMPLICATIONS

The Hybrid Stochastic Neural Ordinary Differential Equation (HS-NODE) model offers significant practical implications for the cryptocurrency market by addressing its inherent volatility and complex dynamics. Its ability to capture both short-term volatility and long-term trends makes it invaluable for traders in optimizing strategies and for investors in mitigating risks associated with abrupt price changes. The model's precision enhances financial planning tools, allowing fintech companies and institutions to deliver improved portfolio management and market analysis services. For stablecoins like Tether, the model's exceptional accuracy supports better management of pegging mechanisms and liquidity, ensuring stability for users. Furthermore, the integration of machine learning, stochastic processes, and neural ODEs sets a foundation for innovative forecasting techniques that can be extended to other financial assets, driving advancements in predictive analytics and aiding stakeholders in making informed decisions in volatile markets.

7. CONCLUSION

The study successfully introduced and evaluated the Hybrid Stochastic Neural Ordinary Differential Equation (HS-NODE) model, a novel framework designed to forecast cryptocurrency close prices with improved accuracy and adaptability to the market's volatile and non-linear dynamics. The model integrates advanced deep learning techniques,

including LSTM layers for capturing temporal dependencies, stochastic layers for addressing volatility, and Neural ODEs for modelling continuous-time price movements. This hybrid architecture overcomes the limitations of traditional forecasting methods like ARIMA and VARIMA, as well as existing deep learning models such as LSTM and GRU, by addressing the challenges posed by the cryptocurrency market's stochastic and chaotic behaviour.

The HS-NODE model was rigorously tested on five cryptocurrencies: Ethereum, Tether, Tron, IOTA, and XRP. Performance metrics like MAE, RMSE, MSE, R^2, and MAPE demonstrate its effectiveness. For instance, Ethereum, a highly volatile cryptocurrency, achieved an R^2 of 0.9838 and a MAPE of 2.77%, indicating excellent predictive accuracy. Similarly, Tron and XRP recorded R^2 values of 0.9675 and 0.9310, respectively, with low percentage errors of 3.0045% and 3.0935%, showcasing the model's robustness for these assets. Tether, a stablecoin, demonstrated near-perfect accuracy with an MAE of 0.0003 and a MAPE of just 0.0310%, underscoring the model's capability to handle low-volatility assets. The HS-NODE model represents a significant step forward in cryptocurrency price forecasting, combining innovation and practical utility. By leveraging sophisticated methodologies and achieving high predictive accuracy across multiple metrics, it provides a reliable framework for navigating the challenges of the dynamic cryptocurrency market, paving the way for its broader adoption and integration into global financial systems.

8. DECLARATION

I, Priyadharshini T, hereby confirm that the manuscript titled " Hybrid Stochastic Neural Ordinary Differential Equation (HS-NODEs) Model for Forecasting Cryptocurrency Close Price" authored by [Priyadharshini T, Prakruthi V], has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to International Management Perspective Conference 2025 (IMPeC-25).

I/we declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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22

The Rise of E-Wallets: A Bibliographic Insights into Digital Banking Trends

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ABSTRACT

Purpose
This study aims to conduct a detailed bibliographic analysis of the adoption of e-wallets and digital banking services and identify trends and growth in the field by reviewing seminal works, conceptual frameworks, and smart networks.

Methodology
To assess the present and future state of digital banking practices and e-wallet research, we carried out a thorough library analysis in this study using scientific databases including Web of Science. Using the scoping review approach, we examined 3623 documents in the subsequent eligibility process using the phrases "digital wallet" and "digital banking" in compliance with the qualified process from 2015 to 2024.

Findings
Numerous studies concentrate on technological innovation and adoption, such as the Internet and mobile banking, however, there are significant gaps in areas like blockchain integration and digital wallets. The findings indicate that China, the United States, England, and India lead research in this area. Data security, usability, and compatibility with conventional payment methods are important elements impacting the uptake of digital wallets. In addition to introducing the first complicated book on digital wallet, this article offers crucial details on emerging developments like blockchain, e-commerce, and digital payments, as well as their implications for financial education in the future.

Originality
The authors are unaware of any recent comparable studies in the consumer financial services sector, and bibliographic analysis has not been applied extensively in management research. This article's primary contributions are to spread knowledge to a larger audience, which includes scholars and practitioners in relevant domains, and to offer a strong platform for spotting potential areas for further study.

Research limitations/implications
The study of e-wallets faces challenges due to rapid technological changes, regional differences in adoption and regulation, underexplored security issues, and limited research on their impact on low-income or underserved populations, raising concerns about financial exclusion.

Despite limitations, e-wallet research has key implications for the financial industry and consumers. It helps institutions improve digital services, security, and compliance while guiding policymakers to create supportive regulations and promote financial literacy. The research also highlights the potential of e-wallets to drive financial inclusion and economic development.

Practical implications
The study of e-wallets helps banks improve digital services, security, and customer experience, while guiding policymakers to create supportive regulations. It also highlights the importance of financial literacy, especially for underserved communities, promoting a more inclusive and secure digital financial ecosystem.

Social implications
The rise of e-wallets can enhance financial inclusion by providing underserved populations with greater access to digital payments, promoting financial autonomy. The study emphasizes the need for improved digital literacy and highlights concerns about privacy and security, especially for vulnerable groups. Ultimately, it advocates for a more inclusive and secure digital financial landscape that helps reduce social and economic disparities.

Keywords: Digital Banking, E-Wallet, Secure Payment, Trend, Bibliometric Analysis.

1. INTRODUCTION

"Digital banking," or the automation of traditional banking services through online and digital platforms, allows customers to manage their money without physically visiting a bank branch. This includes a wide range of activities done via mobile applications or websites, such as loan access, investment management, bill payment, check deposits, and money transfers. The hallmarks of digital banking, which often offers services 24/7, include availability, speed, and

convenience. Technology breakthroughs and shifting consumer demands, which place an emphasis on accessibility and efficiency in financial services, are driving this move towards digital platforms. Digital banking, often known as internet banking, omni channel, or online banking, is the practice of managing financial services and conducting financial transactions through digital channels and technologies. Customers can use web-based or mobile applications for digital banking to access their bank accounts and conduct financial transactions. These include online account creation, loan applications, checking account balances, bill payment, and money transfers across accounts. Digital banking removes the requirement for customers to visit a physical bank branch in order to manage their finances and access their accounts at any time and from any location. The convenience, adaptability, and financial savings this provides are advantageous to the bank as well as the customer. Peer-to-peer transfers, digital wallets, and mobile payments are just a few of the cutting-edge services and products that banks can now provide to their clients thanks to digital banking. The shift from analogue to digital implementations of specific jobs is referred to as "digitization." When consumers had to deal with a human teller to withdraw their money from the bank, consider how far automated teller machines have come. An organization's numerous digital components such as digital operations, procedures, and other activities made possible by technology are unified and streamlined as it goes through a digital transformation. These kinds of initiatives seek to give customers a consistent experience across all platforms and to fully comprehend the needs of every single customer. Digitalization is evolving, and digital reinvention is driving it to new heights. Digital banking is evolving via the application of innovative new technology and banking tools. It aims to harness the benefits of digital technology to link and integrate the standard web, mobile, and electronic banking services in order to enhance the quality of the services offered and the user experience. For instance, Analytics could be running in the background. While seeking to "upsell" or "enforce loyalty" for the bank, the client is simultaneously online and controls the screen-based interactive information in the session to assist the client with their banking needs. In today's digital era, the use of mobile devices has become increasingly prevalent in everyday activities. Consequently, numerous conventional processes, such as conducting transactions through an e-wallet, can now be completed within mobile phone-based virtual environments. Mobile payment applications allow users to execute financial transactions quickly and effortlessly, ensuring a secure and convenient experience. (Singh and Srivastava, 2018). An e-wallet is, by definition, a new medium that makes use of mobile devices to enable, validate, and facilitate conventional exchanges between money and goods and services (Karnouskos, 2004). People are increasingly using electronic wallets, or e-wallets, to make every day internet transactions easier (Nawi et al., 2024). A variety of cashless transactions are made possible by electronic wallets, which mimic the benefits of conventional wallets. In 2017, Seetharaman et al. Even if e-wallets allow users to conduct financial transactions effectively and ethically, it is impossible to ignore the hazards involved. (Karim and others, 2020). The impacts, whether positive or negative, continue to rely on user experiences or how users perceive information through electronic wallets because customers may approach information access differently. Making frequent purchases or processing payments will be simpler and more convenient for individuals who utilize electronic wallets.

The structure of this document is as follows: A review of the literature was covered in Section 2. The study's parameters and analytical methodology are covered in Section 3. Section 4 presents and explains the results of the analysis, and Section 5 concludes with suggestions on how to use this approach to explore the new study topics and locate any gaps in the body of existing literature.

2. LITERATURE REVIEW

Cheap distribution costs and transit times have a big impact on impulsive buying in Pakistan, especially when customers use digital currency. By suggesting that online businesses consider these factors to increase productivity and market share in impulsive purchases, the study contributes to the corpus of knowledge and literature on the topic (Wei et al., 2023). This study examines the effects of e-wallets on the economy and social fabric with the aim of transforming the nation into a cashless society. As intermediaries, it develops a conceptual framework predicated on attitude, perceived value, usability, security, and trust (Kamis et al., 2022). The study explores the Technology Acceptance Model (TAM) and UTAUT2 models to understand user intention, contentment and endorsement for utilization mobile wallets. The results of 206 surveys carried out in India show that perceived risk, attitude, stress, social impact, the utility and user-friendliness of a product greatly influence the intentions of its users and satisfaction. This study offers a framework for assessing the psychological, social, and risk components of adopting technology (Singh et al, 2019). Performance anticipation, social influence, hedonic incentive, trust, facilitating circumstances, and habit components all affect behavioral intention to use an e-wallet. The lack of discernible impact from perceived security suggests that users have a positive perception of financial institutions' security practices (Thaker et al., 2022). Perceived security, ease of use, and enjoyment were the factors that determined e-satisfaction, while perceived trust, cost, and ease of use determined e-loyalty. The study also found that e-WOM had a significant moderating influence. (Al-Okaily, M., 2023). The study provides insights into usage behavior and empirical support for model consistency across client segments. In the era of digital transformation, it also highlights how important it is for businesses to understand

the needs and preferences of their clients in order to facilitate user development and navigation (Truc, 2024). This study examines the desire to continue using Touch 'n Go, an e-wallet system in Malaysia, using a framework based on the theories of mental accounting and diffusion of innovation. The results show that convenience encourages continued intention whereas perceived danger inhibits it. Compatibility and complexity are minimal, and neither PI nor personal worry are proven to be modifiers (Tian et al., 2024). Since the COVID-19 pandemic, e-wallets have gained popularity as a safer payment method. A study employing the cognitive absorption theory found that the perceived usefulness and user-friendliness considerably influence users' intentions to engage continue using e-wallet apps. This relationship is mediated by attitude and subjective well-being, and it is moderated by perceived security (Lim et al., 2022). By highlighting benefits like financial inclusion, drawbacks like infrastructure, opportunities like the elimination of fraud, and risks like virus attacks, the study examines the potential of Malaysian e-wallets for both consumers and companies (Alam et al., 2021). People's propensity to use an e-wallet was positively impacted by factors such as perceived usefulness, ease of use, social impact, alignment with lifestyle, and trustworthiness according to the survey. The relationship between lifestyle suitability and e-wallet intention was influenced by age and gender (Yang et al., 2021). This study investigates the variables influencing Worldcoin wallet usage in Thailand in an effort to raise acceptance rates and user preferences. It implies that marketing initiatives ought to be customized according to demographic categories including age, gender, occupation, income, savings, education, and social media engagement (Kraiwanit et al., 2023). According to a poll, user satisfaction and retention were significantly impacted by e-wallets' security and usability. Consumers depend on the security and dependability of their payment methods (Abas and Puspawati, 2024). According to a poll, user satisfaction and retention were significantly impacted by e-wallets' security and usability. Customers rely on their payment systems for reliability and security (Belmonte et al., 2024). (Teng and Khong,2024) E-wallets are used by study participants to earn reward points and rebates. Real-time customer service and user-friendly interfaces are components of successful business concepts. However, poor merchant uptake, stricter government regulations, and intense competition all contribute to low mass use. Because of the internet revolution, electronic wallets, or "E-Wallets," have been developed. This digital wallet has grown in popularity because to its convenience, security, and ease of usage. This result is consistent with the demographics on gender, geography, employment, income, and educational attainment, with the exception of age, rating of e-wallet usage purpose, and perception of e-wallet (Koh, et al, 2024). The study looks into the factors which influence how alms tax distribution organizations, or "asnaf," as charitable benefactors are called, use e-wallet apps. The results show that perceived usefulness, consumer maqasid index, innovativeness, and subjective norms all influence acceptability alongside the perceived simplicity of use. (Shaikh and Amin, 2024). The study looks into how perceived utility, user-friendliness and benefits affect consumers' inclination to stick with e-wallets. Perceived usefulness was found to partially influence the connection between incentives and user-friendliness and ICU, whereas it completely mediates the association between enjoyment and ICU (Kumar et al., 2024). The study tests the connection between environmental information and individuals' intentions to use e-wallets and finds that perceived utility, behavioral control, and subjective norms all directly affect intention (Zaidan et al., 2024). Mobile wallet users are pleased with e-wallets, which are becoming more accessible and accepted as a common payment method. The best features include availability, privacy, security, ease of use, and benefits. E-wallets are used by young people for online shopping, bill payments, recharge, peer-to-peer bill sharing, and meal purchases (Aggarwal and Vaish, 2024). A study examines the factors influencing behavioral intention and e-wallet usage using UTAUT. The findings indicate that perceived enjoyment plays a substantial role in influencing outcomes on contentment, effort expectancy, and performance expectancy. Nonetheless, the effects of favorable circumstances, contentment, and social influence are minimal (Esawe, 2022).

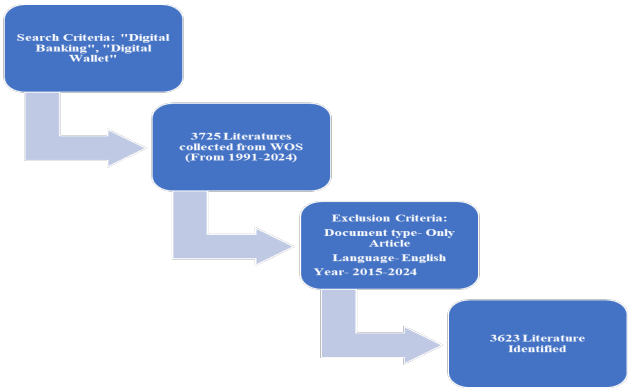
3. OBJECTIVE

- To examine the evolution of e-wallets.
- To identify key trends in digital banking.

Methodology

To assess the present and future state of digital banking practices and e-wallet research, we carried out a thorough library analysis in this study using scientific databases including Web of Science. Using the scoping review approach, we examined 3623 documents in the subsequent eligibility process using the phrases “digital wallet” and “digital banking” in compliance with the qualified process from 2015 to 2024.

Data Extraction Method



4. RESULT AND ANALYSIS

4.1 Main information about the data

Figure-1: Main information about data

An essential tool for bibliometric study, the data is sourced from the Web of Science Database. This study primarily used a timeframe that extended from 2015 to 2025 to draw its conclusions. Key phrases "digital wallet" and "digital banking" were connected using the "AND" operator, which formed the basis of the entire analysis. Publications written in English were the only ones that met the screening criteria. Our final collection contains 3070 papers, as illustrated in figure 1. A total of 1,382 authors were associated with works written by a single author, and 294 of these authors were related.

4.2 Annual Scientific Production

Data presented in Figure 2 shed light on the evolution of research domain under study over the course of several decades. There appears to have been very little, if any, scientific output in the early years, with only a handful of small variants. Beginning in the 2015s and 2025s, there was a considerable surge in the quantity of articles issued each year, indicating some yearly variances. This expansion strengthens starting in the 2019s and extending into the 2023s, a notable and continuous growth in scientific output. The 2010s and thereafter look to be years of quick and sustained development, reflecting a rise in interest and research activities in the topic. This rising tendency suggests a development in the subject and a growth in the research engagement, with more attention from the scientific community and policymakers. Specifically, the decade from 2021 to 2024 is notable for a striking surge in scientific output, with a constantly increasing quantity of articles each year. This could be credited to greater interest from scientists, technical progress, improved financing, or several other aspects that have enhanced research efforts in the subject. In summary, this information reveals a remarkable development of the discipline during the analyzed timeframe and a consistent and heightened passion for research within this sector.

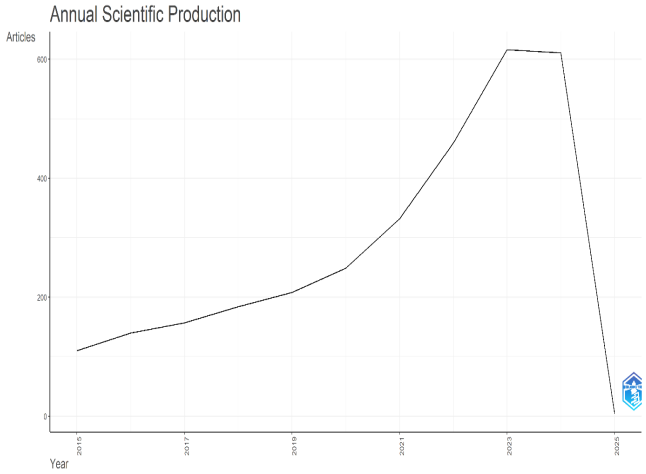


Figure-2: Annual Scientific Production

4.3 The interconnection among Author, Keyword, and Sources

Based on figure-3, we examine the three field studies illustrating the connection between authors, keywords, and sources. The names of the authors are positioned on the left, the journal titles are located on the right, and the keywords are found in the centre. This suggests that the majority of authors have identified "fintech" as their primary keyword. Nevertheless, the terms "blockchain" and "digital transformation" have also been utilized in various other academic articles. The majority ofpublications are done through the ieee access journal and followed by sustainability and research in international business and finance.

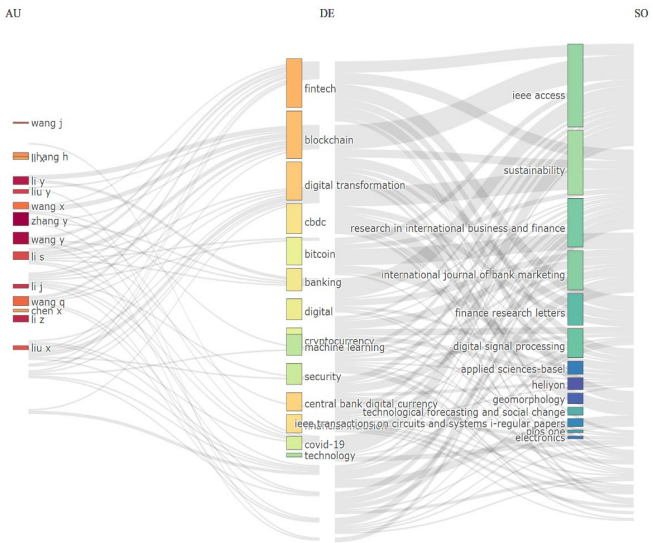


Figure-3: The three-field plot of author, keywords and sources

4.4 Keyword Co-occurrences and all keyword

TABLE 1: shows the most keywords used and what is the link strength among them.

Keywords	Occurrences	Total link strength
Adoption	152	1234
Impact	188	1170
Technology	149	1041
Information-technology	114	979
Innovation	145	979
Fintech	161	976
Model	150	973
Performance	160	908
Banking	122	851
Trust	94	754

As shown in Fig. 4.4: Which main sub-topic relate to the digital banking trend? The secondary bibliometrics analysis is conducted to reveal important themes that are frequently found in the area of digital banking and use of e wallets study for the market. Utilizing a VOS viewer to analyze keyword co-occurrence, this method highlights and displays the most commonly occurring keywords or terms in the literature (Figure 4.4). This approach allows for the recognition of frequently cited keywords or themes, offering insight into the main subjects of interest and their relationships within the field (Kholidah et al., 2022). The bibliometrics map generated from this analysis appears in Figure 4.4. This illustration emphasizes the most common keywords and themes present in digital banking, elucidating the connections between different topics and motifs. The clusters shown are tightly linked and pertinent to digital banking and e wallets. Notably, the largest cluster centers on 'adoption' as the main term, including numerous associated keywords like impact, technology, information- technology and innovation.

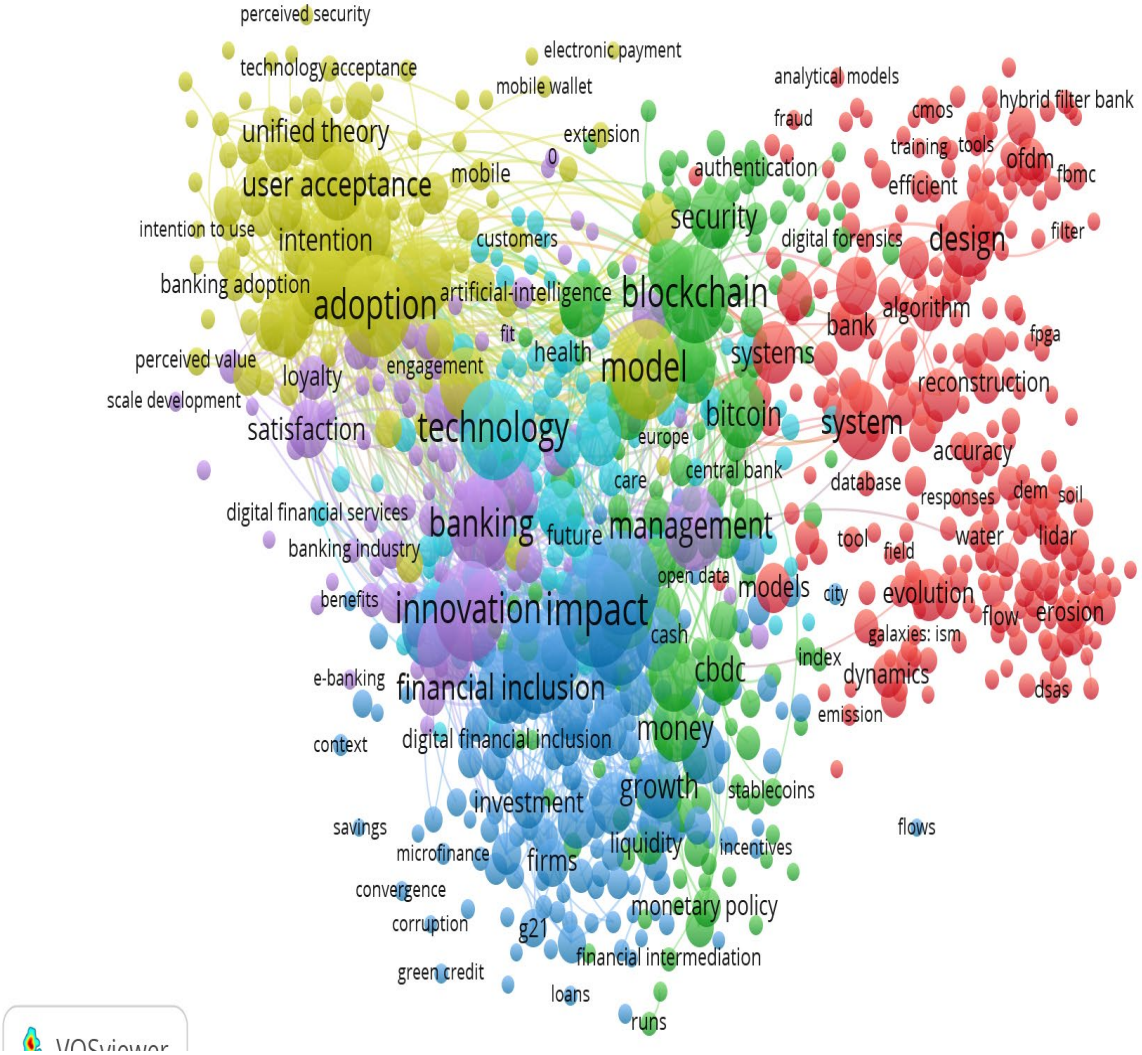


Figure-4.4: keyword Co-occurrences and all keyword

4.5 Citation and Country

TABLE 2: explains the country participation and the influence through the link strength.

Country	Documents	Citations	Total link strength
Peoples r china	746	10546	1863
USA	556	15470	1769
England	310	8745	1597
India	272	4731	817
Germany	184	5518	721
France	130	5274	712
Canada	142	2970	539
Italy	147	3944	478
South Korea	122	1419	454
Malaysia	92	1680	438

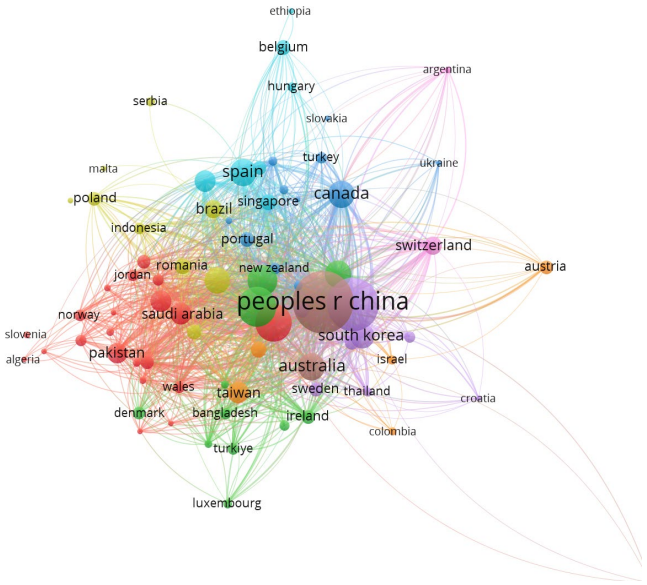


Figure-4.5: Citation and Country

4.6 Bibliographic coupling and Country

From the table 3, we can see the top 10 countries and the identical idea generation among different countries where People r China is in the lead with 746 document and 10546 citations followed by the USA, England, India and France.

TABLE 3

Country	Documents	Citations	Total link strength
People r China	746	10546	155330
USA	556	15470	122464
England	310	8745	118338
India	272	4731	108203

Country	Documents	Citations	Total link strength
France	130	5274	63869
Germany	184	5518	60216
Malaysia	92	1680	59021
Australia	147	3306	49456
Italy	147	3944	48931
Saudi Arabia	97	2226	45747

From the figure 4.6, The minimum number of documents from a country is 5, and the country must have at least a certain number of citations to meet the requirements is taken as 5. From 126 countries, 79 meets the threshold. we can see that majority of work is done in China with citation 10546 and the link strength 155330. In this India also placed in top five with citations 4731 and link strength 108203.

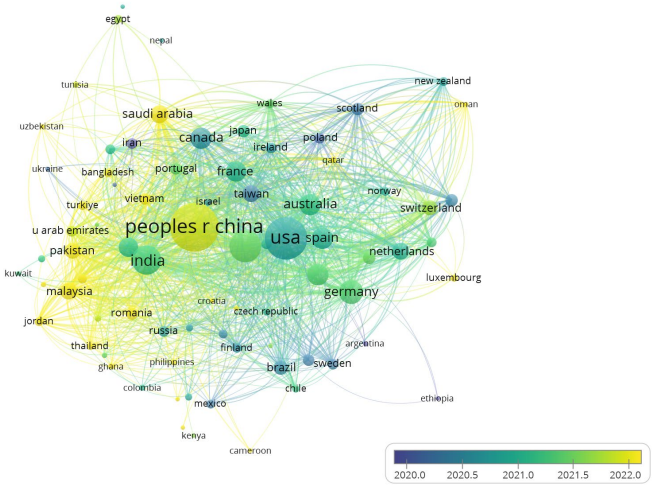


Figure-4.6: Bibliographic coupling and Country

5. CONCLUSION

It appears that the journal covering e-wallets predicts a significant increase beginning in 2021. The widespread use of electronic wallets is likely to blame for this publishing trend. Furthermore, the COVID-19 pandemic alters human behavior in relation to the utilization and uptake of technology. For instance, the movement control order promotes online shopping, which in turn increases the utilization of e-wallets. The outcomes of this study emphasize electronic payment systems as a crucial device for monetary reformation. The research has several key constraints. First, the reliance on data from the Web of Science is significant, which may be overlook important research, particularly from developing areas or non-English speaking regions-language sources. Furthermore, by focusing mainly on bibliometric data, the study misses the opportunity to explore deeper qualitative aspects, such as user behavior and barriers to adoption. For upcoming research, integration of both quantitative and qualitative methodologies will be crucial in enhancing our understanding of the potential evolution of these technologies to deliver inclusive and secure financial solutions on a global scale. By broadening the range of data and techniques employed, we can develop a more thorough perspective of the digital payment ecosystem.

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Access to Formal Financial Services: A Case Study of Six Villages in Keonjhar District

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ABSTRACT

Access to formal financial services is essential for economic development, especially in rural areas, where limited infrastructure and financial awareness often create barriers to financial inclusion. The aim of this paper is to analyse the accessibility of formal sources of financial services in six rural villages of Keonjhar district, Odisha, with a focus on factors influencing the availability and use of services like banking, credit, and insurance in rural areas. The study is based on a survey of 102 households from Ghatagaon, Patna, and Harichandarpur blocks, using binary logistic regression to analyze how factors such as caste, income, education, distance to bank branches, occupation, SHG, and awareness of government schemes like PMJDY impact access to bank accounts. The findings show that caste, education, occupation, and distance to bank branches significantly influence access to bank accounts, while income and awareness of PMJDY have less impact. The study reveals that households from Scheduled Caste (SC) and Scheduled Tribe (ST) communities face more challenges due to socio-economic and geographical barriers. The results point to the need for policies that improve banking infrastructure, raise financial literacy, and make banking services more accessible in rural areas.

[Keywords: Formal Financial Services, Rural Areas, Financial Inclusion, Financial Literacy, Banking Infrastructure, socioeconomic, Binary Logistic Regression, Keonjhar District, Odisha,]

1. INTRODUCTION

Financial institutions known for holding deposits and providing loans are banks. Because they offer essential services to customers. Financial service accessibility may significantly increase economic growth and reduce poverty (Shah, 2020). However, global access to banking remains limited, with only 69% of adults having bank accounts, and even fewer in developing countries, including Nepal, where only 45% of the population is banked (Demirgüç-Kunt et al., 2018; World Bank, 2018). Nepal's financial sector includes various institutions such as commercial banks, development banks, microfinance institutions, and cooperatives, all regulated by the Nepal Rastra Bank and the Department of Cooperative (Acharya, 2019). Despite these efforts, a significant portion of the population remains "unbanked," facing difficulties in saving and accessing credit. Moreover, people with disabilities (PwDs) encounter additional barriers to financial inclusion, with specific challenges in accessing traditional banking services (Sambad & Samal, 2023). Although mobile banking has provided some solutions, there is still a need for targeted policies to better serve PwDs. Chetanbhai and Rajpurohit (2016) point out that while banking services have expanded, issues like limited access to credit continue. Bijoy (2017) notes that the financial infrastructure in areas like Odisha is still not developed enough, despite various government initiatives. Even with these programs, infrastructure problems still limit the success of financial inclusion in some areas. Sailaja and Rao (2018) explain that even though PMJDY has made banking more accessible, many people in rural areas still struggle to use these services effectively because of low financial literacy. Similarly, Sarkar (2020) says many tribal families in Odisha cannot use their savings accounts properly due to a lack of financial knowledge. Gupta and Thakur (2020) emphasize that financial inclusion isn't just about opening accounts but also about people actively using financial services, which is often hindered by a lack of awareness. Districts like Kandhamal and Kalahandi in Odisha face particular challenges. Studies by Rout et al. (2021) and Rout (2018) show that these areas have limited banking facilities, low financial knowledge, and a lack of understanding about how to use banking services. Bhavani and Veni (2015) suggest that awareness programs could help by teaching people about the benefits of inclusive banking. Dinku (2021) and Rao (2017) identify other barriers like long distances to banks, high transaction costs, and missing documents that prevent people from fully using financial services.

Education, income levels, and access to technology are essential for achieving financial inclusion. Jayanti et al., (2021) argue that these factors are essential for determining if rural people can benefit from financial services. Priyadarshini et al., (2020) says that land ownership and income from farming are important factors for farmers' access to financial services. However, even though many farmers own land and generate income from agriculture, they still face financial challenges that prevent them from accessing services. Despite efforts to raise awareness, many rural people still don't understand how to use banking services effectively. Joshi and Rajpurohit (2016) emphasize that more education on financial matters is needed. Agrawal

et al., (2021) highlight that many rural areas in Odisha face problems like low bank account usage, lack of savings, and limited access to credit, making financial inclusion difficult to achieve.

Financial exclusion when people can't access financial resources has often been linked to higher poverty rates. Small farmers, for example, face barriers like a lack of banking infrastructure, which makes it harder for them to invest in farming and improve their economic situation (Priyadarshini et al., 2020). Financial inclusion is essential to addressing poverty and improving economic opportunities for all, especially those who have historically been excluded. Programs like PMJDY aim to provide financial services to all, especially in rural areas (Guru & Panda, 2022). Access to banking services is crucial for economic growth and reducing poverty (Ganga Bhavani & Veni, 2015).

Financial inclusion is not just about having a bank account; it is about empowering individuals to use these services to improve their financial well-being (Sarkar, 2020). Studies show a strong link between financial exclusion and poverty, highlighting the need for policies that ensure everyone can access financial services (Joshi & Rajpurohit, 2016). Financial inclusion plays a big role in improving people's financial stability and driving economic growth. It helps people save money, make investments, and use resources more effectively (Abel et al., 2018). Access to credit, in particular, can help poor households start income-generating businesses and improve their financial situation (Chinnamuthu & Gabriel, 2015). However, achieving full financial inclusion is still difficult due to challenges like inadequate banking infrastructure and the prevalence of informal financial services that often exploit vulnerable people (Dinku, 2021). Financial inclusion is an ongoing process that requires effort from everyone governments, financial institutions, and communities to make sure that all people, regardless of their background, can access the financial services essential to improving their lives. It is a key part of creating fair economic growth, reducing poverty, and giving everyone the opportunity to succeed (Mrunal & Rajpurohit, 2017). Thus, financial inclusion is a key driver of pro-poor growth, creating a more equitable society (Kaur & Singh, 2015).

2. LITERATURE REVIEW

Shah (2020) examines the factors influencing household access to bank accounts use data from the Nepal The demographic information and Health Survey of 2016. Binary logistic regression models are used in the study to determine significant variables the possibility of owning a bank account increased with larger landholdings, higher incomes, larger families, and more members with a secondary education. The study underscores the importance of addressing regional, gender, and socio-economic disparities to improve financial inclusion in Nepal. **Samal & Samal (2023)** in their paper *"People with Disability and Access to Financial Services: Evidence from Odisha"*, explore how disability impacts access to financial services using Probit and IV Probit models on Odisha Economic Survey data. They find PwDs are significantly less likely to access banks but more inclined toward mobile money services, highlighting its potential for financial inclusion. The study emphasizes socio-economic barriers faced by PwDs and calls for broader analysis and targeted policy interventions to bridge inclusion gaps Kabya Sambad and Ashis Kumar Samal (2023). **Agrawal et al., (2021)** in their paper, examine the role of financial inclusion in promoting inclusive growth in the rural areas of Jharsuguda and Sundargarh districts in Odisha. The study assesses the extent of financial inclusion, focusing on parameters like bank account ownership, formal savings, and borrowings. Using primary data from six villages and applying multivariate analysis and probit models, the researchers find that financial literacy and education positively influence financial inclusion, particularly in bank account ownership and formal savings. The study also reveals that civic index plays a key role in influencing borrowings, although financial literacy shows a weaker relationship with it. The study also suggests examining the broader economic impacts of financial inclusion, such as income generation and poverty alleviation. **Sarkar (2020)** examines the borrowing, investing, and saving habits of a selected group of tribal households using both primary and secondary method using multipurpose sampling method in backward villages of Nabarangapur district of Odisha and observe that despite the fact that nearly all sample homes have at least one savings bank account, access to banks and other financial institutions is limited. The majority of bank accounts appear to have been created to obtain government payments and other money transfers. It also shows that individuals are aware of banking and other financial services but do not utilise them correctly due to illiteracy and a low level of income. **Chetanbhai and Rajpurohit (2016**) in their paper tries To investigate the recently introduced PMJDY financial inclusion program, secondly its current status and also awareness programs in rural and factors affecting in awareness about PMJDY among rural customers by both primary and secondary sources using chi square test and cross tabulation and found that while access to formal financial institutions has gradually increased and more than half of the people have access to banking services. **Sailaja & Rao (2018**) in their paper tries to find the current status of PMJDY, factors that affects accessing financial product and services and people awareness about it using descriptive statistics such as mean, ANOVA and T test through primary source where they have taken 150 respondents and found few conclusions such as irrespective of their age both male and female are aware about PMJDY, secondly considering the mean score for accessing the financial product and services. **Gupta & Thakur (2020**) in their paper compare state-wise financial inclusion levels and assesses the performance of financial inclusion before and after the implementation of PMJDY using secondary source of data from various sources

such as CRISIL inclusix, various reports of RBI and found that a significant increase in the number of accounts has been observed since the launch of the PMJDY scheme. **Rout et al.(2021)** in their paper tries to understand the status of financial inclusion in different districts of Odisha by analysing the level of financial inclusion such as high, medium and low level of financial inclusion using a multi-dimensional index by assigning equal weightage to all six indicators that have taken over a time series 2009 to 2017 and found that though an improvement status has been seen over these years in many district of Odisha, still districts like Gajapati, Boudh, Nuapada, Kalahandi, Malkangiri, Kandhamal, Nabarangpur, and Kalahandi, which have persistently been described as having low financial inclusion over the course of the year, rank below 25, which is a very low index value of less than 0.15. Lastly the paper suggests that with an index value between 0 and 0.3, districts like Kalahandi, Kandhamal, Koraput, Balangir, Kendujhar, and Mayurbhanj are found to fall into the group of high and upper middle income. Therefore, governments should quicken the financial inclusion process in these districts. **Jayanti et al. (2021)** in their paper examine the barriers to accessing formal financial services in Indonesia and the preference for informal financial services. Using the SOFIA dataset from the Ministry of National Development Planning, they employed binary logistic regression to analyze these barriers in East Indonesia. Higher income, education, and access to technology were having a positive effect on usage, while self-employment, living in a remote area, and being older had a negative impact.

Rao (2017) examined financial exclusion in Ethiopia using survey and bank data. Key barriers identified were lack of funds, high costs, distance, insufficient documentation, low product diversity, and market failures, disproportionately affecting low-income groups. **Sharda (2020)** studied financial inclusion among farmers using primary data and multistage sampling. Garret's ranking and multiple regression identified key factors influencing inclusion. The study finds that the majority of farmers owned their own land, which enhances the likelihood that they will be included in the financial system. In the research area, bank account penetration was high. Agriculture-related income was discovered to be one of the key predictors of financial inclusion. The farmers encountered numerous difficulties in obtaining the financial services. Insufficient income was identified as one of the main obstacles to financial inclusion among the respondents' different issues.

Joshi and Rajpurohit (2016) in their paper study the level of awareness about PMJDY among rural customers and the key factors influencing it, using both primary and secondary data. They employed the chi-square test to validate the results of cross-tabulation for hypothesis testing. In this study, they found that the government continuously takes action through various programmes to improve the lives of rural population.

3. DATA SOURCES & METHODOLOGY

1. Sampling deigns:

Basically, financial inclusion includes the underprivileged and weaker groups, such as schedule tribes. Out of 30 districts in Odisha, one district has been selected i.e., Keonjhar, it has one of the highest Scheduled Tribe population, has been choosen as the sample district using the simple random sampling method. Primary data are collected from six villages Kundapitha, Chasatangiri, Keri, Thakurpada, Murusuan & Bouripada from Keonjhar district. The 102 households were selected randomly; more than 10 from each village. 102 households are selected for the study.

TABLE 4: Sample units and allocation of sample size

Sl. No.	Selected District	Sample Villages	* Total Household	Sample Size (Number of Households)
1	Keonjhar	Kundapitha	316	24
2		Chasatangiri	215	14
3		Keri	305	22
4		Thakurpada	94	15
5		Murusuan	425	14
6		Bauripada	226	13
Total			1581	102

Notes: * from Census Data

2. Sources of Primary Data

This study is based on primary data collected from six villages in the Keonjhar district of Odisha. The study focused on six villages located within the Ghatagaon, Patna, and Harichandarpur blocks of Keonjhar district. The sample villages are Kundapitha, Chasatangiri, Keri, Murusuan, Thakurpada, and Bauripada. A total of 102 sample has collected from the sample villages using a structured interview schedule, which was carefully designed to cover key areas like the socioeconomic situation of households, their background, and access to formal financial services.

3. Variables & Method of Data Analysis

Descriptive statistical techniques are used to show the status of socioeconomic condition of the household in the study area. To examine the socioeconomic status of the household, descriptive statistics including averages, percentages, cross tabulations, and graphs are used. Whereas the variables are collected from the field survey in order to analyse the accessibility to banking services. The data is analyzed using SPSS and STATA software. The variables are Caste, Gender, Occupation, Family size, Monthly Income, Monthly Expenditure, Educational level, Bank distance from the house of the household, Savings facility, insurance facility, Online Banking services, banking awareness, know about the PMJDY scheme, access to bank account, access to ATM

services, trust on bank, high cost & physical distance of branches.

4. METHODOLOGY

Descriptive analysis is used to understand the characteristics of both dependent and independent variables. For continuous variables, we calculate the mean and standard deviation, while percentages are used for categorical variables. Since the dependent variable, "household having a bank account," is binary, both simple and multiple logistic regression models are used. First, covariates are tested using simple logistic regression, and the significant ones are analyzed further with multiple logistic regression. The final model is created after checking its suitability. Binary Logistic Regression is used to estimate the empirical model of factors affecting financial access. Since the data collected from the primary survey is binary, the Binary Logistic Regression model is used, following standard methodology.

Regression Model:

This study is used binary logistic regression, with independent variables on continuous, binary, discrete, and categorical scales, and a binary dependent variable.. There are two categories of binary logistic regression: logit and probit. So therefore, to evaluate the access to formal financial services, the Binary Logistic Regression model is used.

Model: Logistic estimation of access to bank account

Logistic regression is a statistical technique used to predict the likelihood of an event occurring based on a set of predictor variables. In this case, let Yi represent a household's access to a bank account. The model estimates the likelihood that a household has a bank account (Yi=1) or does not have one (Yi=0) based on the given predictor variables.

Let $\pi_i = P(y_i=1)$ be the probability that the i-th household has a bank account, and $1-\pi_i = P(y_i=0)$ be the probability it does not. **Shah, S. K. (2020)** defined the multivariate logistic regression model as the model of log-odds for m covariates associated with the i-th individual, expressed as:

$$ln\frac{\pi i}{1-\pi i} = \beta 0 + \sum_{j=1}^{m} \beta j Xj$$

Therefore,

$$\frac{\pi i}{1-\pi i} = e^{\beta 0 + \sum_{k=1}^{m} \beta k Xk}$$

The above model can also be written as πi:

$$\pi i = \frac{e^{\beta 0 + \sum_{k=1}^{m} \beta k Xk}}{1 + e^{\beta 0 + \sum_{k=1}^{m} \beta k Xk}}$$

$$1-\pi i = \frac{1}{1 + e^{\beta 0 + \sum_{k=1}^{m} \beta k Xk}}$$

Where $0 \le \pi i \le 1$, i = 1, 2,…n and x_k (k = 1,2,… m) are the explanatory variables. The model parameters, β0 and βj, were estimated using maximum likelihood estimation.

In this study, the binary logistic regression model is specified as:

$$\text{Log}\left[\frac{P(yi=1)}{1-P(yi=1)}\right] = Log\frac{\pi i}{1-\pi i} = Logit(\pi) = \beta 0 + \beta 1 X1 + \beta 2 X2 + \beta 3 X3 + \cdots \ldots\ldots + \beta k Xk$$

$$, 0 \le \pi i \le 1$$

Where, β0 is the constant term, β's are the regression coefficients, and X's are the covariates, which can be categorical, continuous, or both.

From the above equation, P(y=1) or π represents the probability of household having a bank account, while 1−P(y=1) or (1−π) denotes the probability of a household not having a bank account.

5. DATA ANALYSIS AND RESULTS

Descriptive Analysis:

1. Community wise distribution of sample respondents

Similarly, Table 2 shows that most respondents in the selected sample villages belong to the ST community. Out of 102 respondents, 51 (about 50%) are from the ST community, 6% are from the SC community, and 45 respondents (44%) are from the OBC community.

TABLE 2: Community-Wise Distribution of Sample Respondents

Sl. No	Caste	Number of Respondents	%
1	SC	6	5.9
2	ST	51	50
3	OBC	45	44.1
Total		**102**	**100**

Source: Author's field survey data.

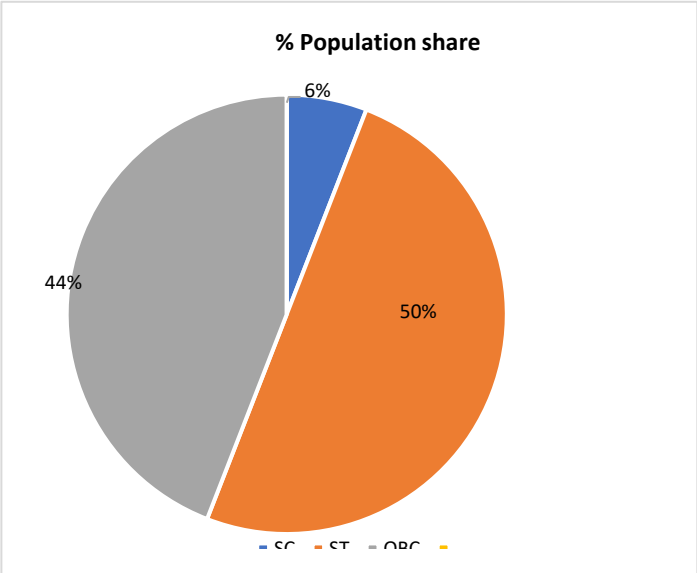


Figure 1: Social Category of the households

2. Educational qualification of the respondents in the sample villages

Education is the light of the society. It provides greater awareness of all social activities. The table below presents the educational qualifications of the sample households.

TABLE 3: Educational qualification of the respondents

Qualification	No. of Respondents	Percent	Cumulative Percent
Illiterate	31	30.4	30.4
Primary	23	22.5	52.9
Secondary	21	20.6	73.5
Higher Secondary	16	15.7	89.2
Graduation	9	8.8	98.0
PG	2	2.0	100.0
Total	**102**	**100.0**	

Source: Author's computation from field survey

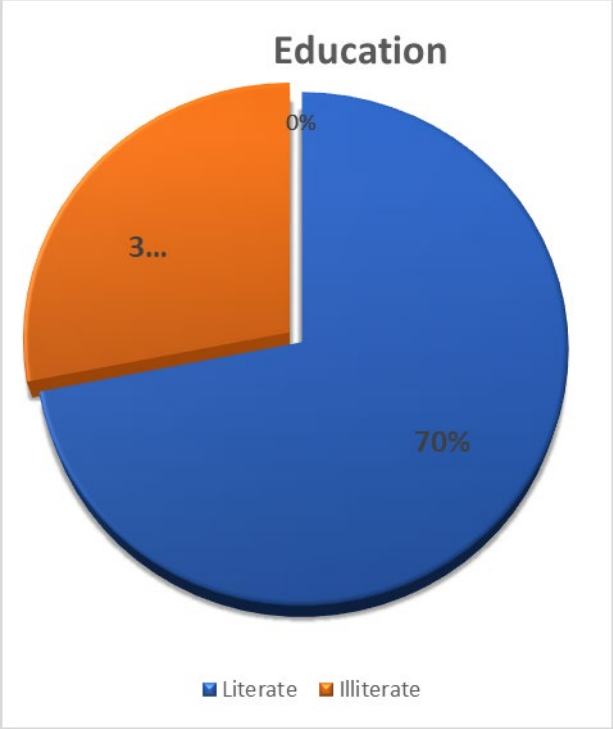


Figure 2: Educational qualification

The above table 3 shows that the 30.4% of the respondents belongs to Illiterate category, 22.5% of the respondents are studied Primary level Education, 20.6 percent of the respondents are Secondary level education, 15.7% of the respondents are completed their Higher Secondary education, 8.8% of the respondent are completed their Graduation education and only 2% of the respondents are completed their PG education. Whereas, the bar dig represents that out of total collected sampled household from the study area 70% are literate while 30% are illiterate. The above statistics represents that majority of people in the study area are literate.

3. Distribution of monthly Average Income, Expenditure & Savings of respondents:

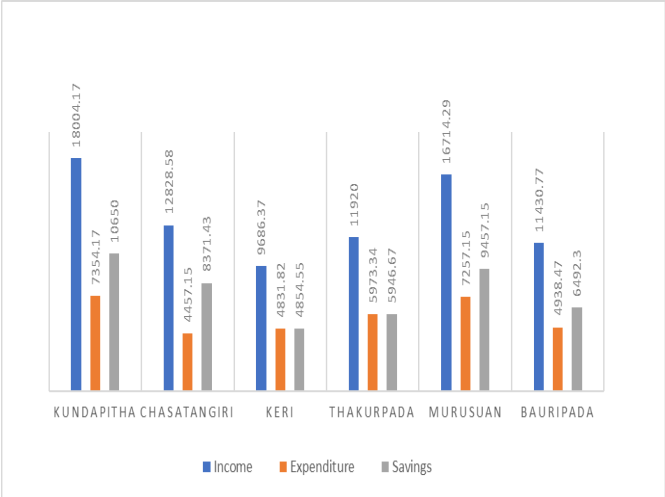
TABLE 4: Distribution of Monthly Average Income, Expenditure, and Savings of Respondents

Name of the Village	Total respondent	Average (income)	Average (expenditure)	Average (Saving)
Kundapitha	24	18004.1667	7354.167	10650
Chasatangiri	14	12828.5714	4457.143	8371.429
Keri	22	9686.36364	4831.818	4854.545
Thakurpada	15	11920	5973.333	5946.667
Murusuan	14	16714.2857	7257.143	9457.143
Bauripada	13	11430.7692	4938.462	6492.308

Source: Author's computation from field survey

Table 4 presents the average monthly income, expenditure, and savings of households across six villages. In Kundapitha, 24 households reported an average income of ₹18,004.16, expenditure of ₹7,354.16, and savings of ₹10,650. Similarly, in Chasatangiri, 14 households had an average income of ₹12,828.57, expenditure of ₹4,457.14, and savings of ₹8,371.42. For Keri's 22 households, the averages were ₹9,686.36, ₹4,831.81, and ₹4,854.54, respectively. In Thakurpada, 15 households showed an average income of ₹11,920, expenditure of ₹5,973.33, and savings of ₹5,946.66. Murusuan's 14 households had an average income of ₹16,714.28, expenditure of ₹7,257.14, and savings of ₹9,457.14. Finally, in Bauripada, 13 households reported an average income of ₹11,430.76, expenditure of ₹4,938.46, and savings of ₹6,492.31.

Figure 3: Monthly Average Income, Expenditure, and Savings of Respondents



Source: Author's computation from field survey

4. Distribution of the respondents According to Occupation

TABLE 5: Occupational Status

Occupational Status		No. of Respondent	Percentage	Cumulative percentage
Unemployed		7	6.86	89.22
Employed type	Agricultural labourers	30	29.41	29.41
	Daily worker	39	38.24	82.35
	Business	15	14.71	44.12
	Salaried people	11	10.78	100.00
Total		**102**	**100.0**	

Source: Author's computation from field survey

The table 5 shows that out of 102 households respondents 30 respondents have i.e 29.4 % of the total respondents are Agricultural labourers, 10.78% of the respondents are Salaried People, 38.24% of the respondents are daily worker, 14.71% respondents are doing business and nearly 7% of the respondents are unemployed type. The data show that the majority of respondents are working as agricultural labourers and daily workers.

4. Accessibility to Financial Services & Its Determining Factors

Financial inclusion starts with access to formal financial services, mainly through bank account ownership, enabling the use of related products and services. In Keonjhar district, 68.28% of households had bank accounts as per the 2011 Census. Table 5 shows that in the study villages, 81.4% of respondents have bank accounts. Murusuan village has the highest bank account ownership at 100%, while Chasatangiri has the lowest at 57.1%.

TABLE 5: Ownership of bank account (in %)

Name of the Village	Total respondents	Own a bank account
Kundapitha	24	83.3
Chasatangiri	14	57.1
Keri	22	86.4
Thakurpada	15	80
Murusuan	14	100
Bauripada	13	76.9
Total	102	81.4

Source: Author's computation from field survey

5. Banking details of the respondents account holder

TABLE 6: Banking details of the sample household (in %)

Owns a bank account	
No	**18.6**
Yes	**81.4**
Distance of Bank branches from the house of Households	
1-2km	9.8
2-4km	22.5
4-10km	22.5
More than 10km	45.1
Availability of ATM	
Less than 1km	8.8
1-3km	24.5
3-5km	18.6
Above 5km	48
Mode of Transport to Bank branches and ATM	
Bicycle	18.6
Walking	3.9
Motor Bike	40.2
Public Transport	18.6
Reasons for opening bank account	
Saving	66.7
Loan	0
Salaries (Labour Card)	10.8
Insurance	3.9
Pensions	0
Account holding of financial institution	
SBI	42.43
BOI	37.08
Odisha Grameen Bank	5.84
Bank of Baroda	14.64
Family member open PMJDY account	
One	32.4
Two	18.6
More than Two	9.8
None	39.2

Source: Author's computation from field survey

The study reveals various banking details of respondents. Out of 102 surveyed households, 83 have bank accounts, while 19 are financially excluded. Proximity to banks varies: 9.8% have accounts in banks within 1-2 km, 22.5% within 2-4 km, another 22.5% within 4-10 km, and 45.1% more than 10 km away. Motorbikes are the preferred mode of travel, with 40.2% using them, while 3.9% of respondents walk to bank branches. Saving is the primary purpose for opening accounts, as stated by 67% of respondents. Among banks, 42.43% hold accounts with the SBI, 37.08% with BOI, 14.64% with Bank of Baroda, and 5.84% with Odisha Grameen Bank. Under PMJDY, 32.4% of respondents have accounts for one family member, 18.6% for two members, 9.8% for more than two, and 39.2% reported no family member with a PMJDY account. Most respondents belong to

the category where no family member holds a PMJDY account.

TABLE 7: Summary statistics of household characteristics of continuous variables

Variable	Mean	Std. Dev.	Min	Max
Age of HoH	50.59804	12.06029	23	80
Mean years of schooling 7.468627	4.050571	0	15.7	
Monthly Income	13590.2	11776.56	3800	55000
Bank distance	8.960784	4.671213	3	15
Family Size|	3.54902	1.354329	1	11

Table 7 illustrates the summary statistics of household characteristics indicate that the mean age of the household head (HoH) was 50.60 years, with a standard deviation of 12.06 years, ranging from 23 to 80 years. This suggests that approximately 68% of household heads were aged between 38.54 and 62.66 years, while 95% fell within the range of 26.48 to 74.72 years. The average years of schooling among household heads were 7.47 years, and a standard deviation of4.05 years, spanning from 0 to 15.7 years, implying that most had between 3.42 and 11.52 years of education.

The mean monthly income was ₹13,590.20, with a standard deviation of ₹11,776.56, ranging from ₹3,800 to ₹55,000, indicating that 68% of households earned between ₹1,813.64 and ₹25,366.76. Additionally, the average distance to the nearest bank was 8.96 kilometers, and a standard deviation of 4.67 kilometers, from 3 to 15 kilometers, with 68% of households having access to banks located between 4.29 and 13.63 kilometers. The average family size was 3.55 members, and a standard deviation of 1.35 members, between 1 to 11 members, showing that 68% of households had between 2.20 and 4.90 members. These statistics highlight significant variations in household demographics, education, income, financial accessibility, and family composition.

6. AWARENESS LEVEL

The majority of non-account holders in the sample villages are from Scheduled Castes and Scheduled Tribes, who tend to be lower-income, illiterate, financially unaware, landless, and do not receive government benefits. Key barriers to opening a bank account include lack of money, low financial awareness, and distrust in banks, high costs, and physical distance from bank branches. Some individuals also lack the required documents or feel their income is too low to justify an account. Additionally, some prefer cash, find banking systems unsuitable, or simply do not see the need for a bank account.

Statistical Modeling:

1. Simple Binary Logistic Regression Model

TABLE 7: Results of Simple Binary Logistic Regression Model for Access to Bank Account

Independent Variables		Coefficient		Std. Err.
Mean years of schooling		0.2242714**		0.1185117
Income		0.0001123		0.0000719
PMJDY awareness		-1.305311		1.043529
Bank distance		-0.3998719***		0.10351
Caste		5.687243***		1.80936
Occ_1		16.35275***		1.755832
Occ_2		18.7546***		1.333344
Occ_3		21.06134***		1.938666
Occ_4		14.61626***		2.98665
SHG		-1.621929**		0.8148491
_cons		-22.72192		2.069563
Pseudo R2		0.9111		
Prob > chi2		0.0000		
Obs		102		

Note: **_cons** estimate baseline odds.

***Denotes significant at 1% level of significance ** Significant at 5% & * Significant at 10%

Source: Author's computation from field survey

The simple binary logistic regression model reveals that access to a bank account is significantly influenced by factors like caste, education, occupation, and bank distance. OBC households have higher odds of having a bank account compared to SC/ST households, while higher education levels and stable occupations like salaried or business jobs increase the likelihood of account ownership. Living farther from a bank reduces access, and membership in self-help groups (SHGs) tends to lower the chances of having an account. Income and PMJDY awareness were not significant predictors in this model.

2. Multiple Binary Logistic Regression Model

TABLE 7: Results of Multiple Binary Logistic Regression Model for Access to Bank Account

Independent Variables		Odds Ratio		Std. Err.
Mean years of schooling		1.251411**		0.1483068
Income		1.000112		0.0000719

Independent Variables		Odds Ratio		Std. Err.
PMJDY awareness		0.2710882		0.2828885
Bank distance		0.6704059***		0.0695714
Caste		295.079***		552.0738
Occ_1		1.26e+07***		2.22e+07
Occ_2		1.43e+08***		1.90e+08
Occ_3		1.40e+09***		2.72e+09
Occ_4		2227221***		6651928
SHG		0.1975173**		0.1609468
_cons		0.00000762		0.051
Pseudo R2		0.9111		
Prob > chi2		0.0000		
Obs		102		

Note: **_cons** estimate baseline odds.

***Denotes significant at 1% level of significance ** Significant at 5% & * Significant at 10%

Source: Author's computation from field survey

The binary logistic regression analysis looks at what factors influence access to a bank account, using socio-economic, structural, and geographic variables. The dependent variable is access to a bank account, which is influenced significantly by several independent variables. **Caste** (SC/ST coded as 0 and OBC as 1) plays an important role, with individuals from OBC groups (OR = 295.08, significant at 1%) being more likely to have bank accounts than SC/ST individuals. This is because SC/ST groups often face barriers like cultural differences, lower income, poor literacy, and less financial awareness.

Mean years of schooling (OR = 1.25, significant at 5%) has a positive effect, as more education helps people understand the benefits and processes of banking. **Occupation** is also important, with salaried people (OCC_4) and businesspeople (OCC_3) having much higher odds of having bank accounts compared to agricultural laborers (OCC_1) and daily wage workers (OCC_2), since stable incomes and formal jobs make it easier to access banking. **Bank distance** (OR = 0.67, significant at 1%) has a negative effect, as people living far from a bank—often more than 10 km away—find it harder to access banking services. Similarly, membership in **self-help groups (SHGs)** (OR = 0.20, significant at 5%) negatively affects access, as these groups often operate outside formal banking systems. **PMJDY awareness** (coded as 1 if aware, 0 otherwise) shows a negative but insignificant relationship (OR = 0.27), suggesting that even awareness of financial schemes does not always lead to account ownership, possibly due to other barriers. Lastly, **income** (OR = 1.00, not significant) does not strongly predict access, showing that issues like distance, education, and caste matter more than income. These results highlight the need to improve education, reduce caste-based barriers, bring banks closer to rural areas, and improve financial literacy to ensure better access to banking.

7. DISCUSSION

The study provides a comprehensive overview of socio-economic characteristics and financial inclusion among households in selected villages. A total of 1,581 households were considered, with a sample of 102 households. A majority (90%) of households were male-headed, and 90.7% lived in nuclear families. Age distribution showed that 44% of respondents were in the 31-50 age group, while 49% were aged over 51 years. Education levels were generally low, with 30% of respondents being illiterate. The community breakdown revealed that 50% of respondents belonged to the ST community, 44% to the OBC community, and 6% to the SC community. Occupation-wise, 21.6% of respondents were agricultural workers, 22.5% were daily laborers, and 13.7% were self-employed. Income levels varied across villages, with some areas reporting higher income and savings.

Out of the 102 sampled households, 83 had bank accounts, indicating some progress in financial inclusion. However, 19 households remained financially excluded, with 45.1% of respondents having to travel over 10 km to access banking services. The majority of respondents had accounts with the State Bank of India (42.43%), followed by BOI (18.3%) and Bank of Baroda (14.64%). The findings suggest that while bank account ownership has improved, challenges remain in achieving broader financial inclusion due to factors such as education, income disparities, geographic distance, and awareness.

A binary logistic regression analysis revealed significant factors influencing access to a bank account. Caste was a key determinant, with individuals from OBC communities (OR = 295.08, significant at 1%) more likely to have bank accounts than SC/ST individuals, reflecting barriers such as cultural differences, lower income, and poor literacy in the SC/ST groups. Education, as measured by mean years of schooling (OR = 1.25, significant at 5%), was positively associated with account ownership, as greater education helps individuals understand the benefits and processes of banking. Occupation also played a significant role, with salaried individuals and businesspeople having higher odds of having a bank account compared to agricultural laborers and daily wage workers. This highlights how stable incomes and formal jobs make it easier to access banking services.

Geographic distance to banks (OR = 0.67, significant at 1%) had a negative effect, with those living more than 10 km away from a bank facing greater difficulties in accessing banking services. Membership in self-help groups (SHGs) also negatively impacted access to banking (OR = 0.20, significant at 5%), as these groups often operate outside the

formal banking system. Although awareness of PMJDY schemes showed a negative but insignificant relationship with account ownership (OR = 0.27), income (OR = 1.00, not significant) did not strongly predict access to bank accounts, indicating that factors like education, caste, and geographic distance played more critical roles.

8. CONCLUSION

In conclusion, the study shows key factors affecting access to banking services in the selected villages. While some progress has been made, many challenges still remain. People from different castes, education backgrounds, and occupations experience different levels of access to bank accounts. Those from OBC communities, with more education, and those with stable jobs are more likely to have bank accounts. On the other hand, people from SC/ST communities, and those working in agriculture or daily labor, face more difficulties in accessing banking services.

Geographic distance is also a major barrier, with those living more than 10 km from a bank being less likely to have an account. Membership in self-help groups also reduces access to formal banking, as these groups often work outside the official banking system. Even though people are aware of government financial schemes like PMJDY, it doesn't always lead to them opening bank accounts, suggesting that awareness alone isn't enough.

The study points out that to improve financial inclusion, efforts should focus on overcoming these barriers, such as providing better financial education, addressing caste-based issues, and making banking services more accessible in remote areas. By doing so, more people, especially in rural and underserved communities, can benefit from banking services and improve their economic opportunities.

Limitations & Scope for Future Research

This study focuses exclusively on bank accounts as a measure of financial inclusion, overlooking other financial service providers such as postal banks and Microfinance Institutions (MFIs). Future research could broaden this scope by including these institutions. The study also relies only on the head of the household's responses, missing insights from other household members. Additionally, limited data on income, expenditures, and reasons for not opening bank accounts was available. The reluctance of bank staff to provide financial inclusion data further constrained the study. Future research could include both rural and urban populations and extend to more villages or districts to improve representativeness and accuracy.

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TRACK 4: PRODUCTION AND OPERATIONS MANAGEMENT

24

Analyzing the Impact of Automation on Sustainability in the Various Stages of Production in the Apparel Industry in India

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ABSTRACT

Background: the apparel manufacturing industry divides the production phase into pre-production (client meeting, design, sampling, pattern making, sourcing, quality assurance, costing, and process planning), production (fabric cutting, printing, embroidery, sewing, thread trimming, washing, ironing, folding, and packing) and post-production (inspection, quality control, defects, shipping etc).

Purpose: the paper's objective is to understand the role of automation in enhancing efficiency and sustainability in various phases of production in the Apparel Industry in India.

Methodology: Field visits were made to apparel manufacturers in the Delhi NCR region, and a qualitative questionnaire-based interview was conducted with the five owners, five designers, five merchandisers, and 25 factory workers to understand the impact of automation on efficiency and sustainability in the apparel industry in India. Qualitative analysis was carried out to determine the findings observed.

Findings: the research analyses the application of advanced automated and semi- automated tools and technologies in different stages of production in the context of production efficacy, process efficiency, environmental sustainability, and social sustainability.

Conclusion: the study reveals that Indian apparel manufacturers are lagging behind the West regarding sustainable production (high carbon emissions, waste dumping in landfills, low wages for laborers, and more). Although few companies lead by example in India, the number is far less.

Keywords: Automation, Sustainability, Production, Apparel Industry, India, SDGs

1. INTRODUCTION

Apparel Industry: a multi-billion-dollar multinational industry that is committed to the designing, manufacturing, distribution, marketing, retailing, and advertising of garments (ranging from casual wear to formal wear, loungewear to outer-wear like coats and jackets, and more) and accessories (including footwear, bags, belts, hats, jewels, and more). *(Nayak, R, 2015)*

Production in the Apparel Industry: *(Silva, C.,2020)* explains how production in an apparel manufacturing unit undergoes three major stages, namely- the pre-production stage (characterized by client meetings, product planning and development, resource accumulation and assessment, and more), the production stage (categorized by cutting, stitching, accessorizing, printing, etc.) and the post-production stage (categorized by quality control, defects, trimming, pressing, folding, packing, shipping).

(Nayak, R., 2018) gives a diagrammatic representation of the same. Diagram 1.0 is inspired by the same.

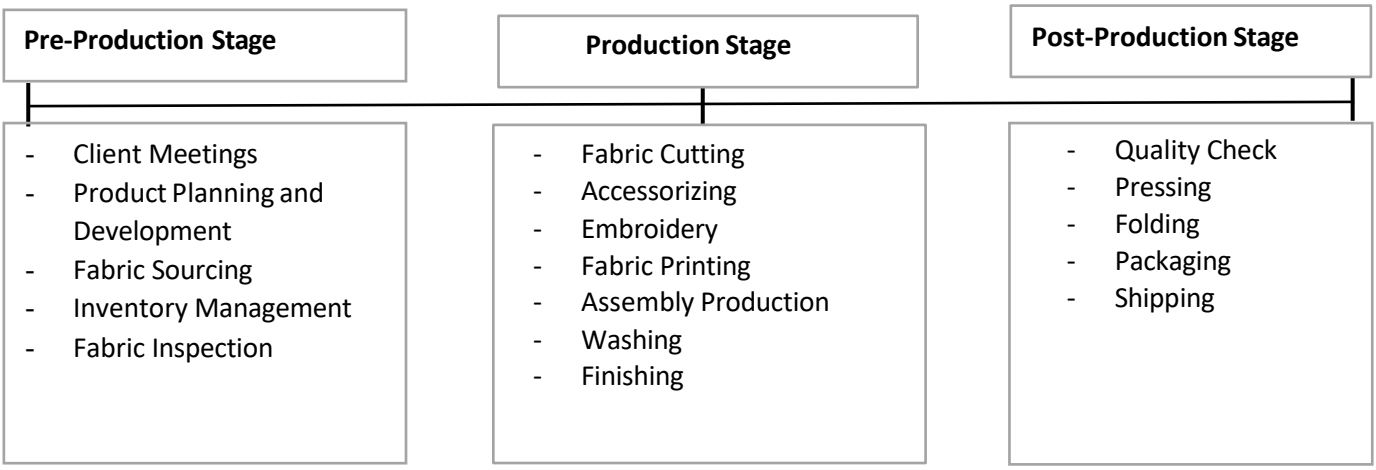

Diagram 1.0: diagrammatical representation of the different stages of production in the apparel industry

Need for Sustainability in Apparel Production: *(de Haro, 2021)* states the need for sustainability in apparel production has become increasingly urgent due to the industry's environmental, social, and economic challenges. The apparel sector is one of the largest contributors to pollution, consuming vast amounts of water, energy, and raw materials while generating significant waste and greenhouse gas emissions. For instance, traditional dyeing and finishing processes are resource-intensive and often lead to the discharge of toxic chemicals into water bodies. Moreover, *(Garg, P, 2020)* explains that fast fashion trends exacerbate the issue, promoting overproduction and overconsumption, which result in textile waste filling landfills at an alarming rate.

(Köksal, D, 2018) explains that socially, the reliance on low-cost labor in many regions raises concerns about fair wages, safe working conditions, and workers' rights. Economically, unsustainable practices threaten the long-term viability of the industry as resources like cotton and water become scarcer.

(Chowdhury, N. R., 2022) elaborates that adopting sustainable practices, such as using eco- friendly materials, improving energy efficiency through automation, and implementing circular economy principles, is essential. He explains that these measures can help reduce the environmental footprint, promote ethical labor practices, and ensure the industry's resilience in the face of global challenges like climate change and resource depletion. By prioritizing sustainability, the apparel sector can transition toward a more responsible and equitable future.

Automation in the Apparel Industry: IBM defines automation as applying technology, programs, robotics, or processes to achieve a desired outcome with minimal human input. It can be basic automation (takes simple, repetitive tasks and automates them to help eliminate errors and speed up transactional work); process automation (complex and multi-step process performed to increase productivity and efficiency within business), and intelligent automation (most advanced level of automation that combines with artificial intelligence (AI) and machine learning (ML) capabilities to enables machines to continuously learn and *make/take* better decision and actions based on data from past situations *they have* encountered and analyzed). (*What Is Intelligent Automation?* n.d.)

The 4th Industrial Revolution (4IR) has been characterized by an explosion of automation across all sectors of the economy, driven by Machine Learning (ML), Artificial Intelligence (AI), Robotics, Internet of Things (IoT), Blockchain, and advanced data analytics. This shift has helped reduce the per unit cost of production and total delivery time, improving factory efficiency and productivity, facilitating customization of the products for customer satisfaction, shifting towards more sustainable practices to reduce waste, and creating a sustainable competitive advantage. (*Suits You - and the Planet*, *2021*)

Automation in apparel can not only help boost the overall production function of the firm but also increase profitability, establish consumer trust and loyalty, and encourage a more flexible business model. It encourages sustainability by reducing waste, promoting energy conversion, improving working conditions, regulating the supply chain, ensuring real-time production, and more. *(Imran, A., 2024))*

(Sarkar, J., 2023) gave a detailed elaboration of the various automation tools and technologies adopted by the apparel manufacturing unit at the three different stages of production.

TABLE 1.0 is a tabular representation of the same.

Stages of Production		***Automation used***
Pre- Production	Client Meeting	- Communication and Collaboration Platforms
	Product Design and Development	2D and 3D Computer Aided Designing software (or CAD) for designing CLO 3D and Optitex for 3D visualization, real-time alteration, and pattern making
	Inventory Management	Radio Frequency Identification (or RFID) Internet of Things (IoT)
	Merchandising	Central Communication Platforms Inventory and Order Management system Product Life-cycle Management (PLM System) Demand Forecasting Tool Other data analytics tools.
	Cutting	Pattern printers Straight knife Bend knife

Production		Tagging Machine
	Sewing and Assembly	Pre-programed stitching machines RFID-enabled hangers
	Printing and Embroidery	Digital Printing Machines like DTG Printing, Sublimation Printing etc Computerized Embroidery Machines for mass designing and pattern making.
Post Production	Washing	Heavy-duty washing machines Hydro Tumbler
	Finishing and Packaging	AI-enabled robots for: Defect detection Ironing Tagging Folding Packaging
	Supply Chain and Logistics	- Blockchain-enabled automated tracking system
	Retail and Online Customer Engagement	Virtual trials via AR and VR ML-enabled recommendation system AI-enabled Chatbots

Table 1.0: tabular representation of the various tools and techniques of automation adopted by the apparel industry at different stages of production.

This study aims to analyze the impact of the above-mentioned tools and technologies in achieving efficiency and sustainability standards in the apparel manufacturing units set in India.

2. LITERATURE REVIEW

Automation in the Apparel Industry- India vs. the West: While automation has transformative potential in both India and the West, its adoption and impact are varied due to the difference in the cost of labor, technological advancement, financial assistance, sustainable priorities, etc in the two. *(Khan, M. M. A., 2024)*

(Singh, N. 2018) studies the impact of automation in the Indian apparel sector and says that India's automation adoption is still in its early stages, driven by export-oriented firms and large manufacturers. Despite the low cost of labor, factors like global quality standards and market competition are encouraging the integration of automated tools like CAD systems, cutting machines, and digital printing technologies.

(Nagaraj, T. S.,2024) studies automation barriers in India and quotes that the benefits associated with automation like-enhanced efficiency and productivity, are restricted to large and medium-scale apparel manufacturers only. SMEs struggle to invest the huge amount required to build an advanced automated manufacturing set-up. They face challenges like high upfront costs, limited access to skilled labor, waste of resources due to human error, and more. Sustainability efforts include energy-efficient machinery and sustainable dyes but are confined to larger players. *(Hammer, A., 2021)* explains that while the Indian government's initiatives like Make in India and Zero Defect, Zero Effect, aim to support this transition, widespread adoption remains a hurdle. Additionally, manufacturers fear the late return on their investments.

On the other hand, the West has significantly increased automation, using advanced technologies like robotic sewing machines, 3D knitting, AI-driven supply chains, and IoT-enabled smart factories. *(Bárcia de Mattos, F, 2021)* explains how the high cost of labor in Western countries has increased dependency on automation, later reducing operational expenses and increasing productivity. Another study by *(Anzolin, G., 2021)* elaborates on how automation promotes precision, speed, and customization, enabling made-to-measure apparel and reducing material waste. Sustainability is a core focus, with automation promoting circular economy practices and consumer demand for ethical, environmentally friendly products.

(Atkar, A.,2021) quotes that the West and India face significant challenges in automation, with India focusing on labor costs and environmental regulations, and the West balancing fast fashion demands with sustainability goals. To overcome these challenges, India must make automation affordable for SMEs and upskill its workforce, while the West should enhance collaboration with global suppliers and promote sustainable practices across its supply chains.

(Atkar, A.,2021) explains that despite their differences, automation holds transformative potential in both contexts. For India, it represents an opportunity to modernize and compete globally, while for the West, it offers a pathway to balance economic efficiency with ethical and sustainable

practices. The combined effect of these initiatives can result in a more sustainable global garment market.

There is sufficient literature that emphasizes the significance of advanced automated technologies in the apparel industry, the difference in the rate of adoption between India and the West, the sustainability standards set by the two, and more. However, very few studies magnify the application and impact of these technologies in the apparel manufacturing units set in India, in each stage of production in the context of efficiency (production Eeficacy and process efficiency) and sustainability standards (environmental sustainability and social sustainability).

3. RESEARCH FOCUS

Literature Analysis suggests that automation when adopted to the best of its ability, can help enhance efficiency and production and reduce cost and waste generation. Studies also suggest that while the apparel industry 4.0 is not shying away from adopting automation at different stages of production, there is a significant gap between India and the West in terms of their adoption rate, sustainability standards, and the benefits derived from automation.

This research focuses on deeply analyzing the working structure of the manufacturing units in India, intending to understand the various technologies adopted by the medium-large scale manufacturers in India, and the impact of these automated technologies on efficiency and sustainability.

The Venn diagram (Diagram 2.0) diagrammatically explains the focus of the research. The intersection of the circles represents the impact of automation in the Indian apparel industry to enhance sustainability.

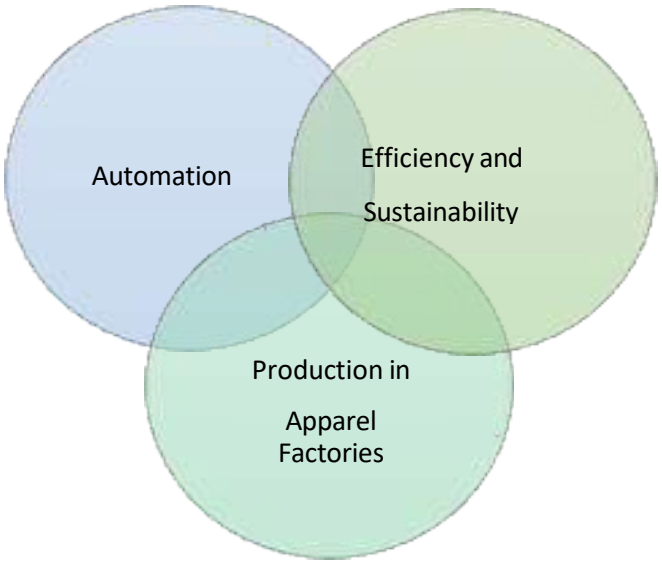

Diagram 2.0: diagrammatically represents the focus of the given research

4. RESEARCH OBJECTIVES

1. To study the impact of automation adopted by apparel manufacturing units in India on efficient resource consumption.
2. To study the impact of automation adopted by apparel manufacturing units in India on production process.
3. To study the impact of automation adopted by apparel manufacturing units in India on waste generation and carbon emission.
4. To study the impact of automation adopted by apparel manufacturing units in India on social sustainability- workmen's compensation, reasonable workload, and other ethical considerations.

5. RESEARCH METHODOLOGY

Field Visit: Five medium to large-scale apparel manufacturing units based at Delhi NCR were visited to observe the flow of activating involved in manufacturing a garment from scratch, understand the technologies used in different stages of production, understand the impact of these technologies on efficiency and sustainability, and more.

A total of 50 factory stakeholders, including factory managers, top-level management in different departments, and factory workers, were interviewed based on a semi-structured questionnaire that has been added to the annexure. The age group of the factory workers was between 30 and 55; designers were 25 to 35, and managers were 45 to 55. 55% of men and 45% of women comprised this demographic.

TABLE 2.0: Tabular representation of the research framework adopted for the given research.

Research Sample	- 5 apparel manufacturing units in Delhi-NCR
Research Design	Direct Non-participatory Observation Structured Observation
	- In-depth interviews with the factory managers and workers
Demographics of the Factory Stakeholders:	Factory workers: age group between 30 to 55 Designers: aged between 25 to 35 Managers and Department heads: aged between 45 to 55.
Research Focus	- 60% men and 40% female
Data Collection Tools	Observation Checklist Real-time field notes Photo and Video Documentation Interview Recordings
Data Analysis	- Categorization and analysis of the data based on sustainability parameters

Qualitative Analysis: The data collected during the field visits was synthesized and analyzed to understand the impact

of automation on efficiency (production and process efficency) and sustainability (environmental and social sustainability) in different stages of production (production, production, and post-production) in the apparel industry in India.

6. FINDING AND ANALYSIS:

In the process of visiting the apparel manufacturing units and analyzing the different technologies adopted for production in different stages, it was observed that while automation leverages efficient production with optimum utilization of time, materials, capital investment, man-power, energy, and other resources invested in the production of a garment, it also reduces waste and helps combat sustainability concerns.

To further evaluate the impact of automation on sustainability, each stage of production was analyzed based on the following sustainability parameters.

i. Production Efficacy:

- Optimum utilization of the raw material
- Optimum utilization of man-power
- Optimum utilization of fuel and power
- Optimum utilization of time
- Cost effective Maximum yield

ii. Process Efficiency:

- Production Speed
- Low Defect Rate
- Managerial efficiency
- Accountability and transparency
- Data Analysis and Forecasting

iii. Environmental Sustainability:

- Energy consumption
- Paper consumption
- Water Consumption
- Carbon emission
- Waste generated

iv. Social Sustainability:

- Optimum allocation of human resources
- Reasonable workmen's compensation
- Reasonable work hours/ work-load
- Safety precautions

A qualitative analysis of each stage is given below in Table 3.0.

Stages of Production		***Automation used***	***Sustainability Parameter***			
			Production Efficacy	***Process Efficiency***	***Environmental Sustainability***	***Social Sustainability***
Pre-Production	Client Meeting	- Communication and Collaboration Platforms	Optimum utilization of fuel and power Optimum utilization of time Cost effective	Boost Production Speed Managerial efficiency	Controlled Energy consumption Controlled Paper consumption Controlled Carbon emission	-
	Product Design and Development	2D and 3D Computer Aided Designing software (or CAD) for designing CLO 3D and Optitex for 3D visualization, real-time alteration, and pattern making	Optimum utilization of the raw material Optimum utilization of fuel and power Optimum utilization of time Cost- effective	- Boost Production Speed	Controlled Energy consumption Controlled Paper consumption Controlled Carbon emission Less Waste generated	-
	Inventory Management	Radio Frequency Identification (or RFID) Internet of Things	Optimum utilization of the raw material Optimum	Low Defect Rate Managerial efficiency	- Controlled Paper consumption	

Stages of Production		*Automation used*	*Sustainability Parameter*			
			Production Efficacy	***Process Efficiency***	***Environmental Sustainability***	***Social Sustainability***
		(IoT)	utilization of time Cost effective	Accountabil ity and transparency Data Analysis and Forecasting		-
	Merchandising	Central Communication Platforms Inventory and Order Management system Product Life- cycle Management (PLM System)	Optimum utilization of the raw material Optimum utilization of fuel and power Optimum utilization of time Cost effective Maximum yield	Managerial efficiency Low Defect Rate Data Analysis and Forecasting Accountabil ity and transparency Boost Production Speed	Energy consumption Water consumption Paper consumption Air quality and emission Carbon emission Less Waste generated	Optimum allocation of human resources Reasonable workmen's compensati on Reasonable work hours/ work-load Safety precautions
		- Demand Forecasting Tool				
Production	Cutting	Pattern printers Straight knife Bend knife Tagging Machine	Optimum utilization of the raw material Optimum utilization of man-power Optimum utilization of time Cost effective Maximum yield	Production Speed Low Defect Rate	- Less Waste generated	Optimum allocation of human resources Reasonable work hours/ work-load Safety precautions
	Sewing and Assembly	Pre-programed stitching machines RFID-enabled hangers	Optimum utilization of the raw material Optimum utilization of man-power Optimum utilization of time Cost effective Maximum yield	Production Speed Low Defect Rate	- Less waste generated	Optimum allocation of human resources Reasonable work hours/ work-load Safety precautions
	Printing and Embroidery	Digital Printing Machines like DTG Printing, Sublimation Printing etc Computerized Embroidery Machines for mass designing and pattern making.	Optimum utilization of the raw material Optimum utilization of man-power Optimum utilization of time Cost effective Maximum yield	Production Speed Low Defect Rate	Paper consumptio n Water Consumpti on	Optimum allocation of human resources Reasonabl e work hours/ work-load Safety precaution s
	Washing	Heavy-duty washing machines Hydro Tumbler	- Cost effective	Production Speed Low Defect Rate	- Controlled Water Consumptio n	- -

Post Production	Finishing and Packaging	Semi-automated machines for- Defect detection Metal detection Ironing Tagging Folding Packaging	Optimum utilization of the man-power Optimum utilization of fuel and power Optimum utilization of time Cost-effective	Production Speed Low Defect Rate	Controlled Energy consumption Controlled Paper consumption Less Waste generated	Optimum allocation of human resources Reasonable work hours/ work-load Safety precautions
	Supply Chain and Logistics	- Blockchain-enabled automated tracking system	-	Managerial efficiency Accountabil ity and transparency Data Analysis and Forecasting	Controlled Paper consumption Less Waste generated	-

TABLE 3.0: tabular representation of the qualitative synthesis conducted to analyze the impact of automation on sustainability in different stages of production in an apparel industry in India

Client Meetings: Automation in client meetings improves production efficacy by streamlining communication between clients and production teams, reducing errors and delays. It also enhances process efficiency by allowing remote visualization and approval of designs, reducing time lags in decision-making and approval processes. Automation also contributes to environmental efficiency by reducing the need for physical travel and promoting paperless operations. Virtual sampling tools reduce fabric waste and encourage paperless operations, contributing to sustainability goals. Automation also enhances social efficiency by allowing seamless collaboration between clients and teams from different geographies and time zones, reducing the strain on employees and fostering better work-life balance. By integrating automation into client meetings, the apparel industry can improve efficiency across production, processes, environmental outcomes, and social well-being, aligning with sustainability goals.

Product Design and Development: with the adoption of modern-day technologies like 2D and 3D Computer-Aided Design (or CAD) Software, CLO 3D, Optitex, etc the process of product designing and development has been simplified from the creation of multiple physical prototypes to a more efficient and sustainable virtual sampling approach.

Automation in product planning and development is a crucial tool for enhancing production efficacy, process efficiency, and environmental sustainability. It enables rapid prototyping and precise planning, minimizing production errors and reducing lead times. It also enhances process efficiency by integrating predictive analytics, Product Lifecycle Management systems, and Enterprise Resource Planning solutions, allowing real-time tracking of material availability, production timelines, and cost estimations. Automation minimizes resource wastage through accurate demand forecasting and material optimization, reducing the need for physical samples and enabling the use of sustainable materials. Additionally, automation in product planning reduces manual workload and repetitive tasks, empowering workers to focus on creative tasks and ensuring fair job distribution. This approach helps the apparel industry meet modern sustainability and efficiency standards, promoting a healthier and more equitable workplace.

Inventory Management: Automation in inventory management is a crucial tool in the apparel industry, enhancing production efficacy, process efficiency, environmental efficiency, and social efficiency. It uses tools like RFID tagging, automated stock monitoring, and AI-based demand forecasting to track raw materials and finished goods, preventing stockouts and overproduction. This aligns inventory levels with production needs, reducing delays and operational costs. Automation also minimizes overstocking and waste risks, reducing the need for emergency shipping or transportation, and reducing carbon emissions. It also reduces the physical workload on employees by handling repetitive tasks and enhancing workplace safety by automating hazardous tasks. This results in fewer disruptions and more consistent work schedules, promoting job satisfaction. Overall, automation in inventory management improves stock control, reduces waste, and promotes sustainability, making it a critical component of sustainable apparel industry practices.

Merchandising: Automation in the apparel industry has significantly improved production efficacy, process efficiency, environmental efficiency, and social efficiency. It streamlines coordination between production teams and sales channels, utilizing AI-driven tools to forecast demand accurately, minimizing overproduction and unsold inventory

risks. Automation also enables real-time inventory tracking, dynamic pricing, and optimized product placement, facilitating quicker decision-making and seamless coordination across online and offline retail channels. It also simplifies order fulfillment processes, reducing delays and improving customer satisfaction.

Automation also reduces waste generated by overproduction or unsold stock by integrating digital marketing and e-commerce platforms, reducing the need for physical marketing materials. It also optimizes shipping routes and delivery methods, reducing carbon emissions.

Moreover, automation enhances customer experience by offering personalized recommendations and seamless shopping experiences, increasing satisfaction and loyalty. It also reduces manual workload for staff, allowing them to focus on strategic roles and fostering job satisfaction and skill development. Overall, automation in the apparel industry ensures sustainable practices, optimizing resources across production and sales and supporting a more balanced and fulfilling workplace for employees.

Cutting: Automation in the apparel industry has significantly improved production efficacy, process efficiency, and environmental sustainability. Automated cutting systems like laser cutting, computer-controlled cutting machines (CNC), and Gerber cutters enhance precision and consistency, reducing fabric waste and manual errors. They also streamline the cutting process by integrating with design software, reducing labor- intensive tasks, and accelerating the transition from design to manufacturing. Automated systems can handle multiple layers of fabric simultaneously, improving throughput.

Automated cutting also contributes to environmental efficiency by optimizing material usage, minimizing fabric waste, and supporting the use of eco-friendly materials. It also reduces physical strain and repetitive tasks associated with manual cutting, creating a safer and more ergonomic work environment for employees. This allows workers to focus on more skilled and creative roles, contributing to job satisfaction and skill enhancement. Overall, automation in the apparel industry contributes to sustainable practices by enhancing production, and process efficiency, and fostering social efficiency.

Sewing and Assembly: Automation in sewing and assembly has a significant impact on sustainability and efficiency in the apparel industry. It enhances production efficacy by increasing precision and reducing human error, enabling consistent quality across large volumes. It also optimizes workflows by integrating with upstream processes like cutting and design, minimizing downtime and rework. Automation also minimizes fabric and material waste by maintaining high accuracy in stitching and reducing errors. Advanced automated machines reduce energy consumption and enable the use of recycled and sustainable materials more effectively. Additionally, automation reduces physical strain and repetitive motions required in manual sewing tasks, improving worker safety and well-being. It allows employees to transition to supervisory or machine-operating roles, fostering skill development. Consistent product quality enhances brand reputation and customer trust, leading to better business stability and potentially more equitable worker benefits. Overall, automation in sewing and assembly is a vital part of sustainable and efficient apparel manufacturing practices, promoting social equity and enhancing workplace conditions.

Printing and Embroidery: Automation in the apparel industry has significantly improved production efficacy, process efficiency, and environmental impact. It streamlines the printing process by providing high-speed, precise, and consistent results, increasing the speed of production while maintaining quality standards. It also optimizes workflows by integrating printing, drying, and assembly processes, ensuring faster turnaround times and reducing bottlenecks. Automation also enables batch printing and assembly, allowing for quicker adaptation to changing orders or designs.

Automated printing systems reduce ink wastage through precision control, using only the necessary amount for each garment. Digital printing methods like DTG eliminate the need for excessive use of water and chemicals, while automation in assembly processes minimizes fabric handling, reducing the likelihood of errors or damaged garments. These systems support the use of sustainable and eco-friendly inks and materials.

Automation also promotes social efficiency by reducing the physical workload on workers involved in manual printing and assembly, improving workplace safety and ergonomics. This shift allows workers to focus on higher-value activities, leading to greater job satisfaction, skill development, and career progression. Overall, automation in the apparel industry contributes to a more sustainable and socially responsible industry.

Washing: Automation in the apparel industry has significantly improved production efficacy, process efficiency, and environmental sustainability. It ensures consistent results with minimal variation between batches, controlling factors like temperature, water levels, and detergent use precisely. This leads to higher productivity and faster processing times, ensuring timely delivery of finished goods.

Automated washing systems also optimize resource use, reducing the need for manual intervention. Technologies like water recycling systems, sensors, and programmable washing machines can adjust parameters in real time for optimal washing conditions, allowing for seamless handling of multiple garment types and washing requirements.

Continuous monitoring ensures efficiency and reduces downtime.

Automated washing systems contribute to environmental sustainability by optimizing water and energy consumption through closed-loop water recycling and precise detergent dosing. This minimizes water wastage and ensures garments are cleaned more effectively with lower energy costs, reducing the carbon footprint of the washing process. Additionally, automated washing processes limit wear and tear on fabrics, leading to longer lifespans and less textile waste.

Socially, automation enhances workplace safety and job satisfaction by reducing physical demands on workers, allowing them to focus on higher-level responsibilities and reducing the risk of garment defects. Overall, automation is a key driver of sustainability and efficiency in the apparel industry.

Finishing and Packaging: Automation in the apparel industry has significantly improved production efficacy, process efficiency, and environmental sustainability. It ensures uniform quality across all garments, reducing human error and enhancing overall output. Automation in finishing and packaging systems, such as robotic arms, automated folding machines, and high-speed packaging lines, optimizes workflow by integrating different stages, minimizing bottlenecks, and allowing for customization of packaging sizes and materials.

Automation also contributes to environmental efficiency by optimizing resource consumption, reducing packaging waste, and promoting the use of sustainable packaging alternatives. By reducing waste and energy consumption, automated systems contribute to the industry's environmental sustainability goals.

Moreover, automation in finishing and packaging reduces manual labor required for repetitive tasks, improving workplace safety and job satisfaction. This leads to faster processing times and reduced labor demand, promoting a healthier, more productive workforce.

In summary, automation in finishing and packaging enhances efficiency by speeding up production, ensuring uniformity in garment presentation, supporting sustainability by minimizing material waste, reducing energy consumption, and promoting eco-friendly packaging solutions. It also improves workplace conditions by reducing physical demands on workers and streamlining operations, contributing to both environmental and social sustainability in the apparel industry.

Supply Chain and Logistics: Automation in the apparel industry has significantly improved production efficacy, process efficiency, environmental efficiency, and social efficiency.

Technologies like warehouse robots, AI-driven demand forecasting, and automated inventory management ensure smooth product movement, reducing delays and optimizing stock levels. These systems can track inventory in real-time, preventing stockouts and overstocking, and ensuring timely deliveries to retailers and customers.

Automated logistics systems streamline order fulfillment, sorting, and distribution, reducing handling time and human error. They also optimize transportation routes, reducing fuel consumption and CO2 emissions. Automated inventory management reduces waste by aligning production and stocking with demand, reducing excess inventory that might end up in landfills. Automation supports sustainable packaging and waste reduction initiatives, further enhancing environmental efficiency.

Automation also improves social efficiency by allowing workers to focus on more complex or strategic roles, leading to better working conditions, reduced workplace injuries, and higher job satisfaction. It also allows for more predictable workflows, enabling better work-life balance for employees.

In summary, automation in the apparel industry is a key enabler of sustainability and efficiency in supply chain and logistics operations. It enhances production efficacy, process efficiency, environmental sustainability, and social efficiency, making it a key enabler of sustainability and efficiency in the apparel industry.

7. RESULT AND CONCLUSION:

Qualitative analysis conducted in the previous stages elaborates how automation adapted by medium to large-scale apparel manufacturing units in India in the different stages of production can help enhance efficiency and productivity and attain major sustainability parameters.

TABLE 4.0 gives a tabular representation of the observations made in this research in the context of each objective.

S. No.	***Objectives***	***Observations***
1	To study the impact of automation adopted by apparel manufacturing units in India on efficient resource consumption.	Application of the advanced tools of automation for production in various stages of an apparel manufacturing unit has enhanced both production and process efficiency by ensuring optimum utilization of resources (like materials, capital invested, manpower, electricity, water, and non- renewable resources like fuel) and reducing the scope of human-error thereby reducing the loss incurred in the process.
	To study the	Automation applied to the

S. No.	*Objectives*	*Observations*
2	impact of automation adopted by apparel manufacturing units in India on the production process.	production process not only accelerates the speed of production (eg: SEM in assembly) and the total units produced in the given time but also helps ensure transparency and accountability in the process. Additionally, automation helps record, track, and analyze data which later helps in predicting future trends, making the process more convenient and efficient.
3	To study the impact of automation adopted by apparel manufacturing units in India on waste generation and carbon emission.	The application of automation in the apparel industry reduces the scope of human error such that it reduces the waste that is otherwise generated during manual cutting, stitching, embroidery, and other stage of production. Additionally, Automation in apparel manufacturing reduces carbon emissions by optimizing energy use, minimizing waste, and utilizing advanced machinery. Smart technologies like IoT and AI enable real-time monitoring, promoting sustainability and renewable energy sources.
4	To study the impact of automation adopted by apparel manufacturing units in India on social sustainability- workmen's compensation, reasonable workload, and other ethical considerations.	Automation in manufacturing improves workplace safety, reduces strain, and ensures fair workloads. It minimizes accidents and allows employees to focus on higher-value roles. Automation supports fair wages by lowering production costs and encouraging upskilling. It promotes ethical labor practices by reducing reliance on exploitative conditions and fostering inclusivity with assistive technologies, creating safer, more equitable, and sustainable work environments.

Table 4.0: tabular representation of the observations made in this research.

Findings suggest that advanced technologies like automated cutting and stitching machines help maximize fabric utilization while drastically lowering material waste. 3D design software helps create virtual samples, reducing the dependency on physical prototypes. Robotics and energy-efficient technologies save resource waste and energy consumption while increasing industrial precision. Digital printing and automated dyeing processes guarantee accurate chemical and water consumption, lowering pollution. Additionally, automation ensures ethical practices by reducing dependence on exploitative labor and enhancing transparency through blockchain-enabled supply chains. Lastly, with tools like predictive analytics, manufacturers can better forecast demand, curbing overproduction and inventory waste. This way, automation is leveraged to enhance efficiency and sustainability by the apparel manufacturers in India.

While this is true for large-scale manufacturers, automation and its benefits cannot be promised in SMEs dealing in apparel manufacturing. Despite being one of the top ten apparel manufacturers in the world, a very small portion of the apparel manufacturers in India have the financial assistance and risk-taking ability to adopt modern tools and techniques of production for efficiency and sustainability.

Besides, when compared with the West, the Indian manufacturing units lag in terms of advanced automation tools and technologies and the sustainability standards achieved. Hence, it can be concluded that while the apparel industry in India is leveraging the modern tools of automation to the best of its ability to meet the sustainability parameters, there is a scope for improvement.

At the same time, it must be noted that in a country like India, where a big portion of the population is dependent on the apparel industry for their livelihood, replacing manpower with technology can be problematic on multiple levels. Hence, we cannot blindly copy the road map set by the West and have to plan one for ourselves that strikes a balance between automation for efficient and sustainable production and automation encouraging employment for skilled and unskilled laborers.

8. FUTURE SCOPE OF RESEARCH:

This study concludes that while the apparel manufacturing units in India are doing well in terms of efficiency and sustainability, there is a long way to go before they can stand on par with the rest of the world. It also focuses on how the apparel manufacturing units are a source of

livelihood for a big portion of the Indian population, and replacing the advanced automation tools and technologies with skilled and unskilled labor may help achieve environmental sustainability for the country but will also root economic and concerns.

Using this study as a base, researchers can study the working structure of the more sustainable apparel manufacturing units across the globe for inspiration and prepare a road map specially designed for the apparel manufacturers in India that can help them balance the two problems efficiently.

Furthermore, researchers can study the sustainability reports published by the leading apparel manufacturing companies from India and the West and compare them to deeply analyze the key differences in their sustainability standards, learn from their actions, set new goals for Indian manufacturers to adopt, and more.

Lastly, this particular study only focuses on large apparel manufacturing units in Delhi-NCR. Researchers can expand the horizon to explore if the same results are true for pan-India, especially the relatively remote places or not.

9. DECLARATION

I, Tooba Rahman Khan, hereby confirm that the manuscript titled "*Analyzing the Impact of Automation on Sustainability in the Various Stages of Production in the Apparel Industry in India*" authored by Tooba Rahman Khan, Prof. Amirul Hasan Ansari, and Dr. Deepshikha, not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to the "International Management Perspective Conference (IMPeC-2025), at IIM Sambalpur".

I declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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Annexure

Unstructured Questionnaire for the factory visits

1.1: Questions for the Factory Workers:

1. How do the machines work?
2. Did they get any official training to operate the advanced machines and any advanced safety training too?
3. How has it reduced their workload/ total work hours?
4. How does it affect their scope of employment?
5. Are they earning reasonable pay? What are the extra perks- mid-day meals, leaves, transportation allowance, insurance, etc.?

1.2: Questions for the Factory Manager:

1. How would you categorize your manufacturing unit- small scale, medium scale, or large scale?
2. Kindly brief the entire manufacturing process (from step one to the last step).
3. Role of modern technologies in different stages of production. (also, not all the modern technologies are being used)
4. Comparison b/w traditional and modern technologies of apparel production- how have the new and updated technologies helped improve efficiency? (efficient utilization of resources, minimum wastage, max production)

   Note: Parameters of efficiency are-

   - Efficient utilization of raw material (minimum waste generated)
   - Efficient utilization of labor (manpower employed based on their skills, reasonable work hours, reasonable wage paid, etc.)
   - Efficient utilization of time (time invested in each production cycle)
   - Efficient utilization of water and electricity

5. Inquire about the total army of workers involved in the factory. Has automation influenced the number of factory workers required to work in the process?
6. Any attempts by the factory to go-
   - Go Paperless
   - Reduce Carbon Emission
7. Has your factory adopted any SDGs? If not, are you planning to adopt any SDG?
8. Kindly share your Sustainability report (if you have one)

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Enhancing Resilience in Humanitarian Supply Chains: A Kraljic Matrix Scorecard Approach

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ABSTRACT

Humanitarian supply chains (HSCs) are critical for delivering life-saving resources during crises such as pandemics, natural disasters, and armed conflicts. These supply chains often face challenges such as disrupted logistics, geopolitical instability, and resource scarcity, which hinder effective aid distribution. To address these challenges, this study introduces a Kraljic Matrix-based scorecard, tailored specifically for humanitarian supply chain risk assessment and resource prioritization.

The scorecard uses weighted scoring of 10 measurable parameters—five under Supply Risk (Y-Axis) and five under Criticality/Necessity (X-Axis)—to categorize humanitarian resources into four Kraljic quadrants: Strategic Items, Leverage Items, Bottleneck Items, and Non-Critical Items. The approach introduces median-based thresholds rather than fixed thresholds to adapt to contextual variations in resource distribution.

The scorecard was applied to real-world case studies, including the COVID-19 pandemic response and flood responses in Southeast Asia. Findings show that vaccines, emergency shelters, and oxygen cylinders fall into the Strategic Items quadrant due to their high criticality and supply risks. Similarly, food supplies were classified as Leverage Items, highlighting availability but moderate risks.

This research provides both theoretical and practical insights into humanitarian logistics by offering a structured, evidence-based prioritization framework. Future work should incorporate real-time data integration, climate change factors, and technological disruptions to enhance adaptability and predictive capabilities.

Keywords: Kraljic Matrix 1, Strategic Items 2, Leverage Items 3, Supply Risk 4, Criticality 5, Pandemic Response 6, Logistics 7, Emergency Response 8, Logistical Bottlenecks 9,

1. INTRODUCTION

Humanitarian supply chains (HSCs) are vital lifelines during crises, ensuring the delivery of resources such as food, medical supplies, emergency shelters, and clean water to vulnerable populations. HSCs operate under volatile and uncertain conditions, often facing logistical challenges, political instability, and supply chain disruptions. Rapid response to humanitarian crises can mean the difference between life and death, making the strategic allocation of resources essential.

During the COVID-19 pandemic, for instance, supply chain disruptions exacerbated delays in vaccine distribution and access to essential supplies. Similarly, natural disasters like floods in Southeast Asia revealed critical gaps in infrastructure and prepositioning strategies. These examples highlight a need for structured decision-making frameworks to prioritize resources, mitigate risks, and strengthen supply chain resilience.

The **Kraljic Matrix**, originally used in corporate supply chain management, categorizes resources into quadrants based on **two axes**: supply risk and profit impact. However, the humanitarian context differs significantly. Instead of prioritizing profitability, humanitarian logistics must focus on **life-saving urgency** and **critical resource availability**.

This study proposes an adaptation of the Kraljic Matrix into a **scorecard specifically for humanitarian supply chains**. The scorecard evaluates resources across two axes:

- **Supply Risk (Y-Axis):** Reflects logistical vulnerabilities such as lead time delays, transportation bottlenecks, geopolitical instability, and limited supplier availability.
- **Criticality/Necessity (X-Axis):** Represents urgency, population density, and life-saving impacts of resources during humanitarian responses.

The scorecard integrates **weighted parameters** to evaluate risks and criticality, using **median-based thresholds** to dynamically define the four quadrants of the Kraljic Matrix:

1. **Strategic Items** (high supply risk and high criticality)
2. **Leverage Items** (low supply risk but high criticality)
3. **Bottleneck Items** (high supply risk but low criticality)
4. **Non-Critical Items** (low supply risk and low criticality)

The study applies this scorecard to historical case studies such as the COVID-19 pandemic response and flood responses in Southeast Asia. The findings illustrate the practical utility of the scorecard for improving resource allocation during humanitarian emergencies.

This research contributes to humanitarian logistics by offering a structured, evidence-based framework to guide operational decision-making, strengthen resource prioritization strategies, and address risks and supply chain vulnerabilities.

2. LITERATURE REVIEW

1. Humanitarian Logistics and Supply Chain Disruptions

Humanitarian supply chains (HSCs) are uniquely designed to prioritize time sensitivity, equity, and the delivery of critical resources. These supply chains differ significantly from commercial supply chains, as they operate under unpredictable and often volatile conditions.

(Altay N, 2023) identify that HSCs are subject to distinct risks such as political instability, natural disasters, pandemics, and supply chain bottlenecks, leading to delays and operational inefficiencies. Their study emphasizes that innovation and technological adaptation are vital in addressing these vulnerabilities. (Altay N, 2023) argue that technological advancements, such as better data sharing, could significantly improve supply chain adaptability in humanitarian contexts.

(Dubey, 2024) focus on supply chain risks during pandemics, particularly COVID-19, highlighting how cross-border dependencies, transportation bottlenecks, and lead time delays hinder timely response. They emphasize that political instability exacerbates these risks and significantly impacts supply chain performance during health crises. Their findings suggest that humanitarian actors need advanced strategies to mitigate these risks through innovation and diversification.

These studies suggest that while humanitarian supply chains play a life-saving role, they are often hampered by geopolitical risks, logistical bottlenecks, and unpredictable lead times. Addressing these issues is vital for improving operational efficiency during crises.

2. Supply Chain Risk Factors in Humanitarian Crises

Humanitarian supply chains face a variety of risk factors that influence supply chain performance during emergencies. The **supply risks** identified in the literature include political instability, transportation bottlenecks, lead time variability, and dependency on few supplier networks.

(Dubey, 2024) provide evidence that pandemics increase supply chain risk due to delays caused by border closures, supply shortages, and reliance on single transport routes. This aligns with (Altay N, 2023) assertion that humanitarian logistics are highly susceptible to **network complexity**. They suggest that supply chains with excessive intermediaries face amplified risks, requiring innovative approaches to build efficiency and resilience.

Key risk factors identified are:

- **Cross-border Supply Chain Dependency:** Geopolitical instability leads to border closures that delay resource delivery.
- **Lead Time Variability:** Delays in manufacturing and supply chain delivery are exacerbated during emergencies.
- **Transportation Infrastructure Bottlenecks:** Natural disasters or pandemics can disrupt routes, especially damaged ports and roads.
- **Supply Chain Network Complexity:** Supply chains with too many intermediaries face bottlenecks and inefficiencies.

These studies support that humanitarian response depends on mitigating these risks through strategic diversification, improved supply chain resilience, and enhanced coordination.

3. CRITICALITY AND RESOURCE PRIORITIZATION

Criticality measures are essential for effective resource allocation during humanitarian emergencies. (Altay N, 2023) highlight that humanitarian aid priorities must balance **supply risk** and **criticality/urgency,** with criticality being defined by population density, time sensitivity, and the direct life-saving impact of resources.

(Dubey, 2024) extend this analysis by emphasizing that resources with higher urgency, such as medical supplies or emergency shelters, must receive precedence. For example, during COVID-19, vaccines and oxygen supplies were essential because of their immediate life-saving potential. Additionally, the availability of substitutes directly impacts supply prioritization. (Dubey, 2024) suggest that limited substitutes increase the urgency to allocate resources strategically.

Effective prioritization models, therefore, must integrate these criticality metrics to ensure resources are allocated to the most vulnerable populations during emergencies. (Altay N, 2023) emphasize that decision-makers must focus on strategic supply chain interventions, including risk assessment, prepositioning, and real-time analytics.

4. ADAPTATION OF THE KRALJIC MATRIX

The Kraljic Matrix is a strategic supply chain framework originally designed for corporate procurement to assess supplier risk and profitability. It divides supply chain risks into four quadrants: **Strategic Items, Leverage Items, Bottleneck Items, and Non-Critical Items**. (Dubey, 2024) and (Altay N, 2023) highlight the need to adapt this corporate model to humanitarian logistics by replacing profit impact with criticality and urgency.

(Dubey, 2024) argue that using the Kraljic Matrix offers humanitarian organizations a structured approach to

prioritizing resources. Their analysis shows that humanitarian crises have distinct risk patterns (e.g., geopolitical instability, supply bottlenecks, time sensitivity) that can be mapped using this type of risk matrix. They support the notion that a Kraljic-based framework helps decision-makers better understand risk factors and allocate supplies more effectively.

(Altay N, 2023) go further by suggesting that the Kraljic Matrix can account for resource criticality and urgency, providing organizations with clarity on which resources should be prioritized in high-risk scenarios.

However, traditional Kraljic models depend on fixed thresholds to divide risk categories, which may not be adaptable across varying humanitarian emergencies. Therefore, innovative models such as median-based thresholds are recommended to allow flexibility in response to dynamic patterns of supply risks.

5. MEDIAN-BASED THRESHOLDS: ADAPTING KRALJIC FOR HUMANITARIAN CRISES

Static thresholds often fail to account for changing crisis dynamics. (Altay N, 2023) propose that humanitarian crises require a more flexible approach to risk assessment, such as **median-based thresholds.** These thresholds dynamically categorize resources by adjusting to the distribution of risk factors and criticality patterns in real-time.

(Dubey, 2024) also support this approach, arguing that humanitarian supply chain patterns exhibit variability depending on context, time, and type of emergency. Median-based thresholds can provide humanitarian actors with the ability to dynamically adjust their prioritization strategies, thereby improving response efficiency and reducing delays.

Dynamic threshold analysis addresses the gaps in traditional Kraljic models by focusing on real-time adjustments rather than rigid classifications. This allows humanitarian organizations to address shifting risk profiles effectively during unpredictable humanitarian crises.

6. LITERATURE GAPS AND FUTURE DIRECTIONS

While the reviewed literature provides strong insights into humanitarian supply chain risks and strategies, certain research gaps remain:

1. **Integration of real-time analytics:** Predictive risk tools are underexplored in current studies.
2. **Technological risks:** Factors like cyberattacks and technological failures should be considered.
3. **Geographic variability:** Limited studies focus on diverse geographic areas beyond Southeast Asia or COVID-19 patterns.

Future research should focus on these areas, leveraging AI, real-time data streams, and advanced risk modeling tools.

7. EVOLVING RISK ASSESSMENT FRAMEWORKS

(Altay N, 2023) and (Dubey, 2024) proposed modifications to traditional risk assessment tools, emphasizing the need for dynamic frameworks like median-based thresholds. Their findings support the adaptability of your Kraljic Matrix-based scorecard for real-time disaster scenarios.

The existing literature on humanitarian supply chain resilience and management highlights several critical themes, methodologies, and frameworks that contribute to the understanding of challenges and solutions in this domain. Recent works emphasize the need for innovation, sustainability, and resilience in addressing disruptions caused by natural disasters, pandemics, and other emergencies.

(Altay N, 2023) explore the potential of technological innovations, such as blockchain and autonomous systems, to enhance adaptability and operational efficiency in humanitarian logistics. Similarly, (Anjomshoae, 2023) provide a systematic review of sustainable practices in humanitarian supply chains, focusing on balancing environmental, social, and economic considerations during crises.

Building on these themes, (Dubey, 2024) analyze lessons from the COVID-19 pandemic, stressing the importance of adaptive supply chain strategies to address cross-border dependencies and logistical bottlenecks. This is complemented by the work of (K. Katsaliaki, 2021), which provides a comprehensive review of resilience strategies for mitigating supply chain vulnerabilities in diverse industries, including the humanitarian sector.

Empirical studies also shed light on specific disaster contexts. For example, (Hossein Shakibaei, 2024) develop a sustainable-resilient humanitarian supply chain model based on earthquake relief efforts in Haiti, while (K. Katsaliaki, 2021) examine flood response strategies in Malaysia. Petrudi et al. (2019) delve into the operational challenges faced by the Iranian Red Crescent Society, offering insights into managerial inefficiencies and logistical barriers that hinder disaster response efforts.

Moreover, (Vega, 2018) outlines a structured approach for conducting case studies in humanitarian logistics, providing valuable frameworks for documenting and analyzing real-world examples. (Xu W, 2023) evaluate supply chain effectiveness in disaster zones, focusing on performance metrics such as timeliness, resource allocation, and cost-efficiency during flash flood responses.

Collectively, these studies offer robust theoretical foundations and practical insights. However, gaps remain, particularly in the empirical validation of models and their application in diverse geographic and operational contexts.

This review aims to integrate these findings to address the challenges of resilience and innovation in humanitarian supply chains.

The literature review highlights key trends:

1. Geopolitical instability and cross-border dependency are major contributors to supply risk.
2. Infrastructure bottlenecks delay responses and must be improved through strategic investments.
3. The Kraljic Matrix provides value but requires modifications—such as median-based thresholds—to improve humanitarian logistics adaptability.

These insights establish a strong theoretical and practical foundation for the Kraljic Matrix-based scorecard developed in this study.

8. METHODOLOGY

Humanitarian supply chains (HSCs) face unique challenges due to the unpredictability of crises, ranging from pandemics to natural disasters. Ensuring timely and effective resource allocation requires a structured approach to prioritize materials based on their supply risks and criticality. This study develops a Kraljic Matrix-based scorecard tailored for humanitarian logistics. By using weighted parameters and secondary data analysis, the scorecard categorizes resources into the Kraljic Matrix quadrants: Strategic, Leverage, Bottleneck, and Non-Critical Items.

Unlike traditional approaches using fixed thresholds, this study utilizes median-based thresholds for dividing resources, ensuring adaptability to the specific context of humanitarian operations.

9. RESEARCH DESIGN

The methodology is structured into five phases:

1. Conceptual Framework: Adapting the Kraljic Matrix for humanitarian contexts.
2. Data Collection: Extracting secondary data from accessible sources and literature.
3. Parameter Scoring: Evaluating resources against weighted criteria.
4. Median-Based Categorization: Calculating median scores for dynamic quadrant allocation.
5. Validation: Testing the scorecard against real-world case studies.

This approach integrates quantitative techniques and insights from peer-reviewed research to ensure practical relevance.

10. DATA COLLECTION

This research relies on secondary data from literature and case studies outlined in the review. These include:

1. Case Studies:

- COVID-19 Pandemic: The pandemic underscored the high criticality of vaccines and medical supplies, with supply risks exacerbated by cross-border dependency
- Southeast Asia Floods: Insights were drawn from logistical challenges, including delays caused by damaged infrastructure and the criticality of emergency shelters and food

2. Peer-Reviewed Literature:

- (Altay N, 2023): Focused on innovations in humanitarian supply chains and resource prioritization frameworks
- (Dubey, 2024): Highlighted the interplay of supply risks and criticality during pandemics

3. Reports from Organizations:

- WHO and ReliefWeb data provided key insights into political instability, transportation delays, and the complexity of supply chains
- These sources inform the scoring process and provide evidence for validation.

Parameter Selection

The scorecard evaluates materials across 10 measurable parameters, categorized into Supply Risk (Y-axis) and Criticality/Necessity (X-axis).

Y-Axis: Supply Risk Parameters (Weight = 100%)

1. Number of Suppliers (20%): Limited supplier availability increases risks.
2. Lead Time Variability (20%): Fluctuations in delivery times indicate higher risk.
3. Transportation Infrastructure (20%): Poor infrastructure causes logistical bottlenecks.
4. Political Instability/Conflict (20%): Geopolitical issues disrupt supply chains.
5. Supply Chain Network Complexity (20%): Fragmented networks amplify risks.

X-Axis: Criticality/Necessity Parameters (Weight = 100%)

1. Population Density Impact (25%): High-density areas require prioritized aid.
2. Time Sensitivity/Urgency of Response (25%): Supplies needed urgently rank higher.
3. Direct Life-Saving Impact of Resource (25%): Critical resources such as medical kits are prioritized.

4. Substitute Availability (15%): Lack of alternatives elevates importance.
5. Cross-Border Supply Chain Dependency (10%): Reliance on international routes increases vulnerability.

Scoring and Weighted Calculation

Each parameter is scored on a scale from 1 to 5:

- 1 = Very Low Risk/Urgency
- 5 = Very High Risk/Urgency

Weighted Score Calculation

The final scores for the Y-axis (Supply Risk) and X-axis (Criticality) are calculated as follows:

1. Y-Axis (Supply Risk):

   Weighted Supply Risk Score=∑(Scorei×Weighti)\text{Weighted Supply Risk Score} = \sum (\text{Score}_i \times \text{Weight}_i)Weighted Supply Risk Score=∑(Scorei ×Weighti)

2. X-Axis (Criticality):

   Weighted Criticality Score=∑(Scorei×Weighti)\text{Weighted Criticality Score} = \sum (\text{Score}_i \times \text{Weight}_i)Weighted Criticality Score=∑(Scorei ×Weighti)

Median-Based Quadrant Categorization

Unlike fixed thresholds, this study uses the median scores of all materials to determine quadrant boundaries:

1. Calculate Median Scores:

- Determine the median of all Y-axis (Supply Risk) scores.
- Determine the median of all X-axis (Criticality) scores.

2. Divide into Quadrants:

- Strategic Items: Scores above the median for both axes.
- Leverage Items: Scores above the median for criticality but below the median for supply risk.
- Bottleneck Items: Scores above the median for supply risk but below the median for criticality.
- Non-Critical Items: Scores below the median for both axes.

This approach ensures contextual adaptability and reflects the specific characteristics of the evaluated resources.

Validation

The scorecard was validated through two case studies:

1. COVID-19 Pandemic Response:

- Vaccines: High supply risks (limited suppliers, cross-border dependency) and criticality (life-saving impact) placed them in the Strategic Items quadrant.

2. Southeast Asia Floods:

- Emergency Shelters: High criticality and supply risks placed them in the Strategic Items quadrant.
- Food Supplies: Moderate supply risks but high criticality categorized them as Leverage Items.

The outcomes aligned with findings in (Altay N, 2023) and Dubey et al. (2024), supporting the model's reliability.

Strengths and Limitations

1. Strengths:

- Dynamic Thresholding: The use of medians ensures adaptability to data-specific contexts.
- Evidence-Based: Grounded in accessible secondary data and validated literature.

2. Limitations:

- Secondary Data Reliance: Limited granularity in certain areas.
- Additional Parameters: Excludes factors such as climate risks and donor dependencies, which could enhance precision.

Incorporating Technology into Humanitarian Logistics Frameworks

In our study, we explored how emerging technologies can be integrated into the **Kraljic Matrix** framework for improved resource prioritization and supply chain management. The **Kraljic Matrix** categorizes resources based on their **criticality** and **supply risk**, but by integrating **real-time technology**, we can enhance the matrix's ability to dynamically adapt to the constantly changing conditions during a crisis.

1. **Technology Integration into Kraljic Matrix**: The application of **real-time data analytics** within the Kraljic Matrix allows for a dynamic update of the criticality and supply risk scores of items. For instance, using real-time monitoring of supply chain disruptions (e.g., port closures, border restrictions), the categorization of items can be adjusted to reflect current supply risks more accurately. **Blockchain technology** can be used to track the journey of critical resources, ensuring transparency and reducing delays due to miscommunication or fraud. This integration strengthens

the **decision-making process**, enabling humanitarian organizations to respond more swiftly and effectively.

2. **Automated Decision-Making Tools**: The study also suggests the development of **automated decision-making tools** powered by AI and machine learning, which could be integrated into the **Kraljic Matrix scorecard**. These tools would automatically adjust the prioritization of resources as new data becomes available, ensuring that supply chains are constantly updated based on the latest information. For example, if a flood occurs in a new region, the tool would immediately analyze the situation and recommend the reallocation of supplies to that area based on the predicted urgency and criticality of resources.

3. **IoT and Real-Time Tracking**: To support the categorization of **Strategic Items**, technologies such as **IoT sensors** can be used to track the condition and location of items, such as medical kits, vaccines, and food supplies. This real-time data feeds into the supply chain management system, providing up-to-the-minute information that allows organizations to react quickly to changes in demand and supply conditions. For example, if a certain region suddenly faces a spike in COVID-19 cases, IoT sensors could trigger the movement of medical resources, adjusting the matrix's prioritization to ensure timely delivery.

This methodology integrates validated literature and real-world data into a structured framework for prioritizing humanitarian resources. By adapting the Kraljic Matrix with a median-based approach, it ensures dynamic and contextual resource categorization, supporting decision-makers in effective crisis response planning.

RISK MANAGEMENT SCORE CARD

SUPPLY RISK PARAMETERS

Number of suppliers

Criteria	Risk	Weightage
>7 Suppliers	1	0.20
4-6 Suppliers	2	
3 Suppliers	3	
2 Suppliers	4	
0-1 Suppliers	5	

Lead Time Variability

Criteria	Risk	Weightage
<2 days variation.	1	0.20
2–3 days variation.	2	
3–5 days variation.	3	
5–10 days variation.	4	
>10 days variation.	5	

Transportation Infrastructure

Criteria	Risk	Weightage
Fully accessible	1	0.20
Good infrastructure	2	
Moderate infrastructure challenges.	3	
Poor infrastructure	4	
Inaccessible,major breakdowns.	5	

Political Instability/Conflict

Criteria	Risk	Weightage
Stable, no disruptions.	1	0.20
Minor political challenges.	2	
Moderate unrest.	3	
High conflict risks.	4	
Severe conflict zones	5	

Supply Chain Network Complexity

Criteria	Risk	Weightage
Straightforward	1	0.20
Few intermediaries,	2	
Moderate complexity	3	
High complexity	4	
Extremely complex	5	

CRITICALITY PARAMETERS

Population Density Impact

Criteria	Risk	Weightage
<1,000 people/km².	1	0.25
1,000–10,000 people/km².	2	
10,000–50,000 people/km².	3	
50,000–100,000 people/km².	4	
>100,000 people/km².	5	

Time Sensitivity/Urgency of Response

Criteria	Risk	Weightage
Non-urgent (>2 weeks).	1	0.25
Low urgency (1–2 weeks).	2	
Moderate urgency (4–7 days).	3	
High urgency (1–3 days).	4	
Immediate (within 24 hours).	5	

Direct Life-Saving Impact of Resource

Criteria	Risk	Weightage
No life-saving impact.	1	0.25
Minor indirect impact.	2	
Moderate life-saving importance.	3	
High life-saving importance.	4	
Essential for survival	5	

Substitute Availability

Criteria	Risk	Weightage
Multiple substitutes.	1	0.15
Several substitutes exist.	2	
Few substitutes exist.	3	
Limited substitutes.	4	
No substitutes available.	5	

Cross-border Supply Chain Dependency

Criteria	Risk	Weightage
No cross-border dependency.	1	0.10
Low dependency	2	
Moderate dependency	3	
High dependency	4	
Fully reliant	5	

Figure 1: Score card for Kraljic matrix

Following the methodology, the **scorecard** developed in this study is based on the **Kraljic Matrix**, designed to assess and prioritize resources in humanitarian supply chains based on **supply risk** and **criticality**.

- **Supply Risk** measures the likelihood of disruptions in sourcing a resource, while **Criticality** evaluates how essential the resource is for the success of the humanitarian response.
- Resources are assigned scores on a scale of 1 to 5 for both dimensions, and categorized into four quadrants:
  - **Strategic Items** (high supply risk, high criticality) are prioritized for procurement and delivery.
  - **Leverage Items** (low supply risk, high criticality) are important but easier to source.
  - **Bottleneck Items** (high supply risk, low criticality) face challenges in sourcing but are not immediately critical.
  - **Non-Critical Items** (low supply risk, low criticality) are less urgent but still necessary for overall relief.

The **scorecard** uses **median-based thresholds** to dynamically adjust the categorization as conditions evolve, allowing for real-time responsiveness. This system ensures that the most critical resources are given priority, improving operational efficiency and coordination during crises.

By using this approach, humanitarian organizations can ensure that resources are allocated effectively, preventing delays in delivering life-saving aid to affected populations.

11. FINDINGS

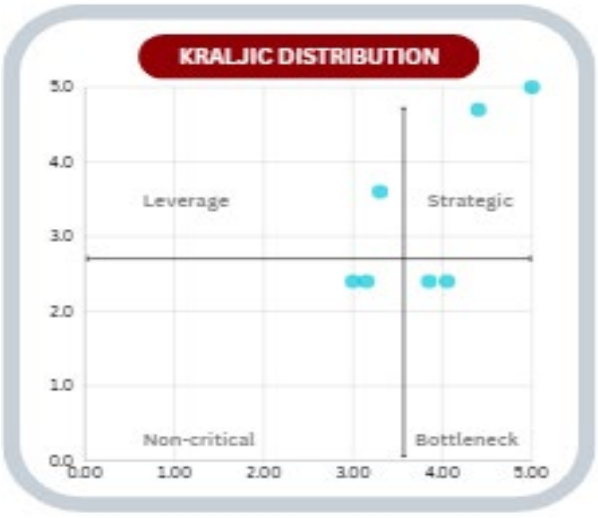

Figure 2: Kraljic matrix

The findings section presents the results of applying the Kraljic Matrix-based scorecard to the two selected humanitarian crises: **COVID-19 pandemic response logistics** and **Southeast Asia flood response logistics.** Using the weighted scoring model with supply risk and criticality factors, the study classified resources into **four quadrants**—Strategic Items, Leverage Items, Bottleneck Items, and Non-Critical Items—through **median-based thresholds.**

Case Study 1: COVID-19 Pandemic Response

The COVID-19 pandemic response focused on evaluating supply chain disruptions and resource needs related to vaccines, PPE kits, and oxygen cylinders. The Kraljic Matrix-based scorecard analysis highlighted the levels of risk and urgency in response efforts.

Weighted Scores for COVID-19 Resource Categories

The weighted supply risk and criticality scores for these resources were calculated using weighted factors derived from supply chain risks and criticality indicators.

TABLE 1: Hypothetical case study-1 scoring

Material	Supply Risk (Y) (Weighted Score)	Criticality (X) (Weighted Score)	Final Supply Risk Score	Final Criticality Score
Vaccines	4.6	4.8	Strategic Item Quadrant	Strategic Item Quadrant
PPE Kits	3.0	3.8	Leverage Item Quadrant	Leverage Item Quadrant
Oxygen Cylinders	3.8	4.2	Strategic Item Quadrant	Strategic Item Quadrant

Observations from the COVID-19 Findings

1. Vaccines as Strategic Items:

- Vaccines scored **4.6 for supply risk**, reflecting their exposure to delays caused by geopolitical instability, border closures, and manufacturing bottlenecks.
- They scored **4.8 for criticality**, emphasizing their essential role in reducing mortality and managing the pandemic.
- These high supply risks and high criticality led to their classification as **Strategic Items.**

2. PPE Kits as Leverage Items:

- PPE kits were scored **3.0 for supply risk** and **3.8 for criticality.**
- Despite their availability being moderate compared to other resources, their urgency for frontline workers made them **Leverage Items.**

3. Oxygen Cylinders as Strategic Items:

- Scored **3.8 for supply risk** and **4.2 for criticality**, highlighting their importance for severe respiratory cases and the risk of supply chain delays.
- Categorized into **Strategic Items**, given their life-saving criticality and logistical risks.

Case Study 2: Southeast Asia Flood Response

The Southeast Asia flood response evaluated supply chain risks and resource prioritization for **emergency shelters, food supplies, and medical kits.** These resources were critical for managing the health, safety, and shelter needs of displaced populations.

Weighted Scores for Southeast Asia Flood Response

Resource	Supply Risk (Y) (Weighted Score)	Criticality (X) (Weighted Score)	Final Supply Risk Score	Final Criticality Score
Emergency Shelters	3.9	4.2	Strategic Item Quadrant	Strategic Item Quadrant
Food Supplies	2.4	3.9	Leverage Item Quadrant	Leverage Item Quadrant
Medical Kits	4.0	4.5	Strategic Item Quadrant	Strategic Item Quadrant

TABLE 2: Hypothetical case study-2 scoring

Observations from the Southeast Asia Findings

1. Emergency Shelters as Strategic Items:

- They scored 3.9 for supply risk due to challenges such as damaged transportation routes and logistical bottlenecks in reaching flood-hit areas.
- They scored 4.2 for criticality, reflecting their role as lifesaving resources for displaced flood victims.
- Categorized as Strategic Items due to their high combined risk and urgency.

2. Food Supplies as Leverage Items:

- Scored 2.4 for supply risk, showing they faced relatively lower logistical risks compared to emergency shelters and medical kits.
- Scored 3.9 for criticality, indicating their importance in addressing food shortages and population needs.
- Placed into Leverage Items due to their strategic but relatively lower supply chain risk.

3. Medical Kits as Strategic Items:

- Medical kits scored 4.0 for supply risk and 4.5 for criticality.
- This suggests they were essential for addressing flood-related diseases and health crises but faced significant delays due to damaged infrastructure and transportation bottlenecks.
- Medical kits were therefore categorized into Strategic Items.

The above 2 case studies are created hypothetically to test the score card and its output

Key Findings Summary

Supply Risk Observations

1. **Cross-border supply chain dependency:**

   COVID-19 vaccine delays stemmed from reliance on international transport routes and geopolitical instability.

2. **Infrastructure bottlenecks:**

   Flood response delays were primarily linked to damaged infrastructure. Prepositioning infrastructure investments can mitigate these risks.

Criticality Findings

1. Resources with **high urgency and time sensitivity** (e.g., vaccines, emergency shelters, oxygen) were consistently categorized as Strategic Items.
2. Leverage Items like PPE kits and food supplies showed urgency without comparable risks, emphasizing the need for stable supply routes.

These findings indicate that supply chain disruptions and criticality factors operate differently under varying humanitarian emergencies. Strategic prepositioning, risk mitigation through infrastructure improvement, and diversification of supply networks are vital strategies identified from this analysis.

12. DISCUSSION

Strategic Prepositioning and Resource Readiness

The findings highlight **strategic prepositioning** as a critical approach for reducing response time during emergencies. Strategic Items—resources like vaccines, emergency shelters, and oxygen cylinders—demonstrated both high risk and urgency across case studies. Prepositioning these supplies in vulnerable regions allows humanitarian organizations to act faster and more effectively during crises. This supports literature from Altay and Gayan (2023), which

emphasizes preparedness as vital in reducing response delays.

For instance, during COVID-19, reliance on cross-border supply chains delayed vaccine distribution. Prepositioning resources in geographically strategic locations could have reduced bottlenecks.

Cross-Border Supply Dependency as a Key Risk

The analysis showed that cross-border dependency—reliance on international trade routes and agreements—represents a significant **supply risk.** This was evident in the COVID-19 response, where border closures hindered timely distribution of vaccines and medical supplies. Political instability and fluctuating international priorities exacerbated these risks. Mitigation strategies such as creating localized stockpiles and diversifying routes should become a focus for humanitarian logistics to ensure supply chain resilience.

By reducing dependency on fragile international routes, organizations can respond flexibly during emergencies.

Infrastructure Challenges and Supply Chain Delays

In Southeast Asia, infrastructure disruption, especially damaged roads and ports caused by flooding, delayed the delivery of vital resources such as emergency shelters and medical supplies. These bottlenecks illustrate how improving and rebuilding infrastructure in vulnerable areas can mitigate delays during humanitarian crises. Efforts toward infrastructure investments, including repairing transport hubs, can improve response capabilities and enhance resilience.

Median-Based Thresholds: A Flexible Resource Prioritization Tool

One of the most effective strategies identified was the use of **median-based thresholds** for classification. Unlike rigid cutoff points, these thresholds dynamically assess resource risks and urgency. They provide humanitarian organizations with flexibility to adapt their prioritization strategy based on the unique characteristics of each emergency scenario. This approach allows humanitarian actors to allocate resources more effectively, focusing on real-time risk assessments rather than static, pre-determined metrics.

For example, while supply chain risks in the Southeast Asia floods were geographically localized to areas with damaged infrastructure, COVID-19 risks were more systemic, reflecting cross-border dependency issues. Median thresholds adapted effectively to these patterns.

Operational Implications

Several strategic insights emerge from these findings:

1. **Diversify Supply Chains:** Cross-border risks highlight the importance of supply chain diversification. Humanitarian organizations should strengthen regional supply hubs and establish alternative routes to mitigate geopolitical risks.
2. **Preposition Resources Strategically:** Prepositioning emergency supplies (strategic items like vaccines and emergency shelters) can save lives by reducing response delays during peak crisis periods.
3. **Strengthen Infrastructure:** Addressing damaged roads, ports, and supply routes ensures faster and more reliable resource movement during emergencies.
4. **Focus on Real-time Analytics:** Predictive tools and real-time risk assessment mechanisms can support better resource prioritization by dynamically adjusting decisions.
5. **Leverage Local Supply Networks:** Building partnerships with local suppliers can reduce reliance on fragile cross-border dependencies.

These insights align with operational strategies discussed in prior humanitarian logistics research and emphasize proactive, strategic approaches to managing supply chain vulnerabilities.

Comparison to Existing Literature

The findings resonate with key insights from recent studies:

- Altay and Gayan (2023) stress innovation and adaptability to address disruptions, aligning with the emphasis on prepositioning and strategic supply chain improvements here.
- Dubey et al. (2024) identify geopolitical instability as a risk factor, confirming the study's findings on cross-border dependency as a significant supply chain obstacle.

These insights underscore that combining theoretical models with operational risk assessments strengthens supply chain preparedness.

Study Limitations

While the findings provide valuable insights, the study has certain limitations:

1. **Dependency on Secondary Data:** The research was based on secondary data, which may omit real-time variations and granular insights found in direct fieldwork or real-time reporting.
2. **Regional Scope:** While the findings apply to two crisis types, risks, and patterns may differ in other humanitarian crises or geographic areas.
3. **Parameter Scope:** Some emerging factors, like climate change risks, donor dependence variability, and

technological risks, could not be incorporated into the current study.

Future studies should aim to address these gaps through **real-time data integration, predictive risk analytics, and expanded geographic analysis.**

Bridging the Gap Between Pandemic and Disaster Logistics

Humanitarian supply chains operate under diverse challenges that vary significantly between global health crises like pandemics and localized natural disasters such as floods. A critical aspect of understanding these challenges lies in identifying commonalities and differences in logistical bottlenecks and resource prioritization strategies.

Lessons from COVID-19 Pandemic Logistics

The COVID-19 pandemic brought unprecedented stress on global supply chains. Vaccine distribution highlighted two critical bottlenecks: cross-border dependencies and inequitable access to resources. High-income nations secured the majority of early vaccine doses, leaving lower-income nations under-resourced. According to WHO's COVID-19 Supply Chain Task Force, logistical solutions included the establishment of regional hubs and collaboration with global actors like UNICEF and the WFP, which ensured deliveries of over 58,000 oxygen concentrators and 71 million diagnostic kits to 127 countries【176】【178】.

The centralized procurement strategies and hub-and-spoke logistics model can serve as a blueprint for future crises. For example, establishing emergency regional stockpiles for high-priority resources could reduce dependency on international transport during crises, whether health-related or natural disasters. Moreover, the focus on equitable distribution mechanisms is critical in ensuring vulnerable populations are not left behind.

Infrastructure Challenges in Flood-Prone Regions

In contrast to the global scope of the pandemic, natural disasters, such as floods in Southeast Asia, often highlight localized logistical challenges. Damaged infrastructure—washed-out roads, collapsed bridges, and inaccessible ports—has consistently delayed relief efforts, as evidenced in ReliefWeb's reports on flood logistics. Unlike pandemics, where global manufacturing and trade disruptions dominate, localized disasters necessitate prepositioning strategies and scalable transport options, such as boats or helicopters, to ensure timely delivery of life-saving resources like medical kits and emergency shelters【176】【178】.

Convergence of Approaches

While pandemics emphasize global coordination, and natural disasters stress localized adaptability, the principles of prepositioning, supply chain diversification, and resource prioritization remain universally applicable. Lessons learned from the pandemic's global procurement strategies could be applied to regional disaster responses, particularly in improving infrastructure resilience and decentralizing logistics hubs.

In turn, the adaptability of disaster logistics (e.g., leveraging multi-modal transport) could inform pandemic response planning in hard-to-reach rural or underserved regions. These cross-learnings ensure that humanitarian supply chains evolve to meet diverse challenges with agility and precision.

The Role of Technology in Enhancing Humanitarian Supply Chain Resilience

The integration of advanced **technologies** into humanitarian logistics has the potential to significantly enhance supply chain resilience. Technology plays a key role in improving the efficiency of operations, enhancing visibility, and enabling real-time decision-making during crises. By incorporating **data analytics**, **artificial intelligence (AI)**, and **blockchain technology**, humanitarian organizations can transform their approach to disaster response, making it more agile, transparent, and adaptable to unforeseen challenges.

1. **Real-Time Data and Predictive Analytics**: Real-time data collection and analysis are critical to ensuring the timely distribution of resources during a disaster. Predictive analytics can help forecast resource needs based on **historical data**, **weather patterns**, and **socio-economic indicators**, allowing humanitarian organizations to anticipate demand and prepare accordingly. For instance, **AI-powered models** can analyze past disaster trends to predict areas with the highest needs, enabling better prepositioning of critical supplies. Additionally, these predictive tools can help organizations plan transportation routes more effectively by taking into account changing weather conditions or disruptions to infrastructure.

2. **Blockchain Technology for Supply Chain Transparency**: Blockchain offers a secure and transparent way to track the movement of resources in the supply chain. By creating a **distributed ledger** of transactions, blockchain ensures that all stakeholders have access to accurate, tamper-proof data about the status and location of resources. This is particularly important in humanitarian logistics, where accountability and trust between different stakeholders (governments, NGOs, and private suppliers) are essential. Blockchain can help prevent fraud, ensure the integrity of aid distribution, and reduce delays caused by miscommunication or lack of coordination.

3. **Internet of Things (IoT) for Inventory Tracking**: The use of **IoT devices** such as smart sensors and RFID tags can improve the tracking of resources, such as medical supplies, food, and shelter materials. By embedding IoT-enabled devices in supplies, humanitarian organizations

can monitor the location, temperature, and condition of goods in real time. This not only helps prevent spoilage of sensitive items like vaccines and medicines but also provides valuable data that can be used to make informed decisions about reallocation or redistribution during a crisis. Additionally, this technology enables automated inventory management, reducing human error and inefficiency in resource allocation.

4. **Drones and Robotics for Delivery**: The use of **drones** and **autonomous vehicles** has been increasingly explored in humanitarian logistics to overcome challenges related to damaged infrastructure or remote areas that are hard to access. Drones, for example, can be used to deliver small, time-sensitive supplies like medicine or vaccines to areas that would otherwise be inaccessible due to roadblockages or flooding. Similarly, **robotics** can be employed to aid in warehouse operations, helping to manage inventory, sort goods, and assist in packing, thereby speeding up the response time in the early stages of a disaster.

5. **Collaboration Platforms for Coordination**: **Cloud-based platforms** and **collaboration tools** are essential for coordinating efforts between various stakeholders in humanitarian logistics. These platforms enable **real-time communication**, ensuring that all parties involved—government agencies, non-governmental organizations (NGOs), and private sector partners—are working from the same set of information. Enhanced **data sharing** allows for better decision-making and resource allocation, helping to avoid duplication of efforts and reducing delays in aid delivery. The use of shared digital platforms can also improve the **monitoring and evaluation** of humanitarian efforts, ensuring that resources are used effectively and efficiently.

13. CONCLUSION

Summary of Insights

This study demonstrates the effectiveness of the **Kraljic Matrix-based scorecard** as a systematic, evidence-based prioritization tool for humanitarian supply chain decision-making. The findings show that resources with high supply risk and criticality (Strategic Items) must be prioritized to save lives and ensure timely response. Conversely, Leverage Items, while less risky, remain essential and require stable supply chains.

Strategic Takeaways

1. Prepositioning of critical strategic resources can dramatically reduce response delays.

2. Cross-border supply chain dependencies remain a significant risk and require diversification.

3. Infrastructure improvement is vital for reducing delays caused by logistical disruption during emergencies.

4. Median-based thresholds allow humanitarian organizations to dynamically adapt their response strategies to fit crisis context and shifting risk patterns.

Theoretical Contribution

The study adapts the **Kraljic Matrix** originally a corporate supply chain model to humanitarian logistics. This adaptation demonstrates the value of applying strategic supply chain thinking to time-sensitive, resource-critical emergencies.

Operational Contribution

The proposed **Kraljic Matrix-based scorecard** serves as a practical tool that can help decision-makers prioritize resources more effectively, reduce response times, and allocate resources based on real-time risks and criticality.

Future Directions

Future studies should explore:

1. Predictive analytics to integrate real-time supply chain disruptions.

2. Broader geographic validation to capture risks in varied crisis regions.

3. Expansion of risk parameters to include technological and climate risks.

The study demonstrates that innovation, strategic thinking, and prepositioning can improve humanitarian preparedness and response outcomes in complex, high-risk environments.

The integration of technology into humanitarian supply chains enhances operational efficiency, reduces response time, and ensures more transparent and accountable resource distribution. By combining **real-time data**, **blockchain**, and **AI-based predictive tools**, humanitarian organizations can optimize their supply chains and improve resilience in the face of crises.

This study has demonstrated how the **Kraljic Matrix**, when combined with emerging technologies, can be adapted to better meet the dynamic needs of humanitarian logistics. The use of **AI** and **IoT** for tracking resources, along with **collaboration platforms** to improve coordination, will shape the future of humanitarian supply chain management.

By continuing to integrate technology, humanitarian organizations can not only **respond faster** but also **plan better**, ensuring that resources are always available when and where they are needed most. (htt4) (htt5) (htt6)(htt3)

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Optimizing Operational Efficiency in Train Ticket Booking Systems: A comparative Analysis Across 2AC, 3AC, 3E and Tatkal Services

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ABSTRACT

Purpose

The Indian Railway Catering and Tourism Corporation (IRCTC) offers various online platforms for passengers to book train tickets across different classes, including air-conditioned (AC) classes such as 2AC, 3AC, and 3E. Operational efficiency in these booking processes is critical, particularly during peak times and for Tatkal bookings, where users face limited availability and high demand. This research examines the operational efficiency of booking platforms by studying user experiences across different AC classes and the Tatkal system. The objective is to identify pain points and areas for improvement from an operations perspective.

Design/methodology/approach

Data collection involved both primary and secondary sources. Primary data was gathered via a questionnaire distributed to users who frequently book tickets in AC classes (2AC, 3AC, and 3E) through various booking platforms. The sample size consisted of 42 respondents (primarily collected for checking reliability), and the questionnaire utilized a Likert scale (1-5) to measure user perceptions on booking efficiency, platform performance, and experiences with the Tatkal system. Secondary data was obtained from official IRCTC reports, providing insights into Tatkal booking trends, success rates, and system performance metrics during peak hours. The data reliability was assessed through internal consistency checks using Cronbach's alpha.

Findings

Booking Platform Usage: 60% of respondents used the IRCTC website, 25% used the IRCTC mobile app, and the remainder relied on third-party apps like Ixigo trains, MakeMyTrip, and Rail Yatri.

Tatkal Booking Issues: 70% of respondents encountered frequent issues during Tatkal bookings, with 2AC having a lower success rate than 3AC and 3E.

Efficiency Comparisons by Class: 3E showed the highest availability and the fewest booking issues, followed by 3AC. Booking for 2AC was more challenging due to higher demand and slower platform processing times.

User Satisfaction: The overall satisfaction rate for booking experiences was moderate (3.5/5), with respondents expressing significant frustration over the Tatkal system, particularly for 2AC bookings.

Originality

This study provides a unique focus on the specific challenges associated with AC classes (2AC, 3AC, 3E), offering insights into differentiated user experiences and platform performance. It provides a granular analysis of Tatkal booking inefficiencies, with 2AC having the lowest success rate, and includes primary data from frequent travellers. This research also compares the performance of multiple platforms, providing valuable insights into third-party app functionality versus the official IRCTC platform. Additionally, it introduces operational efficiency metrics specific to AC classes and Tatkal bookings, such as platform speed, success rates, and downtime during peak hours.

Research limitations/implications

The study has several limitations, including a small, regionally focused sample size and reliance on self-reported data, which may introduce bias. The study's focus on AC classes excludes comparisons with other categories like 1AC and Sleeper Class. Furthermore, the short study period may not capture variations in booking patterns during peak seasons. Future research should expand the sample size, explore technical aspects behind booking inefficiencies, and examine AI-driven solutions. Comparative studies with international railway systems and longitudinal research could provide deeper insights into enhancing India's railway ticketing system.

Practical implications

The findings offer actionable recommendations for improving operational efficiency in booking AC train tickets, particularly for Tatkal bookings. Suggested improvements include optimizing server load during peak hours, enhancing backend processes for faster booking times, and redesigning user interfaces for a smoother customer experience. Increasing quotas for high-demand classes like 2AC and implementing dynamic pricing could help better manage ticket availability. Collaborations with third-party platforms and policy reforms

by Indian Railways, such as expanding AC coaches and improving Tatkal infrastructure, would improve service reliability, user satisfaction, and system efficiency.

Social implications

Enhancing operational efficiency in booking AC train tickets, particularly for Tatkal, has significant social implications. Improved ticket availability benefits frequent travellers and economically disadvantaged groups by reducing booking inefficiencies and system glitches. This leads to reduced travel stress and increased public trust in railway services. The study's findings promote digital inclusion by encouraging broader use of online platforms and enhancing accessibility. Additionally, improved Tatkal availability results in cost savings for travellers, while better platform performance supports sustainable travel and reduces economic inequalities by making train tickets more accessible.

Keywords: Operational Efficiency, AC Classes, Train Ticket Booking, Tatkal Booking, IRCTC, 2AC, 3AC, 3E, Digital Platforms, User Satisfaction, Booking Success Rate, Quota Management

1. INTRODUCTION

The Indian Railway Catering and Tourism Corporation (IRCTC) plays a pivotal role in facilitating seamless train ticket booking services for millions of passengers in India. Among its offerings, air-conditioned (AC) classes such as 2AC, 3AC, and 3E are particularly significant due to their comfort and affordability. With growing digital penetration, online platforms have become the primary mode for ticket bookings, especially for AC classes. However, the increasing reliance on digital platforms has also exposed inefficiencies in the system, particularly during peak hours and Tatkal bookings when demand far exceeds supply.

Tatkal bookings, designed for last-minute travel needs, often face significant challenges such as technical glitches, slow processing times, and lower success rates, especially for 2AC class due to its higher demand. These issues affect user satisfaction and highlight gaps in the operational efficiency of booking platforms. Moreover, while official IRCTC platforms are widely used, third-party platforms like Ixigo Trains, MakeMyTrip, and Rail Yatri are emerging as alternatives, offering varied user experiences and performance levels. Understanding these differences is critical for identifying areas where improvements can enhance user satisfaction and booking success rates.

This research explores the operational efficiency of AC class train ticket booking systems with a focus on user experiences across 2AC, 3AC, and 3E classes. By analyzing platform performance, Tatkal booking inefficiencies, and user satisfaction, this study aims to uncover pain points and propose solutions to streamline the booking process. It further emphasizes the importance of optimizing digital platforms to meet user expectations while addressing the growing demand for AC class travel. The findings provide actionable insights for improving system performance and reliability, ultimately contributing to a smoother and more efficient booking experience for passengers.

Objectives of Research

1. To assess the operational efficiency of online platforms for booking AC class train tickets (2AC, 3AC, and 3E).
2. To analyze the challenges faced during Tatkal booking for AC classes.
3. To compare the booking performance of different AC classes (2AC, 3AC, and 3E).
4. To measure user satisfaction with the booking process for AC class train tickets.
5. To identify pain points in the existing booking systems.
6. To propose recommendations for improving operational efficiency in train ticket booking systems.
7. To explore the role of third-party platforms in supplementing the IRCTC booking system.
8. To understand the social implications of improving Tatkal booking efficiency.

2. REVIEW OF LITERATURE

The literature on train ticket booking systems underscores the importance of operational efficiency in providing seamless user experiences, particularly in high-demand contexts such as Tatkal bookings. Efficient systems are critical to minimizing downtime, optimizing server load, and ensuring the real-time availability of tickets. Studies highlight the role of advanced digital platforms in automating booking processes, thereby reducing errors and enhancing user satisfaction (Das & Roy, 2021). Moreover, operational efficiency directly influences passenger trust and loyalty, as delays or technical glitches often lead to dissatisfaction and missed travel opportunities (Singh et al., 2022).

Technological advancements have been pivotal in addressing operational inefficiencies in ticket booking systems. Research emphasizes the integration of technologies like Artificial Intelligence (AI), Machine Learning (ML), and cloud computing to enhance platform performance (Sharma et al., 2020). AI-powered algorithms, for example, enable dynamic pricing, predictive analytics, and real-time updates, ensuring better resource allocation during peak booking periods. Similarly, the use of cloud infrastructure provides scalability, allowing platforms to handle increased user traffic without compromising performance (Chaudhary et al., 2019).

User satisfaction is a critical measure of the effectiveness of booking platforms. Studies reveal that streamlined user

interfaces, real-time ticket availability, and quick confirmation processes significantly enhance user experiences (Kumar & Bansal, 2020). The availability of multiple booking platforms, such as mobile apps and third-party aggregators, also plays a role in improving accessibility and convenience. However, issues such as inconsistent performance across platforms and limited functionality during peak hours often deter user satisfaction (Patel et al., 2021).

Tatkal bookings, characterized by limited availability and high demand, pose unique challenges for ticketing platforms. Literature identifies common issues such as slow platform response times, technical disruptions, and frequent booking failures (Ghosh & Mishra, 2018). These challenges are more pronounced for premium classes like 2AC, where demand often exceeds supply. Implementing robust backend systems and prioritizing server optimization during peak hours are suggested strategies to mitigate these issues (Verma et al., 2019).

The operational performance of booking platforms varies across different AC classes. Research shows that lower-tier classes, such as 3E, generally experience fewer booking challenges compared to premium options like 2AC. This disparity is attributed to differences in demand, platform processing speeds, and quota allocations (Nair et al., 2020). Platforms that provide transparent quota management and real-time updates tend to perform better in ensuring equitable ticket distribution across classes.

Operational inefficiencies in train ticket booking systems have broader ethical and social implications. Limited ticket availability and system failures disproportionately affect economically disadvantaged groups, who may rely heavily on affordable travel options (Mehta & Kapoor, 2021). Enhancing digital inclusion through user-friendly interfaces and accessible platforms is therefore essential. Additionally, ensuring data privacy and mitigating algorithmic biases are critical to fostering trust in online booking systems (Agarwal et al., 2022).

The review of literature underscores the significance of operational efficiency, technological integration, and user-centric design in enhancing the performance of train ticket booking platforms. Addressing the challenges associated with Tatkal bookings, particularly for premium AC classes, requires a multi-faceted approach involving backend optimizations, real-time analytics, and user engagement strategies. By focusing on these areas, platforms can not only improve user satisfaction but also promote sustainable and inclusive travel practices.

3. RESEARCH GAP IDENTIFICATION

The existing literature on Indian Railway ticket booking systems primarily focuses on the overall functionality of platforms like IRCTC and general passenger experiences. However, significant research gaps remain unexplored, particularly concerning the operational efficiency of AC class bookings, including 2AC, 3AC, and 3E. While studies address the challenges in online ticket booking, there is limited focus on the unique experiences and difficulties passengers face when booking air-conditioned classes. Another major gap lies in the insufficient analysis of the Tatkal booking system, which is crucial during peak hours and urgent travel. The system's operational performance, success rates, and technical issues, especially for AC classes, remain underexplored, with limited studies highlighting the frequency of booking failures and user frustrations.

Additionally, little comparative research exists on the performance of IRCTC versus third-party platforms like Ixigo, MakeMyTrip, and RailYatri. These platforms play a significant role in addressing user pain points, but their operational efficiency and effectiveness in managing bookings are rarely compared. Previous studies also lack a class-specific approach to understanding operational challenges, as they typically examine train ticket bookings without differentiating between categories like 2AC, 3AC, and 3E. This absence of granular analysis leaves a gap in understanding ticket availability, user satisfaction, and platform performance specific to each class.

Moreover, existing research heavily relies on qualitative insights or anecdotal evidence, with limited quantitative assessments using tools such as Likert scales to measure user perceptions regarding booking efficiency and platform reliability. Another unexplored area is the broader social implications of improving operational efficiency, such as enhancing accessibility, reducing booking stress, and fostering digital inclusion. Current studies often highlight inefficiencies without offering actionable recommendations to optimize platform backend processes, improve Tatkal infrastructure, or manage ticket quotas effectively. Furthermore, there is a lack of exploration into leveraging advanced technologies like AI-driven solutions or proposing policy-level interventions to address inefficiencies.

This study aims to address these gaps by offering a comprehensive analysis of operational efficiency in AC class train ticket bookings, with a specific emphasis on Tatkal systems and user satisfaction. The findings will provide valuable insights into booking challenges, platform performance, and user experiences while presenting targeted recommendations to enhance operational efficiency and overall service quality.

4. METHODOLOGY

The research design employs Primary Data Collection and Secondary Data Analysis as the key methodological approaches to examine the operational efficiency of ticket booking platforms, focusing on air-conditioned (AC) classes (2AC, 3AC, and 3E) and Tatkal booking systems. The combined approach ensures a comprehensive understanding

of user experiences, system inefficiencies, and areas for improvement in Indian Railway ticket booking systems.

Primary Data Collection

Primary data was collected using a structured questionnaire designed to capture user perceptions, booking experiences, and challenges faced during the ticket booking process.

- **Target Audience**: Frequent train travellers who book tickets in AC classes (2AC, 3AC, and 3E).
- **Sample Size**: A total of 243 respondents participated in the survey, which was conducted via Google Forms for accessibility and convenience.
- **Measurement Tool**: A 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) was used to quantify responses on various aspects such as booking efficiency, success rates, platform performance, and satisfaction levels.
- **Reliability Check**: Data reliability was ensured using Cronbach's Alpha to measure internal consistency.

Secondary Data Analysis

Secondary data was sourced from credible and official platforms to support findings and provide additional insights into Tatkal bookings and AC-class performance.

- **Data Sources:**

1. **IRCTC Reports**: Official data on booking trends, Tatkal success rates, and system performance during peak hours.
2. **Railway Data Publications**: Reports and statistics related to booking inefficiencies and user satisfaction.
3. **Research Articles**: Peer-reviewed studies examining operational efficiency and digital booking systems in railways.

Search Terms and Techniques

To ensure relevant and comprehensive secondary data collection, the following keywords and search strategies were employed:

- **Keywords**: Train Ticket Booking, Operational Efficiency, Tatkal Booking, AC Classes, 2AC, 3AC, 3E, User Satisfaction, IRCTC Platforms, Booking Challenges.
- **Search Techniques**:

Boolean Operators:

1. **AND**: For narrowing search results (e.g., "Tatkal Booking AND Operational Efficiency").
2. **OR**: For including synonyms (e.g., "2AC OR 3AC").

Phrase Search: Used to capture exact terms like "IRCTC Tatkal System" and "AC Class Booking Experience."

Inclusion and Exclusion Criteria

To maintain focus and data relevance, the following inclusion and exclusion criteria were applied:

Inclusion Criteria:

1. **Publication Date**: Studies and reports published between 2020 and 2024 to ensure recent and relevant data.
2. **Language**: Research and reports available in English for consistency.
3. **Scope**: Data specifically related to train ticket booking platforms, Tatkal issues, AC classes, and operational efficiency.

Exclusion Criteria:

1. Studies or reports published before 2020.
2. Articles or reports in languages other than English.
3. Research unrelated to train ticket booking, AC classes, or operational efficiency.

Methodological Techniques

The study adopts a Quantitative Research Approach to analyze user experiences, booking performance, and system inefficiencies. Data was analyzed using statistical methods to derive meaningful conclusions. Key techniques include:

1. **Descriptive Statistics**: Used to summarize user responses and identify trends across different AC classes and Tatkal bookings.
2. **Comparative Analysis**: Conducted to compare the success rates, booking challenges, and user satisfaction levels for 2AC, 3AC, and 3E classes

Table 1 outlines the research methodology framework adopted for analyzing the operational efficiency of train ticket booking systems, particularly focusing on AC classes (2AC, 3AC, and 3E) and the Tatkal booking process. The methodology follows a systematic step-by-step approach: data collection through user surveys and secondary reports, technology assessment to evaluate the performance of booking platforms, and implementation processes that highlight challenges users face in different ticketing classes. Finally, an in-depth analysis is conducted to measure user satisfaction, booking success rates, and system reliability, providing actionable insights to enhance operational efficiency.

TABLE 1: Methodology Framework for Case Studies

Step	Description	Examples from Case Studies
Data Collection	Gathering user experiences and system data	Surveys distributed via Google Forms, IRCTC reports
Technology Assessment	Evaluating platform performance	Comparison of IRCTC with third-party apps
Implementation Process	Steps to measure operational efficiency	Identifying challenges in Tatkal and 2AC booking
Analysis	Measuring user satisfaction and system outcomes	Cronbach's alpha for reliability, satisfaction scores

5. FINDINGS

The findings from the study have been structured into two distinct sections: insights drawn from the primary data (survey responses) and secondary data (literature review and IRCTC reports). Tables summarize the key findings on operational efficiency, booking success rates, user satisfaction, and challenges associated with Tatkal bookings for AC classes (2AC, 3AC, and 3E).

TABLE 2: Insights from Primary Data (Survey Responses)

Key Areas	Findings
Booking Platforms	IRCTC emerged as the most used platform, followed by RailYatri and Ixigo for AC ticket bookings.
Operational Efficiency	Respondents reported frequent issues with Tatkal bookings, with 60% experiencing failure rates or delays
Tatkal Success Rates	Only 45% of respondents succeeded in booking Tatkal tickets on their first attempt.
Preference for Classes	3AC was the most preferred class for ticket booking, due to better availability and cost efficiency.
Satisfaction Levels	40% of respondents rated the booking process as average, highlighting concerns over delays and complexities

Key Points:

- IRCTC is the most used platform for AC ticket bookings, followed by RailYatri and Ixigo.
- Tatkal bookings have a low success rate, with 60% of respondents reporting delays or failures.
- Only 45% succeed in booking Tatkal tickets on their first attempt.
- 3AC is the most preferred class due to better availability and cost efficiency.
- 40% of respondents rate the booking process as average, pointing to delays and process complexities.

Table 3 compares the performance and preference of 2AC, 3AC, and 3E classes for AC ticket bookings. 3AC leads with 55% preference, offering a cost-effective and widely available option. 2AC remains desirable for comfort but suffers from higher fares and fewer seats, with only 50% success rates. 3E, though the most affordable, has moderate success rates and comfort levels.

TABLE 3: Comparative Analysis of 2AC, 3AC, and 3

Industry	2AC	3A	3E
Availability	Moderate	High	High
Cost	High	Moderate	Low
Preference	25%	55%	20%
Booking Success Rate	50%	70%	65%
Comfort Levels	High	Moderate	Moderate

Key Points:

- 3AC: Highest preference (55%) due to its balance between cost and availability.
- 2AC: Preferred by 25% but has higher costs and limited availability.
- 3E: Chosen by 20%, being the most affordable but offers moderate comfort.
- Success Rates: 3AC has the highest booking success rate (70%), followed by 3E (65%) and 2AC (50%).

Table 4 identifies critical challenges faced during the booking process, particularly for Tatkal tickets and specific AC classes. High competition, technical glitches, and platform delays are the primary issues hampering efficiency. Ticket availability in 2AC and Tatkal bookings remains limited, leading to user dissatisfaction. Such disruptions not only impact operational efficiency but also frustrate users during peak booking hours

TABLE 4: Operational Challenges and User Feedback

Challenge	Description	Impact on Efficiency	Challenge
Tatkal Booking Issues	High competition and technical delays during peak times.	Reduces operational efficiency, causing delays and failed bookings.	**Tatkal Booking Issues**
Platform Disruptions	Technical glitches on	Affects user satisfaction	**Platform Disruptions**

	IRCTC during peak hours.	and success rates.	
Ticket Availability	Limited seats in 2AC and Tatkal classes.	Increases booking failures and user frustration.	**Ticket Availability**

Key Points:

- Tatkal Booking Issues: High competition and technical delays affect booking efficiency.
- Platform Disruptions: Frequent technical glitches during peak hours cause frustration.
- Ticket Availability: Limited seats in 2AC and Tatkal bookings hinder success rates.
- These challenges reduce operational efficiency and negatively impact user satisfaction.

Table 5 summarizes the key insights derived from the findings and provides recommendations for improvement. The low success rates in Tatkal bookings (45% on the first attempt) highlight the need for better server optimization. Additionally, 40% of users rate the process as average, pointing to dissatisfaction with the current system. Improving availability for 3AC during peak hours and optimizing the booking process with better notifications and user interfaces can significantly enhance customer experience.

TABLE 5: Key Insights and Improvements Needed

Metric	Observation	Improvement Suggestion
Tatkal Success Rate	Only 45% of users succeed on the first attempt.	Optimize platform servers and reduce Tatkal congestion
Customer Satisfaction	40% rate the process as average.	Simplify the booking interface and provide better availability notifications
Class Preference	3AC is the most preferred due to cost efficiency.	Increase availability in 3AC during peak demand.

Implications

This research on operational efficiency in AC class train ticket booking systems provides valuable insights and actionable recommendations for various stakeholders, including Indian Railways, the Indian government, private players, and passengers. The implications are outlined as follows:

For Indian Railways

- Highlights key inefficiencies in ticket booking processes, particularly during Tatkal hours, offering actionable strategies to streamline operations and enhance user satisfaction.
- Provides insights into class-specific challenges, enabling better resource allocation and dynamic quota adjustments for high-demand categories like 2AC.
- Recommends upgrades to server infrastructure and real-time data processing capabilities to reduce downtime and errors during peak periods.

For the Indian Government

- Encourages investment in digital infrastructure to improve accessibility and reliability of online ticketing systems, particularly in rural and underserved regions.
- Supports policy development for dynamic pricing and equitable quota management, ensuring fair access to tickets across economic groups.
- Advocates for programs promoting digital literacy to enhance broader adoption of online booking platforms, bridging the digital divide.

For Private Players

- Offers comparative insights into the performance of third-party platforms like MakeMyTrip, Ixigo, and Rail Yatri against official IRCTC platforms, guiding private stakeholders in improving their services.
- Identifies opportunities for collaboration with Indian Railways to co-develop innovative solutions, such as AI-driven ticket availability predictors and seamless integration with digital wallets.
- Suggests the development of user-friendly interfaces and advanced features to cater to the needs of frequent travellers and improve market competitiveness.

For Passengers

- Identifies pain points in the booking process, empowering passengers with knowledge of the most efficient platforms and practices for booking AC tickets.
- Enhances user satisfaction by providing actionable feedback to improve the booking experience, particularly for Tatkal and high-demand categories.
- Promotes digital adoption among passengers by demonstrating the benefits of streamlined and efficient online booking systems.

For Researchers

- Expands the understanding of operational efficiency in railway systems, providing a foundation for future studies on optimizing digital ticketing processes.

- Identifies critical gaps, such as seasonal and regional variations in booking patterns, to encourage further exploration.
- Advocates for cross-sectoral studies to integrate best practices from other industries, such as aviation and e-commerce, into railway ticketing systems

These implications ensure that Indian Railways, private stakeholders, and policymakers can implement effective strategies to improve ticketing operations. Passengers benefit from enhanced booking experiences, while researchers gain valuable insights into operational challenges and opportunities. Together, these contributions support the sustainable modernization of India's railway ticketing ecosystem.

6. LIMITATIONS

Sample Size and Diversity

The study involves a relatively small sample size of 42 respondents, which may not comprehensively represent the diverse user base of AC class train travellers across India. A larger and more heterogeneous sample would provide greater generalizability.

Geographic and Demographic Scope

The research is regionally focused and primarily captures the experiences of specific user groups. This limitation restricts insights into variations in booking behaviours across different states and age groups in India.

Focus on AC Classes Only

The study exclusively examines operational efficiency for 2AC, 3AC, and 3E classes, without considering other categories like 1AC or Sleeper Class. This narrow focus limits the broader applicability of the findings to the entire Indian Railways ticketing ecosystem.

Temporal Constraints

The study's data collection period is limited and may not account for seasonal variations in ticket booking patterns, such as those observed during holiday or festival seasons.

Reliance on Self-Reported Data

The use of self-reported data from respondents introduces the possibility of bias, such as over- or under-reporting experiences due to personal perceptions or recall errors.

Technological Factors Not Examined

The research does not delve into technical aspects of booking inefficiencies, such as server performance, algorithm effectiveness, or AI-driven optimizations that influence operational efficiency.

Exclusion of Comparative International Analysis

The study does not compare the Indian train ticket booking system with international counterparts, which could provide additional context and benchmarks for improvement.

Platform-Specific Limitations

While the study evaluates multiple platforms, it does not include in-depth technical comparisons between the IRCTC official platforms and third-party apps, which could reveal platform-specific bottlenecks

7. FUTURE RESEARCH AGENDA

Exploring the Role of AI and Machine Learning in Booking Efficiency

Future studies should investigate how AI and machine learning can optimize operational efficiency in train ticket booking platforms. This includes developing predictive algorithms for Tatkal ticket availability, real-time demand forecasting, and dynamic quota management systems tailored for 2AC, 3AC, and 3E classes.

Comparative Analysis of Booking Systems Across Transport Modes

Comparative research is needed to assess the efficiency of railway ticket booking systems in India against other modes of transport (e.g., buses, flights) and international railway systems. Such studies can help identify innovative practices and adapt them to improve user satisfaction and operational performance in train ticketing.

Seasonal and Regional Variability in Booking Efficiency

Research should examine how booking efficiency varies across different regions and during peak seasons (e.g., holidays, festivals). This would provide insights into how the booking system can be tailored to address regional and temporal demand fluctuations more effectively.

Impact of Enhanced Digital Inclusion on Operational Efficiency

Future studies should explore how increasing digital literacy and access to online platforms across India impacts user behaviour and operational efficiency. This includes evaluating the role of government initiatives in improving access and addressing disparities in digital adoption.

Investigating the Scalability of Booking Platforms

Research should focus on the technical scalability of IRCTC and third-party platforms to handle surges in demand during Tatkal hours and peak seasons. This includes studying the infrastructure and backend processes required to support higher volumes of transactions.

Ethical and Social Implications of Operational Efficiency Improvements

Studies should explore how operational improvements in ticketing systems impact economically disadvantaged groups and frequent travellers. This includes evaluating policies to ensure equitable access and affordability for all user demographics, particularly during Tatkal booking.

Longitudinal Studies on User Satisfaction Trends

Conducting longitudinal research to track changes in user satisfaction over time as new features and optimizations are introduced in booking systems. These studies can assess whether implemented changes have a sustained positive impact on user experiences.

Adopting International Best Practices in Ticketing Systems

Future research should analyse best practices in ticketing systems worldwide, particularly in countries with high-speed rail or similar operational challenges. These insights can guide the development of next-generation solutions for the Indian railway ticketing ecosystem.

These areas of exploration will contribute to a deeper understanding of operational efficiency in train ticket booking, providing actionable insights for technological, strategic, and policy-level enhancements.

8. DECLARATION

I, Aswin KP with Ajith Krishnan G & Jaladi Sai Sindhuri, hereby confirm that the manuscript titled "Optimizing Operational Efficiency in Train Ticket Booking Systems: A Comparative Analysis Across 2AC, 3AC, 3E and Tatkal Services" authored by Aswin KP, Ajith Krishnan and Jaladi Sai Sindhuri has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to the International Management Perspective Conference 2025 (IMPeC-25)

I/we declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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TRACK 5: INFORMATION SYSTEM MANAGEMENT

27

SALU: An AI− Augmented Smart Digital Assistant for Life and Uttam Heath to Enhance Rural Healthcare

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ABSTRACT

The healthcare system in rural areas of middle—and low-income countries faces multiple challenges. Shortages of doctors and their limited time, lead to insufficient explanations about diseases, medical test reports analysis, and post-treatment guidance- nutrition and dietary suggestions. Some patients are forced to go to private healthcare but do not fully understand the services they access, as they lack adequate information and health literacy. The language barrier worsens the situation, as most of the healthcare materials are written in English. Thus, regional language-speaking individuals cannot get the necessary materials. This communication gap, coupled with the inability to engage the right healthcare providers, causes many people to have delayed treatment and poor health outcomes. Apart from these, several individual doctors do not have websites to help them connect with people; people only connect with them through word-of-mouth methods. New generation technologies like artificial intelligence, natural language processing, digital assistants, Internet of Things, and 5T have been transforming many sectors since Industry 4.0 was introduced, however, these developments remain grossly lacking in rural health care. This motivates us to propose SALU- an AI-augmented bot, a digital assistant for rural residents that supplies reliable medical information before/after examinations and diagnoses. We developed the but on a React Native Expo framework for the front end and Rasa and Flask as the back end, with machine learning and natural language processing techniques for health data analysis and conversation.

Keywords: Healthcare 5.0, Digital Healthcare, Human-AI collaboration, Digital Assistant, Machine Learning

1. INTRODUCTION

In the Industry 4.0 era, several computing technologies have been developed and implemented such as Artificial Intelligence (AI), Big Data, Cyber-physical systems IoT, Natural language processing, and digital assistant. Industry 4.0's main vision is to transform manufacturing Industries(Jan et al., 2023a). Similar to Industry 4.0 an initiative was introduced in health care with the name Healthcare 4.0 (Detwal et al., 2024). Its vision is to implement this advanced computing technology to revolutionize healthcare and make healthcare smarter and more digitally advanced. However, digital healthcare initiatives for the rural sector particularly in developing countries particularly in India is still unexplored. Due to the traditional healthcare system, rural areas are suffering from many challenges. Here are the key challenges that rural people are facing:

1.1 Doctor-Patient Disparity:

Due to the higher population, and low finance, the healthcare in developing countries is unable to provide sufficient health experts to serve people. Specifically, in India, there are only about one million registered doctors are available to serve the 1.4 billion people. This lack of doctors is creating a significant gap in healthcare accessibility. Among these doctors, about 58 % serve urban people while only about 18.8% serve the rural population. This uneven distribution of doctors worsens the rural healthcare system. Due to this lack of doctors and a high number of patients, doctors are spending a very small amount of time around two to three minutes with each patient. With this limited time, doctors only can diagnose patients' conditions and are unable to provide proper health advice, test report explanations as well as nutritional advice, and diet plans.

1.2 Limited Access to Healthcare Information:

In rural areas, only some hospitals are providing their information through the website. Many individual doctors and health service providers do not have websites, and patients often do not explore these websites thoroughly. In addition, the information is in English languages. So, the language barrier is a big challenge for non-English speaking people to understand about the services. Further, for patients, especially in rural areas, there is no standardized process to choose the best doctor for consultation. Individual doctors who do not have an online presence rely on traditional advertising, such as posters, which can become outdated when the doctor relocates. This lack of consistent access to healthcare information further compounds the difficulties patients face in getting the care they need.

1.3 Gaps in Post-Treatment Care and Nutritional Guidance:

In rural areas, there is no specific health nutrition experts to assist people with their diet planning. Patients, only follow informal advice from other people. In addition, India is a

diverse country and foods in all states are different. There is not any A critical aspect of healthcare often overlooked is post-treatment nutritional guidance. Patients, particularly in rural India, are often unaware of the importance of optimized diet plans that consider their medical condition, body weight, and other health factors. As a result, they follow generalized dietary advice, which may not be beneficial for their recovery or long-term health. This lack of access to personalized nutrition plans further hinders the effectiveness of healthcare in the country.

1.4 The Lag in Healthcare Digitalization:

To improve and transform India's healthcare system, the digitalization journey began with AIIM New Delhi's collaboration with UIDAI and DeITY in 2015. They developed a digital health identification system for patients. It was the beginning of a larger Digital India campaign and its objective is to streamline patient care and monitor the overwhelming number of daily visitors. AIIMS in collaboration with TCS and NIC, proposed an e-hospital project, to handle appointments, registration, and follow-ups digitally. They also included other features such as developing patient-friendly infrastructures and specialized roles like Patient Care Coordinators and Nursing Informatics Specialists. By 2016, AIIMS emerged as India's first fully digital public hospital, setting a benchmark for digital health services nationwide(V.Srinivas, n.d.). Further, India introduced the Ayushman Bharat Digital Mission (ABDM) in 2021 with a mission of creating a secure, integrated digital health ecosystem that can emphasize personal health records, ensuring that each citizen's health data is accessible, interoperable, and under their control. This ambitious project introduced five key innovations designed to enhance the delivery and management of healthcare services across the nation. Despite government efforts to make India digitally advanced, still, the healthcare sector particularly in the rural sector has in to adopt this initiative.

1.5 Government ads. and awareness

In India, one of the significant challenges in promoting government healthcare programs, vaccination campaigns, and other health-related initiatives, especially in rural areas, lies in the methods of communication and awareness. While some information is conveyed through phone messages or word of mouth, these approaches are not always reliable or efficient, leading to gaps in public awareness. Additionally, posters displayed in hospitals often go unnoticed or are ignored by patients, contributing to a lack of engagement. These communication barriers hinder the effectiveness of health programs, making it difficult for people to stay informed and participate in essential health services.

1.6 Advancing in Technology and Industry 4.0:

Several advanced technologies have been introduced in the last decades. Artificial intelligence, machine learning, large language models, natural language processing (NLP), IoT, and digital assistants form the foundational pillars of Industry 4.0(Jan et al., 2023b). These technologies drive transformative advancements and connectivity across industries through automation and data-driven decision-making (Rosati et al., 2023).

1.7 Transitioning to Industry 5.0:

Now world is transiting from Industry 4.0 to Industry 5.0, from integrating computing technology for manufacturing and enhancing production and efficiency to generating trust in technology and making human-AI collaboration for human well-being. The Industry 5.0 objective is to put humans at the heart of technological advancement for their well-being. This transformation has more potential in healthcare as healthcare needs more trust, data privacy, and security. These Industry 5.0 ideas for hospital application are also known as healthcare 5.0. There are several challenges in Industry 4.0 for healthcare such as data privacy and black-box machine learning. By implementing explainable AI solutions, and privacy-preserving machine-learning techniques we can address these challenges and develop an effective healthcare system that puts society in the center. In addition, AI assistants have the potential to advance human-AI collaboration.

Our aim is to transform rural healthcare by creating an inclusive multilingual assistant human-oriented healthcare ecosystem using advanced state-of-the-art computing technology. Our proposed tool can address all the above-mentioned challenges from pre-medical-test analysis to the post-medical-dietary suggestion with local food, and telemedicine and awareness programs. The framework comprises several main components such as AI-assistant RASA, machine learning, NLP, Flask, and React. Figure 1, illustrates the key features of our proposed system; however, it is not limited.

Figure 1. Features of the proposed system: SALU: An AI−Augmented Smart Digital Assistant for Life and Uttam Heath to Enhance Rural Healthcare

2. EXISTING DIGITAL TECHNOLOGIES IN HEALTHCARE

Since the new industrial revolution Industry 4.0 (Elnadi & Abdallah, 2024), researchers have developed and implemented several innovative computing technologies to transform industry and human life, among these digital assistants, AI, IoT, and natural language processing stand out as key advancements (Adel, 2024).

Several digital health products serve patients and people in many ways. Babylon Health is a digital-first health service provider that unified an artificial intelligence-powered platform with virtual clinical operations for patients. With this platform, Patients can consult with healthcare professionals through their web and mobile applications (Ciesla, 2024). Doctors use the Ada-health app to fill in patient's signs, symptoms, and findings, providing a ranked list of probabilistic conditions (Foda et al., 2023). Another platform, Mayo Clinic Symptom Checker, is used to detect patient conditions such as COVID-19 and other cold- and flu-like symptoms, rash, pink eye, nausea and vomiting, wounds like cuts and scrapes, and other concerns (Chen et al., 2024). SophieBot assists sexually ill patients, the assistant is augmented with an artificial intelligence model (Tlhokomelo R.B. Monethi, n.d.). WebMD Symptom Check also includes many features from detecting health conditions, set medication reminders (Andreadis et al., 2024). Similarly, people use K Health, to connect with licensed medical providers virtually. K Health includes many medical experts from anxiety to UTIs, and prescribes medication to get you feeling better faster. On the other hand, Woebot Health, which people use for mental illness (Naik et al., 2024).

Another digital platform Sensely's avatar is a chatbot-based platform that assists insurance plan members and patients with the insurance services and healthcare resources they need With the Sensely app, patients can check symptoms and connect with nurses if necessary (Tu et al., 2024). Florence is a staffing app that connects temporary and permanent nurses & care assistants with open shifts and in addition, it provides educational training to nursing staff (Cullen et al., 2024). In the United States, HealthTap provides telehealth services to people via the web and health apps (Yin et al., 2019). A community and market intelligence platform Panda Health, connects hospitals and health systems with technology. Further, their system IT and digital health experts can exchange knowledge and insights to propel digital health advancement.

In the Industry 4.0 era, there are several technological transformations happened, artificial intelligence (AI), the Internet of Things (IoT), digital assistants, and natural language processing (NLP) have significantly transformed many sectors including manufacturing, aviation, and agriculture. However, their application in healthcare centered on disease prediction and diagnosis. However, AI-augmented digital assistants in healthcare that assist patients and families are still unexplored. Particularly, in low- and medium-sized rural areas, a unified digital healthcare system consisting of digital assistants, telemedicine, and government health awareness initiatives is latency-bound.

3. PROPOSED SYSTEM

Our aim is to empower rural patients and families with a clear understanding of their health. With our proposed system, they can begin by inputting their symptoms. After which the bot will reaccommodate a diagnostic test. Then after inputting again the diagnostics test report, it detects potential disease, and it can explain its causes, stages, etc. so that patients can search for a doctor and schedule an appointment. After meeting with the doctor, the bot can help with nutrition and diet planning. The patients can compare doctors, can search best doctors and services. Further, we aim to include Ayushman Bharat Digital Mission (ABDM) so that our system can get information from third parties about patents test report so that in the future our system can analyze their data automatically using patients.

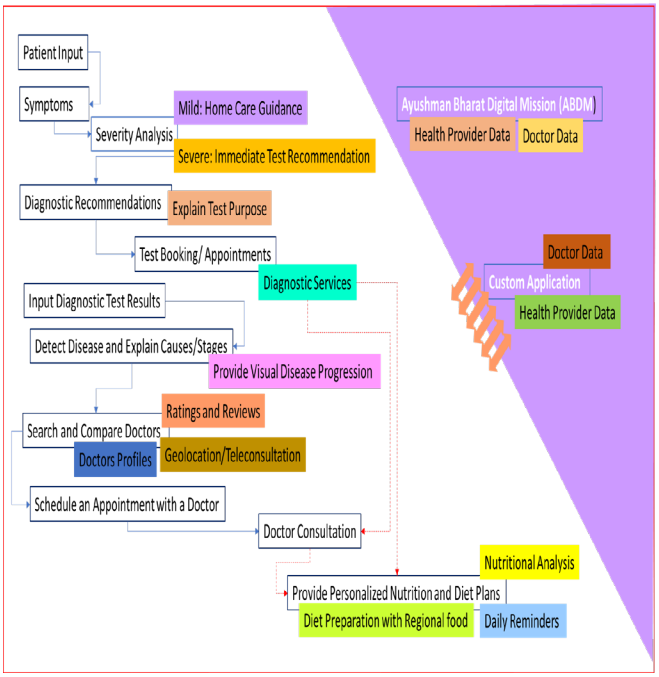

Figure 2. A basic workflow of how our proposed SALU system assists patients in inputting symptoms to the post-treatment

Our proposed framework consists mainly of three features. **1. SALU** – An AI-augmented smart digital assistant bot: in this feature, users can interact with an AI-augmented chatbot named Salu, who will assist patients and families with doctors and health service information, test report analysis, general health information and local diet suggestions and more. **2. Arogya Samvad (telemedicine)**: It is a telemedicine feature with which users can search for doctors

and schedule meetings and they can connect. **3. Government Awareness Interface**: We designed a screen in which users can check timely updates on public health initiatives and other government-led health programs such as vaccination. To design this proposed system, we use several key components as illustrated in Table 1. In the current version, we used the four most critical software components Rasa chatbot development tool, machine learning, React Native Expo to create mobile app development, and Django to connect doctors and patients.

TABLE 1: Key Components for SALU

Component	Library/Program Used	Description
User Interface (UI) SALU Doctor Telemedicine Screen Government Dashboard	React Native (Expo)	**Expo** is an open-source platform, to creates universal **native** Android, iOS, and web apps using JavaScript and **React**. It interacts with the bot through chat functionality.
Routing and Navigation	Expo Router	It manages page transitions, such as from login to the SALU screen to telemedicine
SALU chat Screen	React Native (EXPO) component	Handle conversations between users and Salu.
Natural Language Understanding (NLU)	Rasa NLU	For SALU, in the backend, it handles user inputs, selects intents (e.g., salu_greet), and if needed extracts entities.
Dialogue Management	Rasa Core	Responsible for the state and flow of the conversation. It uses policies, rules, and machine learning to manage flow and prediction.
Tracker Store	Rasa Tracker Store	Maintains the conversation state, including events and slot information.
Custom Actions	Rasa SDK	Executes external tasks like calling machine learning models for predictions or fetching database entries.
Machine Learning Model	Scikit-learn/AutoML	Trained logistic regression model for predicting diabetes based on user-provided health data.
Data Preprocessing	Pandas, Scikit-learn	Converts categorical variables into the numerical format, normalizes data, and prepares it for prediction.
Database	SQLite/MongoDB	Stores user profiles, health history, or session data for personalization.
API Integration	REST API	Connects external healthcare systems or third-party services for health tips or real-time updates.
Deployment Framework	Docker	Containerizes the Rasa server, action server, and other backend services for consistent deployment.
Action Server	Django(Python)	Hosts custom actions and integrates the machine learning model into the Rasa framework.
Monitoring and Analytics	Grafana/Matplotlib	Tracks user interaction data and performance metrics for system improvement.
Version Control	Git/GitHub	Manages codebase versions and collaborative development.
Health Information API	Custom Flask API	Provides real-time health statistics and advice to users.
Multilingual Support	Rasa NLU (Languages)	Processes and responds to user queries in regional languages like Hindi or Odia.
Error Handling	Rasa Fallback Actions	Handles unrecognized user queries or system errors gracefully by providing fallback responses.

3.1 Frontend

We have developed all apps using React Native with Expo. In the current version, the user interface is structured into four main screens. The login point is the gateway to enter SALU. At the same time, the user can quickly navigate to other critical features such as the telemedicine screen and, the health awareness screen directly from the Login screen. We implanted an Expo router for smooth navigation between screens. He first version of SALU app for user is shown in the figure

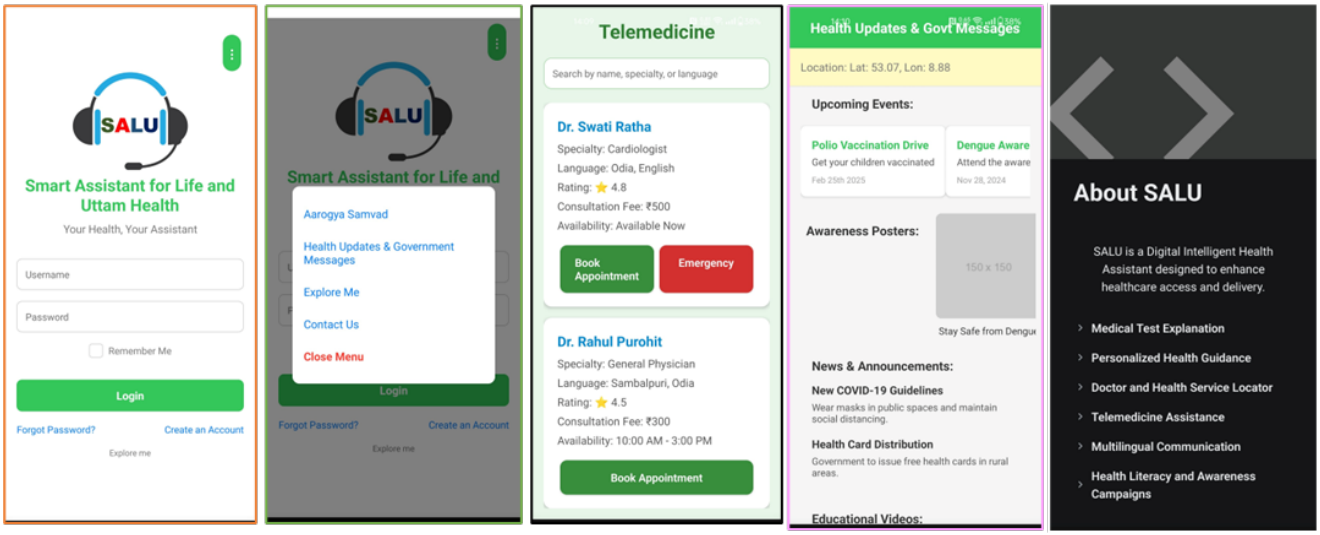

Figure 3: User Interface Screens of the SALU App for Patients

Similarly, for the telemedicine app for doctors, and to provide input from the government officials we have used React Native with Expo. The doctor's app has the feature to log in, view appointments, profile management and registration, financial status, and availability settings. Some screen of the telemedicine app is shown in Figure 4.

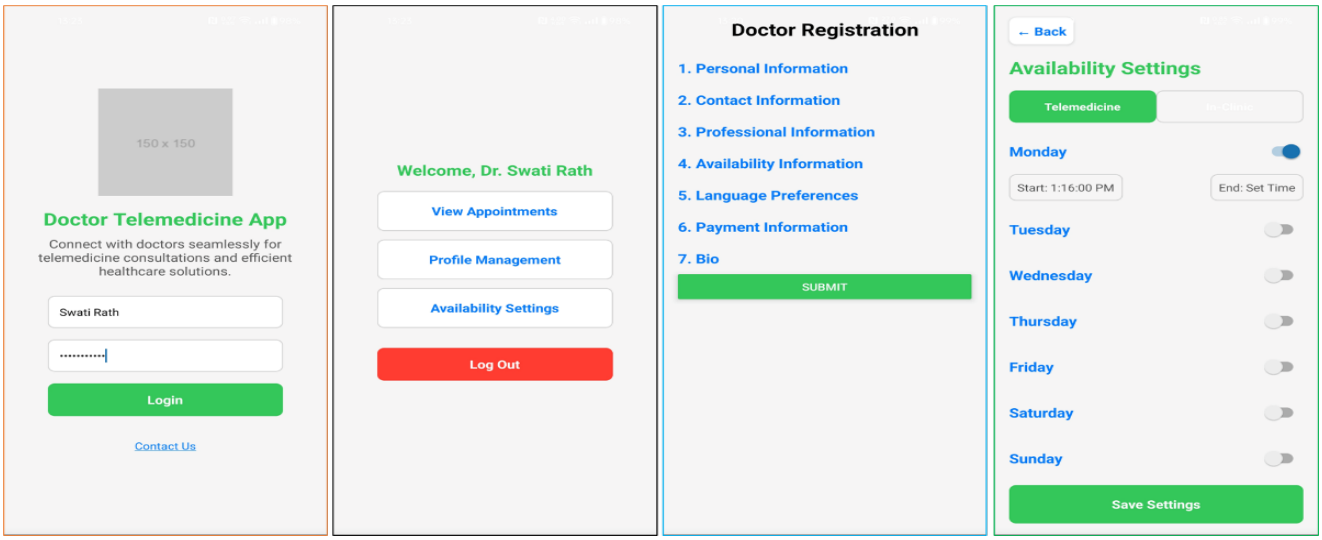

Figure 4. User Interface Screens of the Arogya Sambad (Doctor Telemedicine App) App for doctors

Through Arogya Sambad application doctors can register their details and can manage the appointments. In addition to this, government employees who are responsible for health awareness can also provide inputs

3.2 Backend

The backend of our proposed frameworks consists of RASA components, A Django that communicates between users to telemedicine, a government awareness app, and a data database. Django helps in collecting information from the registration of doctors or health service providers from the government or any private.

3.2.1 RASA for SALU

The backend of the AI-augmented SALU bot is designed to handle multiple health-related intents. The workflow starts from user input and ends with a bot response. Using the SALU interface user sends input as text or voice to the RASA components. If it is voice, we implemented the React Speech-to-text library which translates the text. Then the NLU component understands the user text and classifies the

intent and if needed it extracts necessary entities. Following this, the dialogue management component of RASA collects the information and manages whether it sends a response or needs custom action. Depending upon the intent it sends a response or it can trigger to custom action. The custom action can get information from the database and it is also connected with trained ML models. The architecture for SALU is illustrated in Figure 5.

3.3 DJANGO for Telemedicine and Government Programmes

We developed the Arogya sambad (telemedicine) components using Django framework. Django act as central farmwork that connect the patient's app with the doctor The backend architecture of the telemedicine system, developed using Django, serves as the central framework, ensuring seamless data flow and efficient communication between the React Native-based user and doctor apps built with Expo. The PostgreSQL database is implemented to manage relational data, it will store structured data including user and doctor profiles, appointments, and payment records. In the backend, AI models on multiple levels can improve functionality. We will implement Natural Language Processing (NLP) to enhance in search for doctors and personalized doctor suggestions. Natural Language Processing (NLP) models process user queries to facilitate accurate search results and personalized doctor recommendations. With AI, the telemedicine component can optimize doctor availability, recommend appointment slots, and prioritize emergency cases.

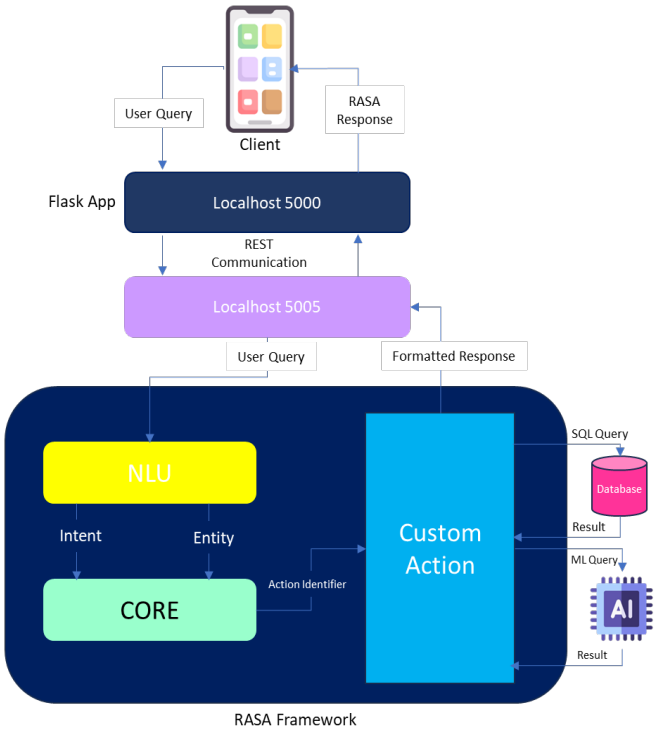

Figure 5. Rasa-based SALU architecture

The virtual meeting between patients and doctors is supported via WebSocket-based protocols, which enables secure, low-latency audio, video, and chat sessions. We use Razorpay for payment through Django with a AI augmented fraud detection system so that it can monitor and prevent unauthorized activities. We used RESTful APIs built by Django Rest Framework (DRF) for data synchronization across the apps and it ensures secure and efficient communication. A workflow for both the user and doctor app for telemedicine is shown in figure 6.

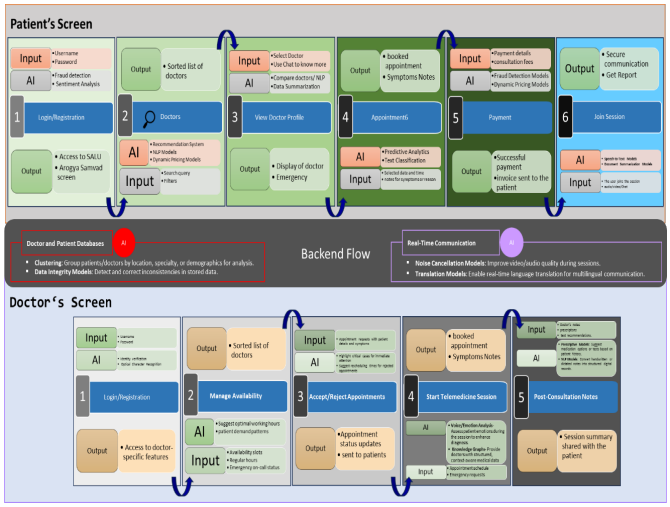

Figure 6. Arogya Sambad (telemedicine) workflow for both user and doctor

3.3.1 Dataset and Machine Learning

Medical Test Data: With the medical test data**,** our objective is to train the best machine-learning models with optimized hyperparameters. In addition, we use the dataset to explain patients' reports.

Nutritional Data: With the patient's condition and patients' data, the Machine Learning models can train to estimate the nutritional values they need and whether the patient is malnourished or not so that they can follow up with a Nutritionist or with our Salu bot.

Food Data: In this system, we will collect all food data with regional features and want to train a machine learning model so that Salu can prepare a diet plan according with regional foods.

Doctor's/ Health Providers Data: The data used in the Salu Bot system is collected through a user-friendly interface where doctors and healthcare providers can register and submit relevant information. This data includes key details such as the doctors' **location**, **years of experience**, **areas of expertise**, **availability**, and **educational background**. These inputs ensure that the system provides a comprehensive and accurate profile of healthcare professionals, making it easier for patients to select the right doctor for their needs. The

platform is designed to collect all the necessary information a patient might require, including specific areas of specialization, certifications, and consultation hours, facilitating informed decision-making. The bot then utilizes this structured data to match patients with suitable healthcare providers based on their medical conditions and preferences. For now, we have trained the fine-tuned model with a dummy dataset.

Before the implementation of ML models in our system. We explore auto-ML techniques for all the datasets using the Pycaret library so that we can use the best ML model with optimized process parameters.

Slowly, many health providers are now connecting with the Ayushman Bharat Digital Mission (ABDM. So, we aim to integrate the Ayushman Bharat Digital Mission (ABDM) database to our proposed system in the future, so that stakeholders can share data inside the system.

4. RESULT AND DISCUSSION

Currently, SALU has three modules: the first General Health Queries module, the pre-medical test analysis module, and the post-medical nutritional analysis module. It aims to add more modules in the future. With the General Health Queries (GHQ) module, our objective is to address common health-related questions; it is a chit-chat conversation. We developed around 200 Intents, such as greet, ask symptoms, what_is_carbohydrate, what_urine_test, etc. We trained each intent with 40-70 examples of phrases per intent. The phrases are created manually. For example, the "what_urine_test" consists of several user inputs such as What does a routine urinalysis involve? What does a standard urine test check for? etc.

Then we train our RASA with 17 categories of diseases for symptoms, to train RASA we develop dummy training data.

We developed several machine-learning models using urine dipstick test datasets to predict diseases such as chronic kidney disease (CKD), Urinary Tract Infections (UTIs), Diabetes Mellitus, Liver Diseases, and more. We collected the urinary data from several sources such as Kaggle, UCI, and Indian medical data. The main input parameters include patient data such as age sex, weight height, protein, glucose, pH, nitrites, and more. We trained about 14 ML Models to detect diseases with different categories such as different ages, with sexes. With weight, pregnancy, infant, etc. Similarly, we also trained several machine learning models for Nutritional calculation and food recommendation. In addition, we serialise the models using Joblib and implemented the models in our RASA custom action using RASA SDK.

For Arogya Sambad (telemedicine) components we implemented the Django framework and used a dummy data set of 500 doctor's profiles. We tested the main features to validate its performance and integration. We successfully set up the PostgreSQL database to manage user and doctor profile data, appointments, and payment records. Further, NLP is also trained to enhance doctor search and personalized recommendations. The tool accurately processes user queries and returns accurate results. The WebSocktet-based protocol is working properly to simulate secure, low-latency online meetings, enabling seamless video, audio, and chat interactions. In the payment section, we set up an initial Razorpay API for testing. We will also use an AI-driven fraud detection mechanism to detect anomalies in dummy transactions. However, the initial version works properly we need more tests before implementation in the real application. Yet we have not trained the predictive model to optimize appointment scheduling.

5. CONCLUSION AND FUTURE WORK

It is our first attempt to propose digital assistants for rural people to bridge the healthcare challenges. Currently, it is trained with a small amount of data; to implement it in the real world it requires more real data with evidence and discussion before assistant designers and decision-makers can use them effectively. Currently, we trained our digital assistant with around 60 intents in three categories, and all these intents working properly. For some intents such as for diet suggestions we used machine learning models, and our digital assistant worked accurately.

We aim to investigate the benefits through experiments *with real people* to determine factors determining digital assistants' use in healthcare. These factors are concepts, such as trust in AI systems, data privacy, impacts on teams and individuals, training, and education. Besides, we will determine the **disadvantages and limitations** of using digital assistants in healthcare. Such as the inherent risk that may poster boys and third parties lose their *autonomy* when assistants influence or take over their tasks. People and service providers always essential and must be participate in designing the system as they are essential.

When digital assistants contribute substantial work in healthcare, people become *dependent*. Hence, our system must work reliably – sometimes even in extreme situations, such as a blackout or network breakdown. We will advance the human-in-the-loop design so that, it can be replaceable by a human to process when an assistant is unavailable.

6. DECLARATION

I, Subrat Kumar Dang, hereby confirm that the manuscript titled " SALU: An AI− Augmented Smart Digital Assistant for Life and Uttam Heath to Enhance Rural Healthcare" authored by [Subrat Kumar Dang, Satabdhi Subhadarsini Baghar and Manas Ranjan Baghar], has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to the *International Management Perspective Conference 2025 (IMPeC-25)*.

We declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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Leveraging Artificial Intelligence for Business Analytics: A Comprehensive Review

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ABSTRACT

Artificial Intelligence (AI) has transformed business an- alytics by enabling organizations to derive actionable in- sights and advice from extensive and complex datasets. This paper offers a comprehensive survey of AI's role in generat- ing insights and guidance for business analytics. It reviews the evolution of AI technologies, explores various AI tech- niques used in business analytics, and analyzes their ap- plications through real-world case studies. Additionally, it addresses the challenges of bias in leveraging AI-driven in- sights and advice for decision-making processes. Further- more, the paper includes a survey conducted among pro- fessionals, revealing current usage patterns, preferred AI tools, perceived accuracy & trust in AI-generated insights, and key challenges faced in utilizing AI for business analyt- ics. These practical insights provide a grounded perspec- tive on the integration and impact of AI in modern business contexts. The primary contributions of this survey encom- pass a thorough review of existing literature, examination of AI techniques, analysis of applications and case studies, identification of challenges, and suggestions for future di- rections.

1. INTRODUCTION

The integration of Artificial Intelligence (AI) with busi- ness analytics [1, 4, 5] has revolutionized how organiza- tions extract value from their data, enabling the genera- tion of actionable insights and advice to drive strategic de- cisionmaking. In recent years, AI technologies have wit- nessed remarkable advancements, facilitating the analysis of vast and complex datasets at unprecedented speed and scale. According to the executive survey by NewVantage Partners [6], 91% of top companies worldwide maintain a consistent commitment to investing in AI, highlighting the importance of harnessing this cutting-edge technology for continual growth and advancement. This intersection of AI

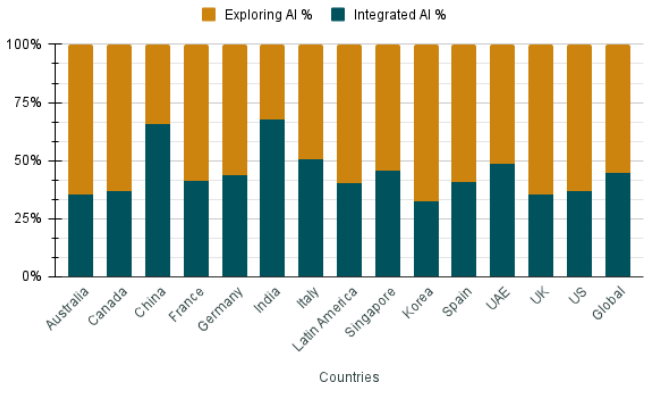


Figure 1. AI adoption rates around the world [6]

and business analytics has not only transformed traditional approaches to data analysis but has also opened up new avenues for innovation and growth across industries. AI technologies [10, 14] like machine learning, deep learning, augmented analytics and predictive modeling has indeed been transformative. These tools have shifted from being mere novelties to becoming critical components of organi- zational strategies across various industries. By harnessing the power of AI, organizations can extract valuable insights from vast datasets and make informed decisions to drive growth and innovation. Existing research in the field of AI for business analytics [9, 10] has explored various tech- niques, methodologies, and applications, shedding light on the potential of AI to enhance decision support systems, op- timize processes, and uncover hidden patterns within data.

These studies have demonstrated the efficacy of machine learning algorithms, deep learning models, natural language processing techniques, and predictive analytics in generat- ing insights and recommendations that empower organiza- tions to stay competitive in today's data-driven economy. However, while existing literature [7, 16] provides valuable insights into the capabilities and limitations of AI in busi- ness analytics, there remains a need for a comprehensive survey that synthesizes the current state of research, iden- tifies emerging trends and challenges, and outlines future directions for leveraging AI in decision-making processes. This paper aims to address this gap by presenting a thor- ough review of the role of AI in generating insights and ad- vice for business analytics, encompassing both theoretical frameworks and practical applications. The key contribu- tions of this survey.

1. Comprehensive Review: This survey offers a compre- hensive overview of the evolution of AI technologies in the context of business analytics, tracing their de- velopment from theoretical concepts to practical tools for data-driven decision-making. By synthesizing ex- isting literature, it provides a holistic understanding of the diverse techniques and methodologies employed in AI-driven insights generation and advice provision.

2. Examination of AI Techniques: The survey explores a wide range of AI techniques utilized in business analytics, including machine learning, deep learning, natural language processing, and predictive analytics. It examines how these techniques are applied to preprocess data, extract meaningful patterns, and generate actionable recommendations, thereby facilitating informed decision-making processes.

3. Analysis of Applications and Case Studies: Through the presentation of real-world applications and case studies, this survey illustrates the practical implica- tions of AI-driven insights and advice across vari- ous industries. From customer segmentation and dy- namic pricing strategies to risk management and sup- ply chain optimization, it showcases how organiza- tions are leveraging AI to gain competitive advantages and drive business success.

4. Market Survey: We conducted a survey to gather insights on the practical application and perception of AI tools in business analytics. It highlights the practical considerations and challenges faced by professionals in adopting AI tools for business analytics, providing a real-world context to the comprehensive review presented in this paper.

5. Identification of Challenges and future directions: By discussing the challenges and limitations associated with AI in business analytics, this survey highlights the importance of addressing issues such as data privacy, algorithm bias, and interpretability of AI-generated insights. Furthermore, it identifies opportunities for future research and innovation, including the development of ethical guidelines and regulatory frameworks to ensure the responsible use of AI technologies.

In summary, this survey paper contributes to the existing body of knowledge by offering a comprehensive examination of the role of AI in generating insights and advice for business analytics. By synthesizing current research, identifying key trends and challenges, and outlining future directions, it provides a roadmap for leveraging AI technologies to drive innovation and excellence in decision-making processes across industries.

2. EVOLUTION OF AI IN BUSINESS ANALYTICS

The evolution of AI technologies in business analytics has been marked by significant advancements and mile- stones over the years. Here is a brief overview of the evolu- tion of AI technologies:

2.1 Traditional Approaches w/o AI

1. Rule-Based Systems: In the early stages of AI development, rule-based systems [17] were prevalent. These systems relied on predefined rules and logic to make decisions and perform tasks. While effective for simple tasks, they lacked the ability to adapt and learn from data.

2. Expert Systems: The development of expert systems [8] in the 1980s marked a significant advancement in AI. Expert systems utilized knowledge bases and in- ference engines to mimic human expertise in specific domains. They were used for tasks such as diagnosis, decision-making, and problem-solving.

2.2 Current Approaches with AI

The evolution of AI technologies in business analytics has paved the way for organizations to leverage data-driven insights, enhance decision-making processes, and drive innovation across industries. AI techniques encompass a variety of methods and algorithms used to enable machines to simulate human intelligence and perform tasks that typically require human cognition. Some common AI techniques utilized in business analytics include:

1. Machine Learning: The resurgence of AI in the 21st century brought a renewed focus on machine learning [2] techniques. Machine learning algorithms enabled systems to learn from data, identify patterns, and make predictions without explicit programming. This led to advancements in areas such as predictive analytics and pattern recognition. Machine learning algorithms include supervised learning, unsupervised learning, and reinforcement learning.

2. Deep Learning: Deep learning [11], a subset of machine learning, gained prominence with the rise of neural networks and deep neural architectures. A subset of AI that enables systems to learn from data and im- prove their performance without being explicitly programmed. A type of machine learning that uses neu- ral networks with multiple layers to extract high-level features from data.

   Deep learning is particularly ef- fective for tasks such as image and speech recogni- tion. The evolution of deep learning in AI may lead to the emergence of autonomous decision-making sys- tems that can make decisions without human interven- tion. These systems leverage real-time data, predictive analytics, and prescriptive algorithms to automate rou- tine decisions and free up human resources for strate- gic tasks. Deep learning models with multiple layers became instrumental in tasks such as image recogni- tion, natural language processing, and speech recogni- tion.

3. Augmented Analytics: Augmented analytics [15], which integrates AI and machine learning capabil- ities into analytics tools, is becoming more preva- lent. These tools empower business users with ad- vanced analytics capabilities, enabling them to derive insights, make predictions, and drive data-driven deci- sions without extensive technical expertise.

4. Natural Language Processing (NLP): NLP [3] focuses on enabling machines to understand, interpret, and generate human language. It has become an indispensable tool for businesses seeking to extract actionable insights from vast amounts of unstructured text data. It is used for tasks such as sentiment analysis, language translation, and chatbots. Through techniques such as sentiment analysis, text classification, and named en- tity recognition, organizations can harness the power of NLP to understand customer feedback, categorize data, and identify key entities within text. Addition- ally, NLP enables businesses to uncover trends and topics through topic modeling, summarize large doc- uments for quick comprehension, and even generate human-like text for various purposes. Moreover, NLP facilitates language translation, automates customer support through chatbots, and aids in competitive anal- ysis by parsing public textual data sources. By lever- aging NLP effectively, businesses can streamline oper- ations, improve decision-making processes, and gain a competitive edge in today's data-driven landscape.

5. Predictive and Prescriptive Analytics: Predictive analytics [12] involves using statistical algorithms and machine learning techniques to forecast future outcomes based on historical data. It helps organizations make informed decisions and anticipate trends. Prescrip- tive analytics [13] goes beyond predicting outcomes to recommend actions that can optimize a particular outcome. It provides decision-makers with actionable insights to improve processes and strategies.

These AI techniques play a crucial role in generating insights, making predictions, and providing recommendations for businesses to enhance decision-making processes and drive strategic outcomes.

3. METHODOLOGY

3.1 Research Approach

This study adopts a systematic literature review approach to gather and analyze relevant research articles, conference papers, books, and reports related to the role of Artificial Intelligence (AI) in generating insights and advice for busi- ness analytics. Both academic databases and grey literature sources are utilized to ensure comprehensive coverage of the topic.

3.2 Search Strategy

A comprehensive search strategy is developed using a combination of keywords and Boolean operators to retrieve relevant literature. Keywords include "Artificial Intelli- gence", "Business Analytics", "Insights Generation", "Ad- vice Generation", "Machine Learning", "Deep Learning", "Predictive Analytics", and "Decision Support". The search is conducted across multiple databases such as PubMed, IEEE Xplore, ACM Digital Library, Google Scholar, and others.

3.3 Inclusion and Exclusion Criteria

Articles are included in the review if they focus on the application of AI techniques for insights generation and ad- vice provision in business analytics. Both theoretical and empirical studies are considered, encompassing various in- dustries and domains. Exclusion criteria include articles not written in English, duplicates, and studies not directly re- lated to the topic.

3.4 Screening and Selection

Initially, titles and abstracts of retrieved articles are screened to assess their relevance to the research topic. Sub- sequently, full-text articles meeting the inclusion criteria are thoroughly reviewed and selected for further analysis. The screening process is conducted independently by two re- viewers to ensure consistency and minimize bias.

3.5 Data Extraction

Data extraction is performed to capture relevant informa- tion from selected articles, including author(s), publication year, research objectives, AI techniques employed, appli- cations, case studies, challenges, and future directions. A standardized data extraction form is developed to facilitate systematic data collection.

3.6 Synthesis and Analysis

The synthesized data are analyzed using thematic analysis to identify recurring themes, patterns, and trends across the literature. Key findings related to AI techniques, appli- cations, challenges, and opportunities are summarized and synthesized into coherent narratives. The analysis process involves iterative discussions among the research team to ensure robustness and reliability.

3.7 Quality Assessment and Reporting

The quality of selected studies is assessed using established criteria such as research methodology, relevance, rigor, and contribution to the field. Studies deemed to have methodological flaws or low relevance are critically evalu- ated, and their impact on the overall findings is considered during interpretation. The findings of the literature review are reported following the guidelines of academic research papers, including clear and concise presentation of results, discussion of implications, and identification of gaps for fu- ture research. Visual aids such as tables, figures, and diagrams are utilized to enhance readability and facilitate un- derstanding of complex concepts.

By following this systematic methodology, this study aims to provide a rigorous and comprehensive review of the role of

AI in generating insights and advice for business an- alytics, contributing to the existing body of knowledge and informing future research and practice in the field.

4. STATISTICAL DATA AND NUMERICAL SURVEYS

These statistical data and numerical surveys provide insights into the current landscape of AI adoption, market trends, the impact on decision-making, adoption of AI techniques, challenges, and the business impact of AI in business analytics. Integrating these findings into the review paper can enhance its credibility and provide valuable context for readers.

4.1 Adoption of AI in Business Analytics

1. According to a survey conducted by Gartner in 2021, 82% of organizations have reported that they have started to implement AI in some form within their business operations.

2. A report by McKinsey Global Institute indicates that AI adoption has the potential to create between $3.5 trillion and $5.8 trillion in value annually across nine business functions, including marketing, sales, and supply chain management.

4.2 Growth of AI Market in Business Analytics

1. The global AI market size in business analytics was valued at $7.96 billion in 2020 and is projected to reach $69.1 billion by 2027, with a compound annual growth rate (CAGR) of 40.2% during the forecast pe- riod (source: Grand View Research).

2. A survey conducted by IDC forecasts that worldwide spending on AI systems for business analytics will grow to $97.9 billion in 2023, reflecting a five-year CAGR of 28.4%.

4.3 Impact of AI on Decision-Making

1. A survey conducted by PwC found that 63% of business leaders believe that AI will have a significant impact on decision-making processes in their organizations.

2. According to a study by MIT Sloan Management Review, 80% of respondents reported that AI has improved their ability to make predictions and decisions.

4.4 Challenges in AI Implementation

1. According to a survey by KPMG, 45% of organizations identified data quality and data integration as the biggest challenge in implementing AI for business analytics.

2. A study by Forrester Research found that 37% of organizations struggle with a lack of skilled personnel to implement and manage AI systems effectively.

4.5 ROI and Business Impact

1. An analysis by McKinsey & Company revealed that companies that extensively use AI for business analytics experienced a 5% increase in profit margins and a 5% increase in revenue on average.

2. A survey conducted by Accenture found that 83% of executives reported that AI has already delivered business outcomes beyond their expectations.

These statistical data and numerical surveys provide insights into the current landscape of AI adoption, market trends, the impact on decision-making, adoption of AI techniques, challenges, and the business impact of AI in business analytics. Integrating these findings into the review paper can enhance its credibility and provide valuable context for readers.

5. MARKET SURVEY

We conducted a market survey with approximately 54 participants, consisting of equal split of males and females across various age groups. The survey revealed a higher percentage of participants in the 19 to 35 age range. The respondents come from diverse educational backgrounds, highlighting the widespread use of AI tools among professionals with varying qualifications. The statistical data from the survey offer valuable insights into the perceptions of AI tools for business analytics. The survey design, demographics, and key findings from the collected data are summarized below:

- **Age Distribution**: Out of a total of 54 respondents, the age distribution is as follows:
  Under 18: This group comprises 7.4% of the respondents.
  19 to 35: This age range includes 87% of the respondents, representing the largest segment.
  36 to 55: Respondents in this category make up to 5.6% of the total respondents.

- **Gender Distribution**: Our survey encompassed a to- tal of 54 respondents, consisting of 22 males and 32 females. This results in a gender distribution where males represent 40.7% and females represents 59.3% of the participants.

- **Education Distribution:**

  Out of a total of 54 respondents, the distribution of educational background is as follows:

  High School or Equivalent: 5.6% of respondents

- **Bachelor's Degree:** 46.3% of respondents Master's Degree: 44.4% of respondents Doctorate: 3.7% of respondents

5.1 Usage of AI tools

The survey reveals insightful patterns in the usage of AI tools based on gender, age, and education level:

- **Gender-Wise Usage:** Both male and female respon- dents frequently use AI tools, with a notable prefer- ence for weekly usage. Daily usage rates are 30.3% for males and 30.8% for females. Weekly usage is more common among males at 57.6%, compared to 43.6% for females. Females tend to use AI tools monthly more often than males, while both genders show simi- lar rates of rare usage. We show this data visually for comparison in Figure 2(a).
- **Age-Wise Usage:** Respondents under 18 use AI tools daily and weekly at equal rates of 28.6%, with no us- age reported for monthly or rarely. The 19 to 35 age group shows a preference for daily use at 36.4% and weekly use at 52.2%. Those aged 36 to 55 primar- ily use AI tools weekly (66.7%) and monthly (33.3%), with no daily use. There are no respondents from the 56 and above age group. Younger users (under 18 and 19 to 35) generally prefer daily usage, while older re- spondents (36 to 55) lean towards weekly use. We show this data visually for comparison in Figure 2(b).
- **Education-Wise Usage:** Respondents with a high school education use AI tools only weekly (100%). Those with a Bachelor's degree use AI tools daily 30.6% of the time and weekly 54.4%. Master's de- gree holders show the highest daily usage at 41.4%, with 48.6% using them weekly. Doctorate holders use AI tools daily 25.0% of the time and weekly 50.0%. Higher education levels, particularly Master's degrees, are associated with more frequent daily usage of AI tools. We show this data visually for comparison in Figure 2(c).

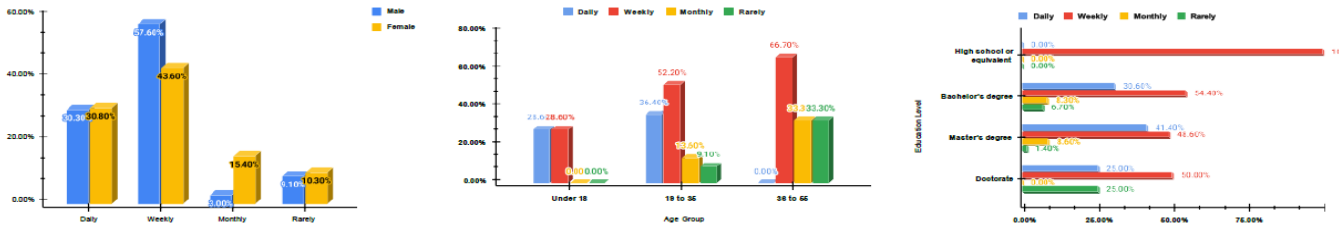
Overall, the key findings from this survey indicate that males and females both favor weekly usage of AI tools, younger age groups prefer daily usage, and higher educa- tion levels, especially Master's degrees, are associated with more frequent daily usage of AI tools.

5.2 Preferred AI Tools for Business Analytics

The survey reveals respondents' preferences for AI tools in business analytics, with ChatGPT emerging as the most favored tool across various demographics.

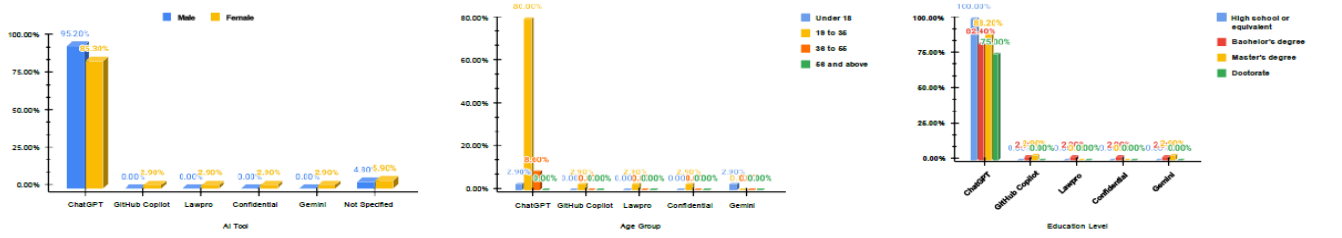
- **Gender Distribution:** Among the respondents, Chat- GPT is the dominant AI tool for both males (95.2%) and females (85.3%). This indicates a strong prefer- ence for ChatGPT across genders. In contrast, tools like GitHub Copilot, Lawpro, Confidential, and Gem- ini are used by only a small percentage of females, with negligible usage reported among males. This high- lights that while ChatGPT is widely accepted, other AI tools have not achieved similar levels of popularity. We show this data visually for comparison in Figure 3(a).

- **Age Distribution:** The preference for ChatGPT is most pronounced among individuals aged 19 to 35, who use it 80.0% of the time. This age group demonstrates the highest engagement with ChatGPT, reflecting its relevance and appeal to a younger demographic. In comparison, the usage of ChatGPT drops significantly among those aged 36 to 55 (8.6%) and is non-existent among those aged 56 and above. This suggests that ChatGPT is less favored by older age groups, possibly due to varying needs or familiarity with technology. We show this data visually for comparison in Figure 3(b).



(a) Gender wise (b) Age wise (c) Education wise

Figure 2. Usage of AI tools



(a) Gender wise (b) Age wise (c) Education wise

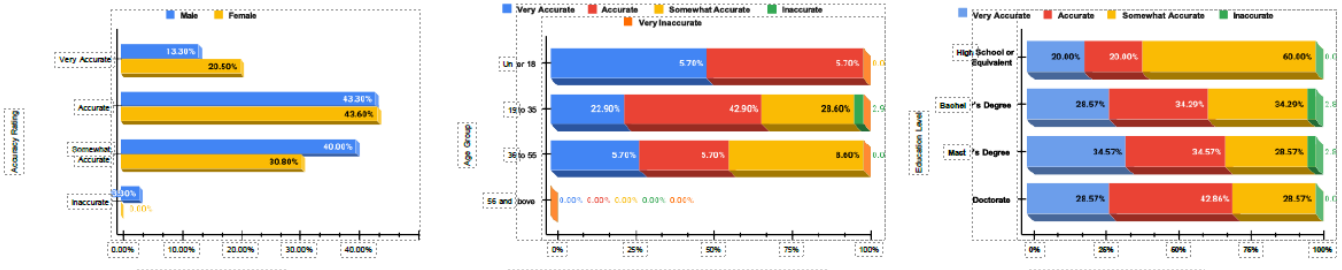
Figure 3. Preferred AI Tools

used by 100.0%, indicating its broad accessibility. For those with a bachelor's degree, 82.4% prefer ChatGPT, while 88.2% of respondents with a master's degree and 75.0% with a doctorate also favor it. Other tools such as GitHub Copilot, Lawpro, Confidential, and Gem- ini have minimal adoption rates across all education levels. This suggests that ChatGPT's appeal is con- sistent regardless of educational background, although its popularity is slightly lower among those with ad- vanced degrees. We show this data visually for com- parison in Figure 3(c).

5.3 *Accuracy of AI Tools*

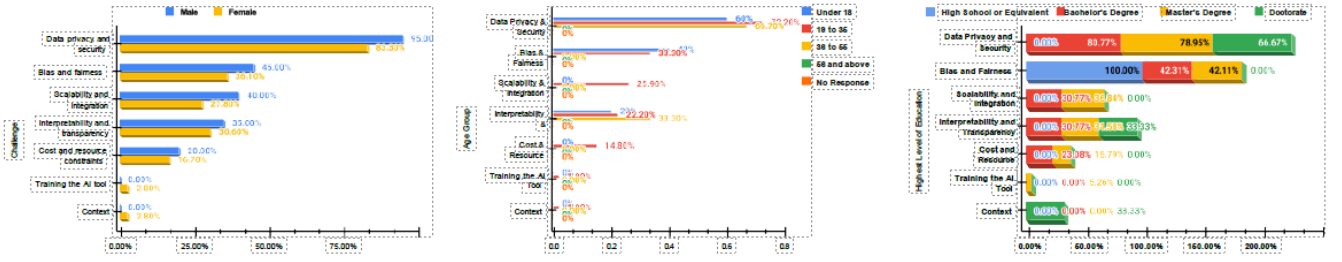
When evaluating ChatGPT's accuracy, the survey reveals varied responses across gender and age groups.

- **Accuracy Ratings by Gender:** When it comes to evaluating the accuracy of AI tools, females gener- ally express a higher level of confidence. They are more likely to rate AI responses as "Very Accurate" (20.5%) compared to males (13.3%). Both genders share a similar view regarding AI tools being "Accu- rate," with males at 43.3% and females slightly higher at 43.6%. Males are more inclined to consider the tools as "Somewhat Accurate" (40.0%) compared to females (30.8%). Interestingly, while a small proportion of males (3.3%) find the tools "Inaccurate," no females share this sentiment. We show this data visually for comparison in Figure 4(a).
- **Accuracy Ratings by Age:** The perceptions of AI tool accuracy vary significantly across different age groups. For those under 18, there is an equal distribution of opinions with 5.7% rating the tools as "Very Accurate" and "Accurate," and no feedback on "Some- what Accurate" or "Inaccurate." Among individuals aged 19 to 35, 22.9% rate the tools as "Very Accu- rate," 42.9% consider them "Accurate," and 28.6% see them as "Somewhat Accurate." This group also in- cludes 2.9% who find the tools "Inaccurate." The 36 to 55 age group rates the tools with 5.7% each for "Very Accurate" and "Accurate," and 8.6% as "Some- what Accurate," but there are no ratings for "Inaccu- rate" or "Very Inaccurate." Unfortunately, there is no data from respondents aged 56 and above. We show this data visually for comparison in Figure 4(b).
- **Accuracy Ratings by Education Level:** Education level also plays a role in how AI tool accuracy is perceived. Those with a high school education or equivalent are most likely to rate the tools as "Some- what Accurate" (60%), with 20% rating them as "Very Accurate" and another 20% as "Accurate," but none finding them "Inaccurate." Respondents with a bach- elor's degree show a balanced view: 28.57% find the tools "Very Accurate," 34.29% "Accurate," and 34.29% "Somewhat Accurate," with a small fraction (2.86%) rating them as "Inaccurate." For those with a master's degree, 34.57% rate the tools as "Very Ac- curate," with an equal percentage rating them as "Ac- curate" and 28.57% as "Somewhat Accurate," while 2.86% find them "Inaccurate." Lastly, individuals with a doctorate tend to rate the tools as "Very Accurate" (28.57%) and "Accurate" (42.86%), with 28.57% considering them "Somewhat Accurate," and no one rating them as "Inaccurate." We show this data visually for comparison in Figure 4(c).



(a) Gender wise (b) Age wise (c) Education wise

Figure 4. Accuracy of AI Tools



(a) Gender wise (b) Age wise (c) Education wise

Figure 5. Challenges in Leveraging AI

5.4 Challenges in Leveraging AI

- **Gender-wise Analysis:** Men and women both express significant concerns about the challenges of using AI in business. Data privacy and security are top worries for both, with 95% of men and 83.3% of women highlighting this issue. Bias and fairness are also significant, affecting 45% of men and 36.1% of women. Men and women similarly point out issues with scalability (40% of men and 27.8% of women) and transparency (35% of men and 30.6% of women). Cost and resources are slightly more of a concern for men (20%) compared to women (16.7%). Only a small number of women (2.8%) mentioned the need for better training of AI tools and context understanding. We show this data visually for comparison in Figure 5(a).

- **Age-wise Analysis:** Examining concerns by age group reveals distinct patterns. For respondents under 18, data privacy (60%) and bias (40%) are their main con- cerns, with transparency also noted by 20%. Among those aged 19 to 35, data privacy remains a significant issue (72.2%), followed by bias (33.3%), scalability (25.9%), and transparency (22.2%). Concerns about costs, training, and context are less prominent in this group. For individuals aged 36 to 55, data privacy is the primary concern (66.7%), with transparency also noted (33.3%). Notably, no respondents aged 56 and above participated, which may suggest either a lack of interest or familiarity with AI in this older age group. We show this data visually for comparison in Figure 5(b).

- **Education-wise Analysis:** Educational background influences how individuals perceive challenges in AI. Those with only a high school education are most concerned about bias and fairness (100%). Indi- viduals with a bachelor's degree primarily worry about data privacy (80.77%), but also have concerns about bias (42.31%), scalability (30.77%), and trans- parency (30.77%), with cost being a concern for 23.08%. For those with a master's degree, data pri- vacy remains the primary issue (78.95%), followed by bias (42.11%), scalability (36.84%), and trans- parency (31.58%). They also note concerns about cost and the need for improved AI training. Respondents with a doctorate focus on data privacy (66.67%) and transparency (33.33%), with some attention to context (33.33%). We show this data visually for comparison in Figure 5(c).

6. LIMITATIONS AND CHALLENGES

6.1 Major Limitations

The mojor limitation of AI-driven business analytics is the groeing biases in the AI world which impacts the accu- racy, fairness, and reliability of insights and recommenda- tions. Some common types of biases include:

1. Sampling Bias: This occurs when the data used to train AI models is not representative of the broader pop- ulation or target audience. For example, if a dataset used to train a customer segmentation model primarily consists of data from a specific demographic group, the resulting segmentation may not accurately reflect the diversity of the customer base.

2. Selection Bias: Selection bias occurs when certain data points are systematically excluded or included in the analysis, leading to skewed results. For instance, if a pre- dictive model for loan approvals is trained on historical data that disproportionately includes loan applications from a certain demographic group, the model may learn to favor that group, perpetuating existing biases.

3. Algorithmic Bias: Algorithmic bias refers to biases inherent in the design or implementation of AI algorithms. This can occur due to factors such as feature selection, al- gorithmic complexity, or model hyperparameters. For ex- ample, if a facial recognition algorithm is trained predomi- nantly on images of individuals from a specific race or eth- nicity, it may perform poorly when applied to individuals from underrepresented groups.

3. Temporal Bias: Temporal bias arises when histori- cal data used to train AI models becomes outdated or no longer reflective of current trends or patterns. This can lead to inaccurate predictions or recommendations, especially in dynamic environments where trends and preferences evolve over time.

6.2 Other Limitations

1. Data Quality and Availability: One of the primary challenges in AI-driven business analytics is the quality and availability of data. Poor data quality, incomplete datasets, and data silos can hinder the effectiveness of AI algorithms and lead to inaccurate or biased insights. Addressing these challenges requires robust data governance frameworks and data quality assurance processes.

2. Interpretability and Trust: The lack of interpretabil- ity and transparency in AI models poses a challenge to their adoption in business analytics. Stakeholders may be reluc- tant to trust AI-generated insights and recommendations if they cannot understand how these decisions are made. Fu- ture research is needed to develop interpretable AI tech- niques and enhance the trustworthiness of AI systems.

3. Ethical and Societal Implications: The use of AI in business analytics raises ethical and societal concerns related to privacy, security, and job displacement. Ensuring that AI technologies are deployed responsibly and ethi- cally requires proactive measures to address these concerns and mitigate potential risks to individuals and society as a whole.

Overall, while AI holds immense potential to transform business analytics, addressing these limitations and challenges is essential to realizing its full benefits and ensur- ing its responsible and ethical use in decision-making processes.

7. CASE STUDIES OF REAL-WORLD EXAMPLES TO STUDY THE GROWING BIAS IN AI-DRIVEN BUSINESS AN- ALYTICS

In this section, we highlight the growing nature of bias in AI-driven business analytics and underscore the impor- tance of addressing bias mitigation strategies to ensure the fairness, equity, and reliability of AI systems in real-world applications. Addressing biases requires a concerted effort to critically evaluate and improve AI algorithms, increase diversity and inclusivity in dataset collection and model development, and implement transparency and accountability measures to monitor and mitigate biases throughout the AI lifecycle.

7.1 Gender Bias

1. Amazon's Recruiting Tool: In 2018, it was reported that Amazon had developed an AI-driven recruiting tool to help automate the hiring process. However, the system was found to exhibit gender bias, as it con- sistently downgraded resumes that included the word "women's" (e.g., "women's chess club captain"). This bias likely stemmed from the historical data used to train the model, which reflected gender disparities in the tech industry. As a result, Amazon ultimately scrapped the tool.

2. Apple Card Credit Limits In 2019, several reports emerged suggesting that the Apple Card, a credit card issued by Goldman Sachs and powered by Apple's AI algorithms, was granting higher credit limits to men than to women with similar creditworthiness. This bias was attributed to the AI algorithms used to determine credit limits, which may have been influenced by his- torical data reflecting gender-based disparities in finan- cial decision-making.

3. Online Advertising Algorithms Online advertising platforms often use AI algorithms to target ads to specific demographics. However, these algorithms can inadvertently perpetuate stereotypes and discrimination. For example, a study by Carnegie Mellon University found that Google's ad targeting system showed ads for high-income jobs to men more frequently than to women, reflecting gender biases in job-related advertising. Similarly, Facebook's ad targeting system has faced criticism for allowing advertisers to exclude certain demographic groups from seeing their ads, potentially leading to discriminatory practices in housing, employment, and financial services.

4. Voice Recognition Systems Voice recognition systems, such as virtual assistants and voice-activated devices, have been found to exhibit gender bias in their speech recognition capabilities. For example, a study by UNESCO found that several popular voice recognition systems, including those developed by Google, Amazon, and Apple, were more accurate at recognizing male voices than female voices. This bias can lead to disparities in user experience and accessibility, particularly for individuals with marginalized gender identities.

7.2 Racial bias

1. Google Photos' Labeling System Google Photos' image labeling system has faced criticism for its tendency to mislabel people of color. For example, in 2015, the system labeled two African American individuals as "gorillas," highlighting inherent racial biases in the AI algorithms used for image recognition. Google issued an apology and pledged to improve the system's ac- curacy, but the incident underscored the importance of addressing racial biases in AI technologies.

2. Biased Healthcare Algorithms AI-driven healthcare algorithms have been found to exhibit biases that disproportionately affect certain demographic groups. For example, a study published in Science in 2019 found that an algorithm used to prioritize healthcare re- sources for patients with complex medical needs sys- tematically underestimated the needs of Black patients compared to white patients. This bias could exacerbate healthcare disparities and contribute to inequitable ac- cess to medical care.

3. Loan Approval Algorithms AI algorithms used by financial institutions to assess loan applications have been found to exhibit racial biases, leading to dispari- ties in loan approval rates for minority applicants. For example, a study by the National Bureau of Economic Research found evidence of racial bias in online lend- ing platforms, with Black and Hispanic borrowers fac- ing higher rejection rates and receiving less favorable loan terms compared to white borrowers with similar credit profiles.

4. Facial Recognition Software Facial recognition algorithms have been found to exhibit racial bias, with higher error rates for individuals with darker skin tones. For example, a study by the National Institute of Standards and Technology (NIST) found that many commercial facial recognition systems had higher rates

of false positive matches for Black and Asian faces compared to white faces. This bias can have serious implications for applications such as law enforcement, where inaccurate facial recognition results may lead to wrongful arrests or surveillance of innocent individuals.

5. Predictive Policing Software Predictive policing algorithms, which use AI to forecast crime hotspots and allocate law enforcement resources, have been criticized for reinforcing biases present in historical crime data. For example, a study by the Human Rights Data Analysis Group found that predictive policing software used in several U.S. cities disproportionately targeted communities of color, leading to over-policing and increased rates of surveillance and arrests in these neighborhoods.

Addressing these biases requires a multi-faceted ap- proach, including careful curation and preprocessing of data, algorithmic fairness assessments, ongoing monitoring and validation of AI models, and the implementation of bias mitigation strategies such as fairness-aware algorithms and diverse training datasets. Additionally, promoting diversity and inclusion in AI development teams can help mitigate biases and foster more equitable AI systems.

8. FUTURE DIRECTIONS

1. Hybrid Intelligence: The future of AI in business analytics may involve the development of hybrid intelligence systems that combine the strengths of AI algorithms with human expertise. Collaborative decision-making frame- works, where AI systems provide insights and recommen- dations while humans contribute domain knowledge and in- tuition, could lead to more robust and effective decision- making processes.

2. Explainable AI: As AI systems become more complex and autonomous, there is a growing need for transparency and interpretability. Future research may focus on devel- oping explainable AI techniques that provide insights into how AI models arrive at their decisions, enabling stakehold- ers to understand, trust, and validate the recommendations provided by these systems.

3. Autonomous Decision-Making: The evolution of AI may lead to the emergence of autonomous decision-making systems capable of making decisions without human inter- vention. These systems could leverage real-time data, pre- dictive analytics, and prescriptive algorithms to automate routine decisions, freeing up human resources to focus on more strategic tasks and innovation.

4. Ethical and Regulatory Frameworks: With the increasing adoption of AI in business analytics, there is a growing need for ethical guidelines and regulatory frame- works to ensure the responsible and ethical use of AI tech- nologies. Future research may focus on developing guide- lines, standards, and policies to address issues such as data privacy, algorithmic bias, and accountability in AI-driven decision-making processes.

9. CONCLUSION

This paper examines how Artificial Intelligence (AI) is transforming business analytics by generating actionable insights and recommendations. It reviews existing literature, analyzes various AI techniques, and showcases real-world applications through case studies. The key contributions include a detailed literature review, practical case studies, a market survey on AI's impact, and guidance for practitioners and policymakers. By adopting AI technologies responsibly, organizations can drive innovation, enhance decision-making, and gain a competitive edge in today's data-driven economy.

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29

Concept for Empowering Maintenance Efficiency and Employee Well-being: Digital Assistant for Maintenance

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ABSTRACT

In the era of Industry 4.0, we have witnessed many technological advancements, including sensors, IoT, AI, and cloud computing, which have profoundly reshaped the landscape of Industrial Maintenance. These advancements hold vast potential. AI analytics, encompassing components such as machine image data analytics, audio data analytics, operational sensor time series data analytics, and maintenance text mining, are integral to this transformation. However, the separate implementation of these components poses challenges for operators, impeding the seamless inspection and scheduling of maintenance actions due to the lack of integration within a unified platform. Additionally, needing protective clothing and accessories when accessing predictive maintenance tools adds complexity. To tackle these challenges, we aim to adhere to the principles of Industry 5.0, emphasizing human-centric technologies. We focus on presenting a concept that can utilize explainable AI in Predictive maintenance and seamlessly integrates the mentioned analytical components with a voice assistant. This framework empowers operators to use voice commands to evaluate equipment and monitor industrial maintenance status. By leveraging voice-activated maintenance, the capabilities of the voice assistant are extended to provide manual instructions and insights related to equipment maintenance, thereby offering comprehensive support to operators. The test results state that platform users will continue to be willing to use it if the platform is easy to use and they have the device to run the application.

Keywords: Human-Machine Collaboration, Predictive maintenance, Digital Assistant, AI, Industry 5.0.

1. INTRODUCTION

The advent of Industry 4.0 has transformed maintenance and manufacturing, driven by the widespread adoption of advanced technologies such as low-cost sensors, IoT, AI, and cloud computing (Jan et al., 2023). This technological convergence has bestowed the capability to detect asset health and predict potential failures before they occur(Zonta et al., 2020). Within this transformative landscape, the practice of predictive maintenance has emerged as a beacon of innovation. Predictive maintenance is very complex and involves various tasks, these encompass image data analytics (De Santo et al., 2022), audio data analytics (Prieto & Bravo, 2023), text mining (Rahman & Mahbub, 2023), and the intricate examination of sensor readings, particularly time series data(Nunes et al., 2023). This diversity of analytical opportunities harmoniously contributes to the preservation of equipment quality and boosts availability, reliability, and safety.

Nonetheless, an existing challenge in the realm of these predictive maintenance components lies in the utilization of mostly opaque, non-intuitive machine learning techniques. From the operator's point of view, these machine-learning methods cannot address various questions such as: Why did you do that? Why not a different outcome? When do you do well? When do you make mistakes? When should I rely on you? How can I fix an error? and so on (Molęda et al., 2023). In addition, these components tend to operate in isolation, lacking a cohesive integration. Contrastingly, maintenance technicians find themselves deeply entrenched within the dynamic environment of a busy manufacturing plant. They assume the role of alert supervisor, continuously monitoring machine performance, diagnosing potential failures, consulting technical manuals, and meticulously devising maintenance strategies. The demands of their role often propel them into motion, traversing the extensive terrain of the plant, and adeptly adjusting tools and components along their path. The present challenges arise from how these predictive maintenance technologies were introduced separately. Maintenance technicians find themselves compelled to access various tools and functionalities separately and manually, a circumstance that inadvertently obstructs their workflow and introduces unwarranted interruptions during critical maintenance operations. This fragmentation of resources impedes their ability to efficiently address challenges, engendering a compelling need for a more unified and harmonized approach. Presently, industries are embracing the goal of Industry 5.0, which aims to prioritize human-centered systems. A potential remedy for this technological challenge could be a cohesive platform that combines predictive maintenance technologies and explainable AI methods.

Furthermore, there remain various obstacles in the realm of predictive maintenance. Maintenance operators, who must wear protective gloves and gear, often experience frequent interruptions as they access computer interfaces or mobile devices. These interruptions, which can range from short pauses to more significant relocations, have the potential to hinder workflow efficiency and overall productivity (Wellsandt et al., 2022). A promising solution to overcome these challenges is a Voice assistant. The assistant will function as a link connecting maintenance activities,

including the complex predictive maintenance platform, maintenance training, inventory management, and more, to the maintenance stakeholders.

The natural language communication aspect enables the assistant to both listen or read and speak or write. Operators using their natural language on a computer or mobile can access functions seamlessly throughout a conversation. In contrast, accessing functions through a graphical user interface usually requires knowing how to locate buttons, links, and interactive elements (Wellsandt et al., 2022). The state-of-the-art voice assistant utilizes advanced artificial intelligence (AI) for voice recognition and generation (Subhash et al., 2020). Voice communication brings several notable advantages. Firstly, users can access functions hands-free, making it feasible during tasks like operative maintenance when hands are occupied, such as holding tools (Wellsandt et al., 2021). Secondly, using voice is often quicker than writing. This can save workers time – typically seconds or a few minutes per interaction – when they need to, for instance, make a call or access specific information. Third, workers can access several maintenance activities within a single platform.

This article aims to investigate specialized user needs in the realm of integrated maintenance and voice assistants, with the objective of human-centric predictive maintenance by enhancing maintenance efficiency and employee well-being. It seeks to delineate the roles of a voice assistant within maintenance and further, to present a conceptual framework for a predictive maintenance-focused digital assistant with voice capabilities.

The following parts of this paper are structured as follows: Section 2 presents a depiction of the stakeholders involved in manufacturing maintenance processes, who can benefit from a digital voice assistant. In Section 3, we offer an outline of the identified concept. Section 4 delves into the technologies required to achieve the said concept. Lastly, Section 5 encompasses the concluding thoughts and an outlook for future work.

2. STAKEHOLDER IDENTIFICATION AND USE-CASE EXAMINATION

We have recognized various stakeholders poised to benefit from the amalgamation of predictive maintenance components and voice-enabled maintenance solutions within the manufacturing sector. Here are the key individuals and groups:

2.1 Maintenance Technicians:

Maintenance technicians currently rely on conventional approaches like email or paper-based systems, which often impede their ability to swiftly access accurate equipment information and they typically check the predictive maintenance components individually. This, in turn, results in missed or delayed alerts, ultimately hampering their capacity to respond promptly and address issues in a timely manner. Given their need to frequently multitask, technicians encounter challenges when attempting to retrieve information manually during tasks such as inspections and repairs. By integrating voice assistants, technicians can get the advantage of accessing equipment information, receiving real-time maintenance task notifications, conducting inspections, documenting maintenance activities, and resolving issues hands-free while engaged on the shop floor.

2.2 Maintenance Managers and Supervisors:

Like maintenance technicians, supervisors also rely on traditional methods for task assignment and progress tracking. However, these methods often result in time-consuming processes that are susceptible to errors, potentially leading to confusion and delays in task execution. By adopting voice-enabled systems, supervisors and managers can streamline their operations. They can efficiently assign tasks, monitor progress, prioritize maintenance activities, analyze data trends, and make well-informed decisions related to resource allocation and preventive measures. This integration of voice technology helps address the challenges associated with manual task management, promoting more effective and error-free supervision of maintenance activities.

2.3 Production Operations Teams:

Production operators often face challenges such as limited visibility into asset health conditions and maintenance schedules, which leads to disrupted production due to lack of timely information, inefficient resource allocation, missed opportunities for optimization, and potential impacts of unexpected downtime on production output. Using voice assistant, production operators can receive updates on equipment status, maintenance schedules, and potential downtime, allowing them to optimize production schedules and minimize disruptions.

2.4 Health and Safety Personnel:

The voice assistant stands ready to deliver on-demand safety training and instructions to both technicians and new employees, guiding them in the adept utilization of diverse tools and equipment. It further extends its capabilities by furnishing meticulous, step-by-step directions encompassing proper usage, identification of potential hazards, and endorsement of recommended safety measures.

2.5 Training and Onboarding:

New employees undergoing training or onboarding can utilize voice assistants for interactive learning, guided instructions, and accessing training materials, facilitating a smoother integration into the maintenance team. Learning

2.6 Maintenance Inventory manager:

This can provide real-time updates on maintenance inventory levels, ensuring that the maintenance team and technician are always informed about the availability of materials and

supplies. Technicians can get information about specific items, their quantities, and their location within the inventory.

2.7 All Maintenance Workers:

In maintenance environments, maintenance workers commonly experience two types of stress. Firstly, there's physical stress, which arises from activities like heavy lifting, repetitive motions, and extended periods of standing or crouching. Secondly, there's cognitive stress. Workers frequently engage with intricate technical information, troubleshooting, and real-time decision-making. This cognitive stress stems from the urgency to rapidly diagnose and resolve issues. Additionally, communication stress can also occur. Miscommunication or challenges in transmitting information among workers can result in errors and delays, thereby inducing stress. Voice assistants can offer hands-free communication and interaction, providing instant access to information, procedures, and guidelines. They optimize time management, effectively reducing the mental burden on workers.

3. CONCEPT DESCRIPTION

We aim to create a voice-enabled maintenance system that seamlessly retrieves insights from our integrated predictive maintenance components and maintenance database. To achieve this, our initial step involves integrating diverse prognostic components within a unified platform. Subsequently, we will integrate voice-enabled capabilities into this platform, enhancing its accessibility and user-friendliness. We utilized user stories and domain-specific requirements to create sample dialogs for distinct types of maintenance activities. Additionally, we categorized similar user stories and established functional modules to cater to them. Each module operates autonomously, allowing the service provider to enable the specific modules needed by the client. The subsequent sections describe the extent of these modules. The concept diagram is illustrated in Figure 1.

Integrated Platform: An integrated platform that combines various maintenance analytics components, including audio data analytics, image data analytics, sensor data analytics, maintenance databases, maintenance inventory databases, and text mining.

Real-time Monitoring and Alerts: Skill in which voice assistant can retrieve the data from the unified platform and continuously monitor equipment and processes, providing real-time updates and alerts in case of anomalies, deviations, and prediction results. It also retrieves the real-time sensor data.

Work Order Management: Skill to assist in generating, assigning, and tracking work orders for maintenance tasks, including scheduling, prioritization, and status updates.

Documentation and Knowledge Retrieval: Skill in which voice assistants can retrieve relevant maintenance manuals, documentation, and procedural information, making it easier for technicians to access critical resources on the go.

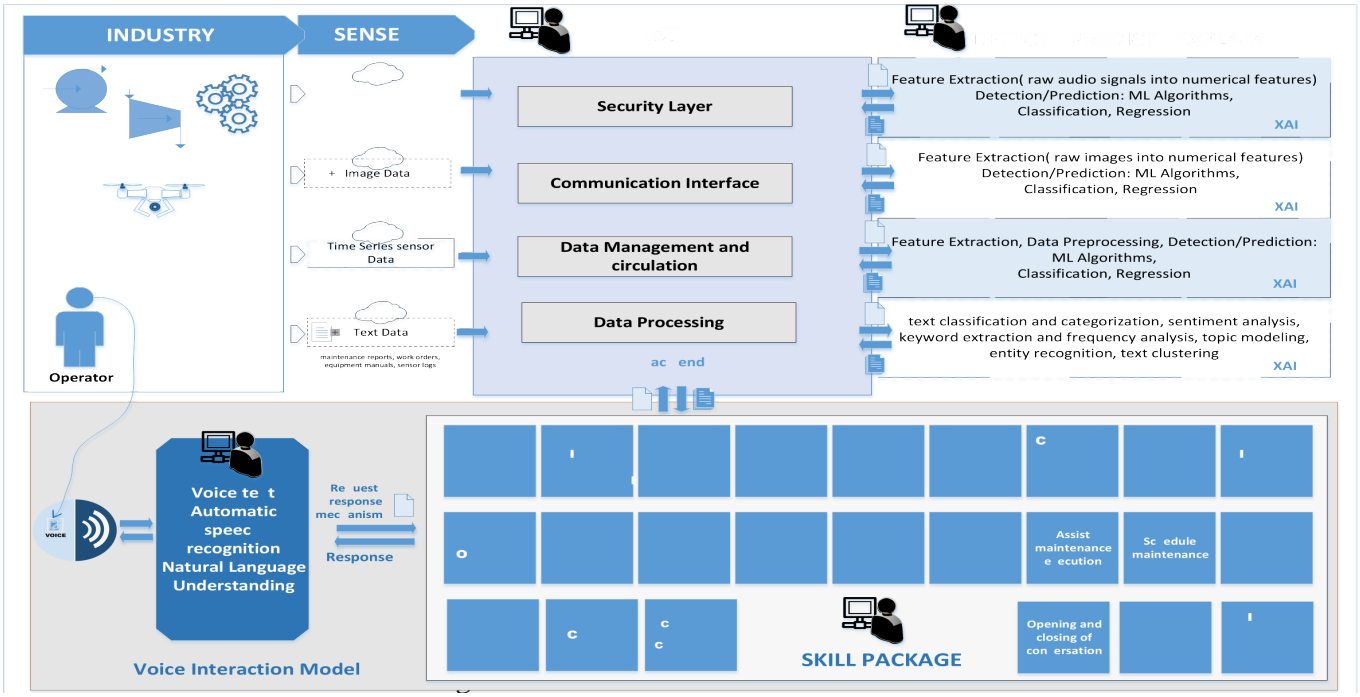

Figure 1: Illustration depicting the operational structure of a digital voice assistant designed to facilitate predictive maintenance.

Training and Guidance: Skill in which voice assistants can provide step-by-step instructions, tutorials, and guidance for performing complex maintenance procedures, especially for less experienced technicians.

Inventory Management: Skill that helps manage maintenance spare parts and inventory levels, notifying maintenance personnel when stock is low or needs replenishment.

Regulatory Compliance: Skill to assist in ensuring compliance with industry regulations and safety standards by providing relevant information and checklists.

Performance Benchmarking: Skill to compare equipment performance against industry benchmarks and best practices, identifying areas for improvement.

Collaboration and Communication: Skill to facilitate communication and collaboration between maintenance operator and manager or other departments, helping to streamline processes and enhance efficiency.

Employee Well-being: Skill to promote the mental and physical well-being of employees. It might include relaxation techniques, gamification, mindfulness exercises, relaxation techniques, stress-reduction strategies, access to counseling or mental health resources, healthy lifestyle guidance, and fostering a positive work environment.

4. DISCUSSION

The design and execution of our human-centric unified predictive maintenance components and voice assistant have provided valuable insights that can guide future endeavors in this domain. This section will delve into pivotal aspects, and strategic considerations, and illuminate significant limitations. Our observations indicate that the fundamental technologies necessary to create and maintain the integrated system currently exist. To bring the envisaged concept to fruition, the following essential technologies are imperative prerequisites:

The landscape of predictive maintenance analytics components is complex and diverse, including various data types, including images, audio, text, and sensor readings like temperature and pressure. Its journey spans from the initial data capture from the asset to the deployment of predictive models in the production, each step underpinned by state-of-the-art technologies. The advent of low-cost sensors with modern data capture capabilities has significantly simplified the task of data sensing from machinery and assets (Yin et al., 2020). This convenience is facilitated by the deployment of specialized devices; such as cameras (Galatanu et al., 2019; Ullah et al., 2017a), drones, microphones [4,15], and an array of sensors. Asset's raw data undergoes careful preprocessing, involving techniques like denoising for audio clarity, calibration for accurate sensor readings, and normalization for consistent image pixel values. Feature extraction methods, encompassing Convolutional Neural Networks (CNNs) for images(Ullah et al., 2017b), spectrogram analysis for audio(Di Fiore et al., 2022), and statistical methods such as fast Fourier transform (FFT), wavelet transform, principal component analysis (PCA) for sensor data, drive the subsequent phases of model development and training. Deep learning (DP) frameworks like TensorFlow and PyTorch facilitate the development of predictive models, fortified by the computational prowess of GPUs or TPUs. The iterative process of hyperparameter optimization refines these models for optimal performance across diverse data types. Rigorous evaluation, encompassing metric analysis, cross-validation, and visualization of outcomes, validates the predictive power of these models.

As the trajectory advances to model deployment, the infrastructure of cloud services, exemplified by AWS, Azure, and Google Cloud, provides the platform for hosting models. Containerization ensures uniform deployment, while APIs seamlessly integrate these predictive insights into applications. Serverless paradigms, such as AWS Lambda, further streamline execution, alleviating users from infrastructure management burdens. To sustain and enhance performance, continuous monitoring and maintenance deploy logging, analytics, and feedback loops, iteratively refining the models over time. In essence, this comprehensive approach to data analytics orchestrates an ensemble of technologies, customized to the intricacies of various data forms.

Several open assistant frameworks, such as Mycroft (Wilson, 2019), Alexa, Siri, Google Assistant, and Bixbi. Besides, some closed assistants, such as Spix or NeoHelden are available for implementing digital assistants(Hoy, 2018). These tools can be applied to various devices including Smartphones, Tablets, Smart speakers, and augmented reality devices. On the natural language understanding (NLU) front, tools like Duckling (Staliunaite & Iacobacci, 2020) address specific challenging NLU issues. They are interoperable and can seamlessly integrate into an assistant's data processing pipeline. The infrastructure itself can operate within a containerized environment. Each container acts as a self-contained unit of software and can potentially interact with other containers. Deploying and maintaining containers requires minimal effort, and containerized environments usually offer scalability mechanisms.

Several IoT platforms have been introduced in the context of Industry 4.0, and among these is the Asset Administration Shell (AAS) (Rahal et al., 2023). AAS offers a standardized and methodical means to depict and convey information regarding industrial assets. This encompasses the potential inclusion of predictive maintenance data, and analytics tools

and facilitates seamless collaboration between voice assistants.

5. CONCLUSION AND FUTURE WORK

We have already worked on a unified solution for predictive analytics and production scheduling components using an asset administrative shell, that motivates us to develop this innovative concept. Integrating AI-driven analytics into a unified, human-centric platform will represent a significant step forward in addressing the current challenges in industrial maintenance. On working on the principles of Industry 5.0, our proposed system will enhance efficiency and prioritize human operators' well-being and ease of use. The implementation of explainable AI will develop trust for operator and they will better understand the insights provided by the system, while the integration of a digital assistant will simplify the interaction process, making it more accessible. Furthermore, our approach of controlling and monitoring the maintenance process through voice or text commands introduces a new level of convenience and flexibility, aligning with the evolving needs of modern industries. Looking ahead, we aim to explore more technologies and now we are working on developing the tool, In addition, we will work to implement this framework in the edge.

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30

Enhancing Strategic Layout Planning Phase with Advanced 3D Visualization Technologies

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ABSTRACT

Strategic layout and factory planning are key stages in any company's lifecycle, during which management makes decisions about manufacturing sites, infrastructure, and future development opportunities. This study describes a unique 3D Visualization technique for converting typical 2D layout drawings into dynamic, interactive 3D models. This strategy uses real-world components like highways, railways, topographic, logistical pathways and Vehicle Movement Simulations. This enhanced visualization dramatically improves decision-making processes by presenting a realistic and comprehensive view of robable project outcomes.

Keywords: 3DVisualization Micro station Lumen RT CAD, Automotive - Industry Strategic - Planning Real-Time -Rendering

1. INTRODUCTION

Background of Strategic Layout Planning Strategic layout planning becomes a fundamental aspect in industrial development, one of the most critical phases in the lifecycle of manufacturing and infrastructure projects. Designing and organizing production processes and logistical systems for various stages and functional zones live at the very heart of such action and strive toward optimizing operational efficiency, safety, and growth potential.

A layout, itself well-conceived, is essential for not only meeting the production objectives in the short term but for ensuring scalability and flexibility over the long term in an ever-changing industrial environment. Historically, the strategic layout planning process has been based heavily on 2D drawings, manual calculations, and isolated decision models. Somewhat efficient in less complicated industrial cases, those traditional techniques have, however, a number of significant limitations.

The conventional two-dimensional schematics are capable of only providing basic spatial relationships that do not capture the complexities that pervade modern production environments. Most manual calculations are liable to human errors and, as a result, create an inaccuracy that could increase throughout a project. Furthermore, traditional planning tools have less integrative approach meaning that it becomes difficult for the stakeholders to visualize component interaction and final function of the system. This disintegration in the decision-making process resulted in many issues. Teams tended to work in silos and thus found it difficult to share meaningful insights, leading to misalignment between design intent and execution. Changes occurred often due to unforeseen conflicts during implementation, leading to wasted time, cost overruns, and an altered project schedule.

Evolution of Visualization in Industrial Planning

From simple tools such as maps, charts, and blueprints, this history has ventured into the futuristic concepts of visualization in industrial plan making. Although, seemingly revolutionary at that time, these early visual aids were always limited. They offered only a flat two-dimensional representation of space, limited to solving a linearly defined set of cube points that failed to suffice even for fundamental complexities of space, not to mention the increased detail of industrial layouts and complex processes.

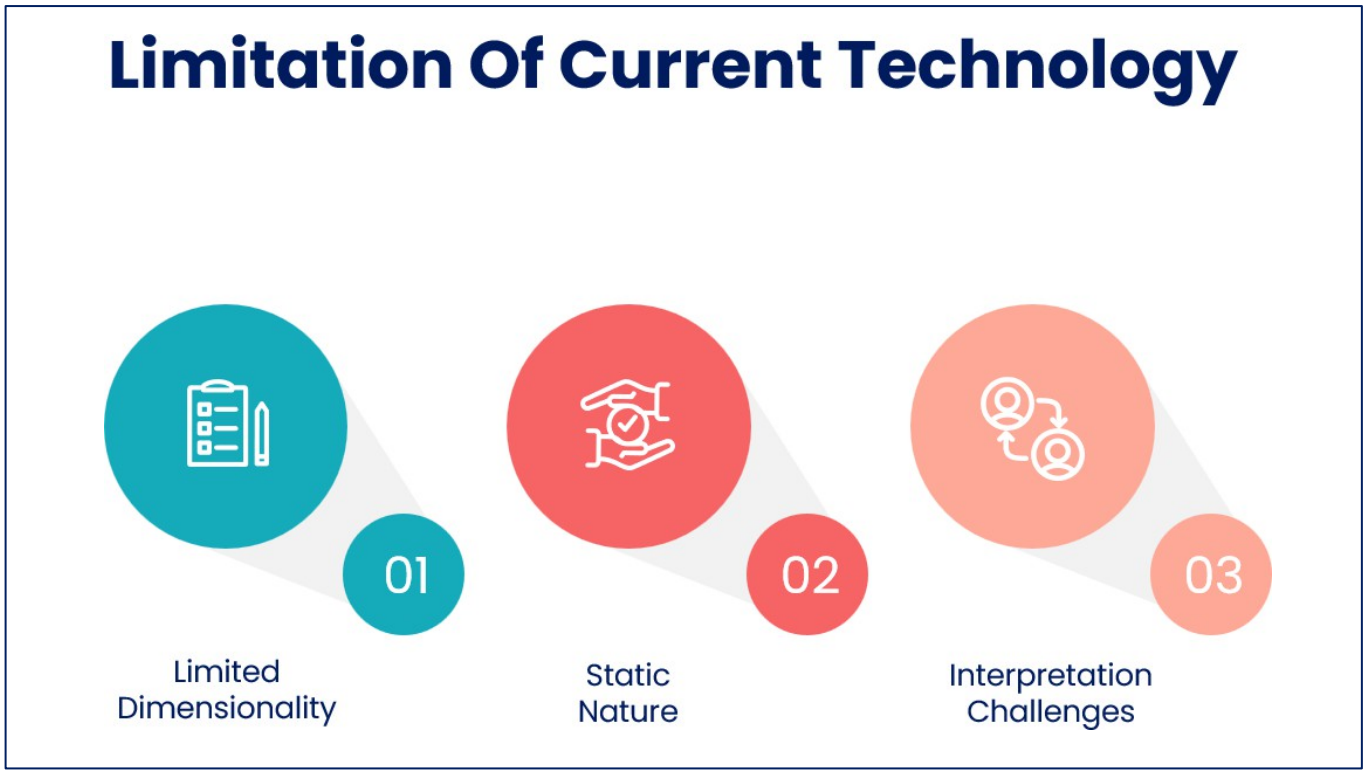
Some Early Tools for Visualization: Maps, Charts, and Blueprints

In the pre-digital age, industrial planners relied on hand-drawn maps, blueprints, etc., to communicate spatial relationships and concepts of design. They have been the real dimension tools for the longitudinal consideration of planners to understand layout, resource allocation, and actual process flows. But some disadvantages were also there.

For instance:

- Limited Dimensionality: Flat drawings could not well communicate separation in depth, height, or the three-dimensional interaction of objects in space.
- Static Nature: Blueprints and charts generally are static and cannot inform you about changes over time or the behavior of a dynamic process such as materials flows or logistics.
- Interpretation Challenges: The absence of interactive or real-time elements in such tools leads to a strong preference for interpreting it by well-qualified people, making collaboration across diverse teams more difficult.
- Although these tools performed well against some relatively simpler demands, they were quickly

overwhelmed in comparison to the demand for modernization.



Importance of 3D Visualization in Automotive and Related Industries

In the high-tech age, 3D visualizing has become the new potent agent converting into maturing instance dimension of industries by bringing precision, collaboration, and efficiency. However, among many of them, the automotive industry has achieved quite a lot in the development and employment of 3D modeling in factory design, process optimization, and innovative product development. This alone stresses the great importance that 3D visualization brings to the highly complex issues being solved, including assembly line layout, robotic automation, logistics planning, and safety management. Besides these applications in the automotive sector, 3D visualization can also be extended to other industries such as construction, urban design, healthcare, aerospace, etc., thereby making it a cornerstone of modern design and operations excellence.

2. 3D VISUALIZATION IN AUTOMOTIVE

Facilitating Manufacturing Simulations

However, an important area in which 3D modeling tools are found to be useful in the automobile industry is in carrying out detailed manufacturing simulations. Through such simulations, manufacturers are given a virtual arena in which to try out and analyze assembly lines, workflow efficiency, and equipment performance prior to ever building anything in the plant itself. Companies will thus be able to determine, prior to them having to produce it 9

- Maximized Production: Efforts shall be made towards optimization of the Production process, through adjusting flows, resource allocations, and configurations of machines.
- Forecast Bottlenecks: Identify where there might be delays or interruptions in the process of production so that they can be pre-empted and ensure a smooth run of operations.
- Improve Quality Control: Simulate the coming together of vehicles so that faults in design or operational errors become visible and high quality is achieved in the final product.

Space is at a premium in automotive factories, where equipment, storage, and logistics all need to co-exist. 3D visualization enables precise planning by

- Optimizing Layouts: Allowing manufacturers to visualize factory layouts in three dimensions to ensure maximum efficiency use of available space. 5
- Improving Material Flow: Designing pathways where raw materials and finished goods move easily with transport time and cost savings.

- Supporting Future Expansion: Consideration for the space and provision of layout should be in place for more equipment or processes to support future expansion.
- Better Cross-Functional Collaboration. Indeed, collaboration is extremely important in the automotive industry, where teams within functions, such as design, engineering, production, and quality assurance, should work seamlessly. 3D visualization supports this healthy collaboration through providing a unified vision for projects within the organization.
- Better Communication: Stakeholders will have an edge in understanding complicated designs and processes as visual models will close the gaps between the two ends of the vision.
- Faster Decision-Making: Presenting easily well-understood, authentic layouts of factories and their processes allows teams to make sound decisions promptly.
- Less Rework: Reduced cost and time lost through using early identification of design defects or operational inefficiencies.

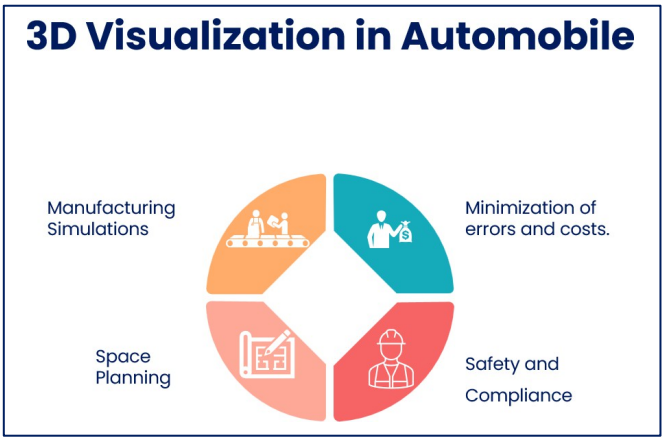
In this context, minimization of errors and costs.

- It can bring in substantial losses concerning finance and operation when there is a design error or planning error in the factory. 3D visualization serves several purposes in reducing these risks, most important of which are:
- Detecting Design Errors: Complex modeling tools identify mismatch or mistake in design even before making a physical implementation.
- Reducing Reprogramming Needs: Simulations can make necessary changes before having to reprogram any machinery or actually change physical layouts.
- Enhancing Resource Utilization: By providing resource-understanding in spatial and operational requirements, manufacturers can prevent waste and create efficiency when allocation the resource.

Safety and Compliance

Safety considerations are a great priority in the automotive factories where a wide variety of operation takes place combined with heavy material handling input from the machines with lots of automated systems operating at higher speeds. 3D visualization brings safety by:

- Computer Simulating Hazard Situations: Virtual environments can even include simulated events where these events could have safety relevant consequences, allowing adoption of proactive measures that lower the risk of these events occurring.
- Ergonomically Designing Workstations: Planners can now see if workstation layouts can be designed for a safe working environment.
- Keeping within Industry Compliance: An extensive visualization will help manufacturers complete conformance to compliance from industry standards to standard regulations.



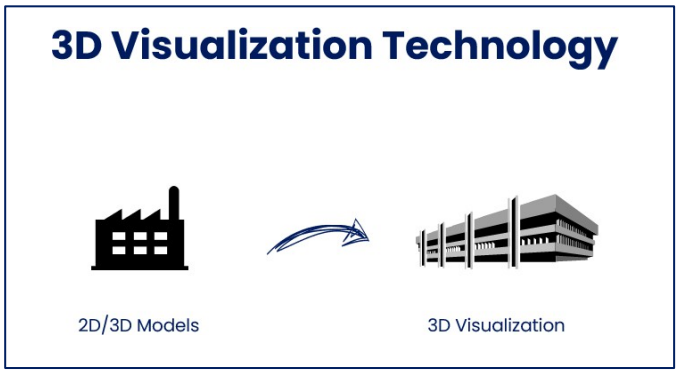
Objectives of the Study

Aspects of Advanced 3D Visualization Technologies for Strategic Layout Planning:

Converting Static 3D CAD Models into Dynamic Living 3D Models:

This study aims to demonstrate potential methodologies to change static 3D computer-aided design (CAD) models into dynamic real-time interactive forms, which allow users to interact with the data in real-time, thereby availing better understanding of the layouts, designs, and potential inefficiencies. Stakeholders will then get the facility live experience of the models and can:

- Interactivity with Virtual Environments: Navigate through factory layouts or product designs to identify issues and opportunities for improvement.
- Perform Dynamic Analyses: For example, evaluate real-time scenarios like machinery, material flow, and ergonomic factors.
- Experience a Greater Visualization Impact: Create a more engaging, intuitive depiction of complex data that is accessible to both technical and non-technical stakeholders.



Enhancing Decision Making by Big Data Visualizations

This study illustrates the benefits of making 3D big data visualizations in decision- making processes. By modeling the large amounts of data being collected into 3D models, decision-makers will have the following benefits:

- **Gain In-Depth Insight:** Afford relationships and patterns to visualize within the data that may not be visible in a traditional 2D model.
- **Enhance Communication with Stakeholders:** Communicate insights in 3D visuals to join various teams and ensure alignment in their scope of activities.
- **Support Operational Efficiency:** Identify inefficiencies and optimization potentials for processes, layouts, and resource allocation.

Facilitating Outcome Visualization Using MicroStation and Lumen RT

This research also shows the application of these tools, such as MicroStation or Lumen- RT, in ensuring effective outcome visualization. The tools offer:

- Realistic and Precise Modeling: Create accurate and detailed 3D models of factory layouts, equipment, and workflows.
- Real-Time Rendering: Visualize dynamic changes in the environment, such as lighting, movement, and material flow.
- Scenario Simulation: Test different scenarios: what-if scenarios to investigate the consequences of changes in design or process. 30 31 1 2

Detect Challenges or Constraints in 3D Technology

Another main objective of the study is to identify and solve the limitations of existing 3D visualization technologies. This study will try to:

- Identification of the Technical Constraints: Open the discussions on hardware limitations, software compatibilities, and data integration challenges.
- User Adoption Barriers: learning curbs and resistance to change by the users.
- Solutions: Proposals to these issues for a successful implementation of 3D visualization tools.

Forging Future Directions of Work

Finally, the study will open up possible new avenues for future research and development in the direction of 3D visualization. Some key areas in the study include:

- Integrating Up-and-Coming Technologies: Analyze and explore the full potential of artificial intelligence, machine learning, and augmented reality in furthering 3D visualization.
- Access for More: Develop easy-to-use tools and interfaces that allow more access to advanced visualization technologies.
- Sustainable Design: Study the role of 3D visualization in achieving environmental sustainability through industrial planning.

3. LITERATURE REVIEW

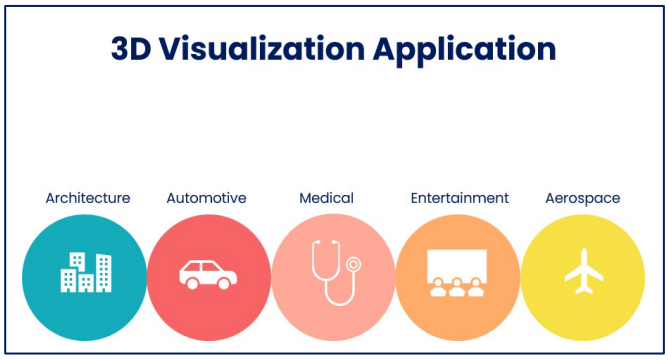
Historical Perspective on Visualization Techniques

- Visualization has been vital relatively since ancient times, when the very first maps and diagrams came about as the means of representing spatial and physical information, all the way until today. Now back then, those tools were fundamentally revolutionary because they were the only static and had no possibilities of adapting to changing parameters for different scales.
- During the period of the industrial revolution, the growing complexities of the projects concerned more people than any other practical visualization method available. The introduction of engineering drawings allowed perfect communication to be offered for designers and constructors, but was quite deficient when it came to interactivity and dimensionality. CAD systems came in with the 20th century and created the revolution.
- CAD also allowed people to realize some very exact two-dimensional and rudimentary three- dimensional models, truly revolutionizing design and manufacturing. However, critical decision-making still relied heavily on 2-D schematic drawing, allowing many errors and waste of time and money.
- It has also defined modern 3-D visualization. Enhanced computing power and software capabilities offer now tools that are capable of simulating a real-world environment and building dynamic and interactive models within decision-making and strategic planning.

Advances in 3D Visualization Technologies

These transformations in 3D visualization technology result from the rapid advancement in software and hardware. These include some of the greatest revolutionizers:

- AutoCAD: A program common within most design industry practices has become a specialization level where 3D modeling features are drawn into lines planning detailed instances and customizable object representations.
- MicroStation: Multi-functioning because of its vast design capabilities in complicated 3D modelling, MicroStation offers great support to join other visualization tools making it a real choice for large industrial undertakings.
- Lumen RT: Real-time rendering allows for easy visualization and modification of designs. It also has the power to simulate lighting, textures, and environmental conditions to make rendering feel real.
- BIM (Building Information Modeling) Platforms: Work revolves around the association of 3D visualization with data management. Thus, each stakeholder will have access to correct up-to-date information.



Applications Across Industries

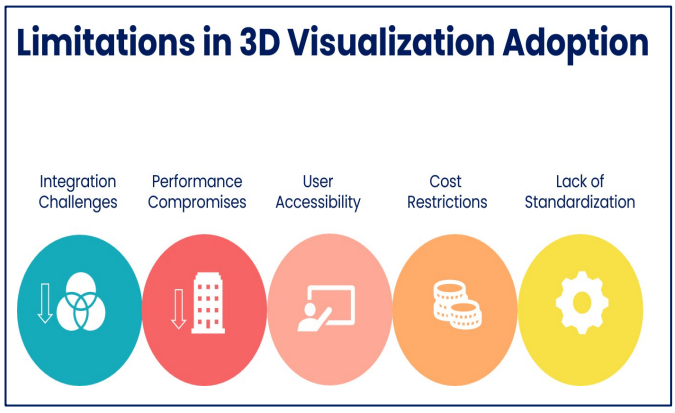
3D visualization is versatile and not limited to a single field. It becomes immensely important across the domains:

- **Architecture and Urban Planning**: The architect can present the design to the clients before demonstrating simulated effects on the environment or optimizing space in an urban development.
- **Automotive Industry:** From designing manufacturing facilities to simulating production workflows, everything with 3D visualization would make it all efficient and precise.
- **Investigation of Medical:** 3D visualization is the basis of advanced techniques such as MRI and CT, giving very detailed representations of internal organs to aid diagnosis and treatment.
- **Entertainment:** The film and gaming industries have generated presentations that are captivating and interesting to further immerse audiences into the illusion.
- **Aerospace:** The engineers use 3D models to design and test modern machinery to guarantee safety and functionality before production.

4. RESEARCH GAP IDENTIFICATION

Overview of Current Limitations in 3D Visualization Adoption

- 3D visualization technologies have gained increasing popularity and promising approaches in their transformative capability applications; however, industrial uses have faced impediments. One of the most significant limitations is the complexity and cost associated with such technologies. For many organizations and especially SMEs, the high initial investment in hardware, software, and training poses a significant deterrent.
- 3D visualization tools have not integrated well with old systems. Industries usually live on long-established workflows and platforms, which often are not compatible with modern 3D visualization tools. It brings inefficiencies and a lack of seamless data exchange, reducing the effectiveness of these technologies.
- Another critical issue is that access to these tools is limited to nontechnical stakeholders. Quick intuitive visualizations are possible with 3D models, but to create and manipulate them requires the acquisition of specialized knowledge. And thus, the outputs will often make little sense to those decision-makers without any technical skills: a surefire set-up for creating a black hole between teams.



Despite impressive technologies in 3D visualization, several research gaps and limitations remain:

- **Integration Challenges:** Most industries suffer from the inability to integrate 3D visualization tools with their legacy systems, and this often requires additional manual intervention due to data incompatibility, reducing efficiency.
- Realism and Performance Compromises: Real-time rendering has made great strides, but it's still not capable of producing high realism with no degrading of performance, especially when considering large industrial models.
- User Accessibility: Special training is usually required to use advanced tools, which creates restrictions for non-technical stakeholders. This limitation hinders its use in the general population.
- Cost Restrictions: High licensing and hardware make such an essential area of work inaccessible to many SMEs.
- Lack of Standardization: There is no universal standard for formats or protocols of 3D visualization; it leads to inconsistencies and inefficiencies while working together on a project.

Overcoming these research-facing challenges will be critical for advancement in this field and thus unlocking the future the potential of 3D visualization in strategic layout planning and beyond. 26 27

5. METHODOLOGY

Tools and Technologies Used

- MicroStation is typically used to develop models which allow very exact and thorough detailing of designs.
- Lumen RT has been used for rendering and simulation, with real-time visualization providing environmental context.

Detailed Workflow

- Data Collection and Preparation:
  - Collect site-specific data such as topographical maps, factory layouts, and logistics.
  - Clean and structure the data to be compatible with a 3D-modelling software.
- Model Creation and Framework Integration: 19 o Create detailed 3D models in MicroStation based on what spatial and operational parameters are being incorporated into them.
  - Topographical data include the datasets required for accurate real-world representation.
- Real-time rendering and Simulation with Lumen RT:
  - Apply realistic textures, lighting, and environmental factors to the models.
  - Simulate workflows, bottlenecks, and layout optimization.

Microstation

3D Building Models

Lumen- RT

3D Visualization

Validation Techniques

- Comparison of 2D versus 3D Models in Strategic Decision-Making Assessment:
- Comparison of the traditional layout with the new 3D models.

- Assessing how much these enhancements in understanding among 8 stakeholders as well as the decision-making speed and accuracy.

Stakeholder Feedback:

- Getting responses from cross teams of factory planners, engineers, and decision makers.
- Use the stakeholder feedback to evolve models to fix concerns and validate overall effectiveness.

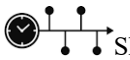
6. FINDINGS

Overview of Rendering Processes

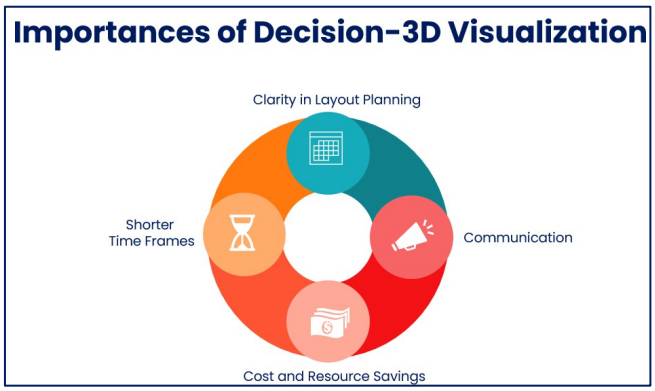
The rendering processes investigated in this study have come a long way over the years- from simple wireframes to highly sophisticated photorealistic representations. This has indeed changed the way industries see and work with complex data. 6 o Wireframe Models:

- Wireframe modeling presents the preliminary stage of 3D visualization. It is skeleton frames that give the shapes and structures of an object. While not very detailed and not very good to look at, they represent excellent initial design planning because they are simple and computationally efficient.
- Surface Models: Some bone structures join surfaces in surface models. Thus it clarifies somewhat the object's contour and its spatial relationships. Such models are very much used in the middle design stage when the basic aesthetic and the basic functional intentions of the object are to be assessed.
- Solid Models: Solid modeling realizes visualization through the data of volume and mass, which makes the approach robust and realistic. Being in such a solid model, it is feasible to perform simulations and analysis like stress tests on the model itself; hence, it is one of the prerequisites for industries such as automotive and manufacturing.
- Photorealistic Rendering: Photorealistic rendering is the topmost approach of 3D visualization, wherein the models have achieved lifelike accuracy. It uses the most advanced techniques of lighting, texture mapping, and shading to mimic real-life environments. Lumen RT is of great importance in reaching that level of detail because it is necessary for presentations and buy-in into the project. The transition from wireframes to photorealistic images makes clear the increase in detail, realism, and usefulness. All these contribute to aiding better decision-making during every stage of the design and implementation

Key Improvements in Decision-Making Through 3D Visualization

- The most recent advances in decision-making across diverse sectors are attributed to 3D visual technologies. These include the following improvements:
-  Greater Clarity in Layout Planning:
  - Three-dimensional perspectives within visualization tools help eliminate confusion from 2D layouts.
  - Factory planners can now assess the spatial relations, machinery placements, and paths of workflow with a very strong accuracy, reducing errors and rework.
  - Operational scenario simulations reveal potential bottlenecks and enable optimizations to the layout prior to implementation.
-  Improved Communication Among Interest Groups:
  - Photorealistic models indeed provide common language for all the technical realities and for all yer non-technical ones.
  - 3D visualization of the factory layout allows clients, engineers, and executives to have a shared vision of the project.
  - Interactive models allow stakeholders to navigate and even explore layouts in real-time which brings about collaborative decision making all the way down to reducing resistance to proposed changes.
-  Shorter Time Frames for Decision Making:
  - Cut time by using real-time rendering like that done by Lumen RT to stay up to date and test scenarios in real time bringing unanimity.
  - Predictive analytics plus 3D models will provide useful insights and thus forward decision-making.
- Cost and Resource Savings:
  - Modifications in construction would be very costly but would be reduced by early identification of design flaws using 3D visualization.
  - Costly modifications would be costly during the stage of construction and were thus reduced through early identification of the design flaw through 3D visualization.
  - With highly accurate models, the precision for material estimation and resource allocation thus reduces wastages.
  - These would cumulatively promote greater efficiency, precision, and even satisfaction in

decision-making processes, thus establishing 3D visualization in modern-day industrial planning.



7. IMPLICATIONS

Industrial Benefits of 3D Visualization

Adoption of 3-dimensional visualization technology has brought forth quite a few great gains, transforming the whole area of planning and decision-making in industries. Some of these benefits are:

- Increased Accuracy and Reduced Planning Time:
  - With full view of spatial configurations and layouts, 3D visualization ensures accuracy in planning processes.
  - Suppresses most errors that occur in 2D plans, for example, wrong scaling and misplaced machinery.
  - Brought about faster cuts and iteration of designs thus facilitating shorter overall timelines for projects.
- Better Resource Allocation and Workflow Management:
  - From visualization tools, it is possible to understand clearly the expected use of resources so they can effectively allocate space, materials, and manpower.
  - Workflow simulation will identify bottlenecks within the production process that will recommend setting adjustment to achieve better productivity.
  - Scalable real-time updates into 3D models have secured planning flexibility to ensure that such resources are efficient, even where requirements of the project by the final clients have changed.

Sector-Wise Applications

3D visualization improves the technique and processes of many fields because it addresses the various challenges faced and offers unique solutions. Some of the very prominent fields and uses are:

- Architecture
  - To Design Precise and Creative Buildings: 3D visualization helps architects to design buildings more precisely and creatively while integrating the structural, aesthetic, and functional values into the design.
  - Virtual walk-throughs: this enables the client to see the design even before construction, thus ensuring the expectation meets such a construction.
  - The environmental simulations assess and measure the factors within sustainability as lighting, airflow, and energy effectiveness that an excellent design offers. 22 23 24 25 26 27 28 29 1
- Automotive:
  - Automobile manufacturers apply a triple filter to define their assembly lines, optimize the layout of parts, and improve production flows.
  - The virtual model prototypes lessen the prototyping practice towards physical modelling, reduce the cycle time in development, and incur fewer costs.
  - Crash simulations as well as performance tests done on three-dimensional models improve the safety and reliability of vehicles.

3D visualization tools are increasingly being used by industry leaders as they become more innovative and resourceful with their production processes.

The emergence of 3D visualization tools couriers a new era in thinking in terms of design, planning, and execution for any industry. Not just simple sketches or stilled 2D CAD drawings, today's offerings are dynamic, animated, engaging taking one into the realm bridging the conceptual and the executed. Contrary to what some might think about its complexity, the actual process of 3D visualization comes really easy with the current advancements in software technologies and visual capture methodologies. These tools simply integrate and extend a long, historical field of design practice supported by familiar techniques such as computer-aided design (CAD), infrared imaging, animation software, and high-resolution photo capture. The synergy between these methods allows the user to lay out their concepts in clarity and detail.

Capture underpins the entire 3D modelling process with respect to delivering loyalty and relevance in every visualized aspect.

It uses a variety of state-of-the-art technologies customized to project specifications. Of old techniques, however, standard photography and laser scanning, and aerial imaging,

and even the newest: motion capture have earned their places as the most frequently adopted. Each one's merits include the following:

- Photography and Aerial Imagery. Most ideal for large sites, such as factories, or cities. High-resolution aerial photographs provide a bird's eye view for the overall scale of the models.
- Laser scanning. It makes exact measurements by pinpointing surfaces that would allow them to be mapped. This is quite useful especially for the interiors of factories or complicated designs of machinery.
- The entire data which has been captured can be brought to life through the rendering procedure, and at the end of it, all that can be translated to make interpretations in creating an action-oriented interactive 3D image.

Rendered models are excellent models for any project that one may include in three- dimensional images. These act as a guide for development stakeholders in decision- making and implementation. Such models can never be static images but are stories in action capable of:

- Conducting Virtual Walkthroughs: Where users navigate through the whole model to see the layout firsthand and detect any pinch points or inefficient designs.
- Simulating realities: Models can represent an impending operational condition such as the movement of materials in a plant, or traffic in an urban design.
- Increasing efficiency in regard to collaboration: The very natural, visual nature of the 3D models means that anyone-even those with little technical expertise-can understand and contribute to discussions and decisions.

Don't be put off by how broader, deeper, and more detailed these models are for project goals.

Almost every element of the model-be it the layout of a production line, the ergonomy of machinery installations, or the logistical flow of materials-is designed accurately. Such accurateness quickens the planning and processing stages by eliminating ambiguities and lowering errors. These models also provide a very detailed preview of the intended target which will avoid expensive rework from corrective changes and saves generous time and resources.

- Medical Imaging:
  - In most of the healthcare settings, there are 3D visualization applications in such exercises as diagnostic imaging, preoperative and surgical planning, and medical device development.
  - Data from advanced imaging technologies have changed the scene, further allowing the creation of anatomical models such that surgeries and care can be done with higher precision.
  - This shared vision technology creates a perfect link between engineers and health care professionals.
- Urban Planning.
  - 3D modelling now provides the city planners with a useful tool in planning infrastructure using simulation of various factors such as traffic flows, population densities, and environmental effects.
  - They can view simulated urban environments and examine those attributes in terms of their feasibility and aesthetics with stakeholders towards proposed developments.
  - Citizens can visualize and provide feedback on community projects.

Challenges and Considerations

Adopting 3D visualization technologies brings enormous advantages, but certain factors will have to be taken into account if implementation is to be successful:

- ***Costly Initials:***
- The business enterprise relies very much on the acquisition of advanced software and hardware, together with qualified personnel as significant contributions to high upfront investments.
- Therefore, these costs are unaffordable for small and medium-sized organizations limiting their capacity of financing 3D technologies into their moulds.
- Need of Skilled Personnel:
  - Utilization of such tools for 3D visualization requires training in the software operation, data interpretation, and design principles.
  - Training and professional development will be continuous to catch up with the very fast-growing technologies.
- Integration Problems with Existing Systems:
  - By meeting these challenges, industries will access all benefits that technology in three-dimensional visualization holds for productivity and innovation in addition to competitive advantage.
  - A majority of organizations have encountered hurdles arising from a lack of integration of 3D visualization tools within legacy systems and workflows.

There arises a mismatch, therefore, between various platforms causing inefficiency and loss of data. 22

Addressing the same entails proper planning, collaboration between departments, and investment in interoperability solutions.

8. FURTHER RESEARCH AGENDA

Integrating AI and Machine Learning in 3D Visualization

Artificial Intelligence (AI) and Machine Learning (ML) portend very great lenses through which they redefine 3D visualization while offering more than traditional means. Research into the areas will concern AI and ML for:

- **Predictive Modeling:** AI could enable prediction of some critical issues in factory layout, such as bottlenecks or inefficiencies, using historical data and patterns in the factory, thus allowing proactive modification in design.
- **Smart Object Behavior Simulation:** The ML algorithms can simulate the realistic behavior of machines and flows in a 3D space. For example, predictive simulation can demonstrate how the conveyor systems would respond to production load variations, which would help in optimization.
- **Data Conversion Automation:** Data that is raw can easily be injected into the 3D models by AI. There can be tools that convert 2D blueprints into fully detailed 3D designs, thus saving time and effort for manual work chances.
- **Proffer Change to Systems on All Decisions:** Merge Machine Learning with real-time data from the sensors to have dynamic clear images for the decision makers on the factory. In turn, the layouts would be dynamically adjusted based on real-life conditions.

In the nearer term, future research would aim to create tools driven by AI that democratize and allow even non-technical stakeholders access to 3D visualization

Enhancing User Interaction with Immersive Technologies (e.g., VR).

Immersive technologies like Virtual Reality (VR) offer the ability to engage with 3D visualizations in ways never before possible, promoting a more profound experience and understanding. Areas of future exploration include:

- Interactive Factory Walkthroughs: Stakeholders can take virtual navigation through factory layouts using headsets and experience placements of machinery, and designing workflows, as though they are inside the factory.
- Collaborative Design Platforms: Immersive technologies will enable real time collaboration for teams that are separated by miles apart. They can brainstorm and make common decisions more effective jointly via shared VR spaces.
- Training and Simulation: VR-based training modules will allow new factory layouts and machinery for training purposes in preparation for workers. For example, simulations could help by training staff in how to respond in emergency situations, sliding equipment malfunctions, and improving readiness and safety protocols.

Research could also be in perfecting the affordability and usability of these VR tools and seamlessly integrating them into already existent factory planning workflows.

Potential for Automation in Factory Layout Planning

Automation developed in order to revolutionize planning for a factory layout, lessen manual input, and speed up decision-making. Areas that will be looked at include:

- Automated Design Generation: With AI-powered software, it is possible to automatically create numerous design layouts using key indicators such as space, workflow efficiency, and safety regulations. The layouts are then analyzed and revised instead of starting from scratch.
- Adaptive Workflows: Factory layouts become adaptive by including IoT sensors embedded in their consideration. An automated system, for instance, can redesign one's place according to the newly added products or production volumes.
- Robotic Help for the Making of the Models: Equipment like drones and robotic arms can be employed for the acquisition of spatial data and its translation into detailed 3D models, ensuring very accurate and efficient model creation.
- Standardization across Industries: Automated Planning Tools can integrate best practices and compliance regulations into the system in order to prevent eliciting oversight from regulatory compliance.

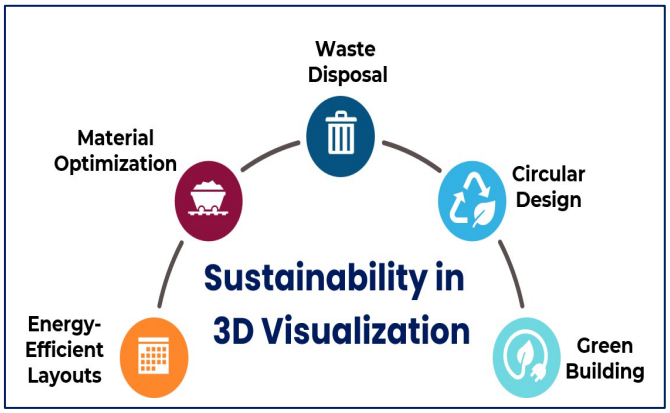
Research into ethical, costing, or any other constraints concerning the full automation of factory planning systems can also be encouraged.

Sustainability and Innovations in Industrial Design

Sustainability is a key focus for increasingly diverse industries today. One of the primary driving forces behind increased eco-friendliness in industrial design layouts is 3D visualization. Future research areas may include:

- Energy-Efficient Factory Layouts: 3D visualization tools to determine energy-consumed spaces in a factory and suggest designs or layouts that minimize energy use, such as optimizing lighting placement and airflow systems.

- Material Optimization: New simulation tools must be used to evaluate the specific environmental impacts of materials to be used in the construction and machinery. Therefore, planners may select sustainable alternatives without losing the functionality.
- Waste Disposal Planning: Factory plans should include areas for the segregation and recycling of wastes designed in a 3D way.
- Circular Design Principles: Research could investigate how 3D visualization can contribute to designing factories that enable circular economies through re-use, remanufacturing, and recycling.
- Green Building Certifications: Planners could thus leverage visualization tools to attain certainties such as LEED (Leadership in Energy and Environmental Design) through simulations of compliance with sustainability principles and criteria.



9. CONCLUSION

The development of 3D visualization in all industry sectors has changed the game for presenting factories or other commercial entities planning, designing, and optimization works. In this way, the study has demonstrated the multiple possibilities of different ways, as potential transformations that 3D visualization technologies can offer, particularly to factory layout planning and related fields.

Recap of the benefits and transformative potential of 3D visualization.

These advantages of 3D visualization are indeed very deep and far-reaching. Truer and fuller representations of factory layouts and workflows allow stakeholders to make better decisions. Other benefits would include:

- Greater Accuracy: Using topographical data and exact measurements makes sure that factory layouts remain very close to actual conditions.
- Enhanced Decision-Making: 3D models, and especially photorealistic renderings, provide clarity that two-dimensional blueprints cannot reach. Clarity enhances strategic planning for and allocation of resources.
- Improved Collaboration: Interactive models serve as universal language, shortening the time needed by technical and non-technical people to come to consensus with fewer misunderstandings.
- Economy of Resources and Cost: Early detection of design shortcomings, inefficiencies, cost precious revision cuts in the implementation phases.
- Flexibility: Planners are able to try multiple scenarios rapidly, with real- time rendering and simulation capabilities, leading to adaptive strategies in a changing industrial landscape.
- These advantages explain how 3D visualization has moved beyond just being an ornament to serving as an important strategic decision-aiding tool.

Discussion of findings and implications for future industry practices.

- This study suggests a necessity which is growing to adopt advanced technology of 3D visualization for production across industries. Important highlights include:
- A Paradigm Shift in Planning: The shift from the conventional method to a new dimension, that is 3D visualization, takes us towards an epoch in which planning becomes periodical instead of static. Real-time simulation and predictive modeling allow factories to be agile, future-ready, and flexible.
- Enhanced Stakeholder Engagement: Case studies showed how photorealistic and interactive models improve many different stakeholders' communication and prove to be a critical factor for project success.
- Opportunities for Innovations: It is foreseen that the amalgamation of emerging technologies, such as AI, ML, V and VR, will also revolutionize 3D visualization. These can make planning solutions smarter, more interactive, and sustainable.

Clear are implications: the industries investing in these will not only ensure higher productivity within their operations but will also secure their position at the forefront of innovation. On the other hand, it should also address the challenges and costs at the beginning, skills shortage, and integration with legacy systems to achieve the full potential of these tools.

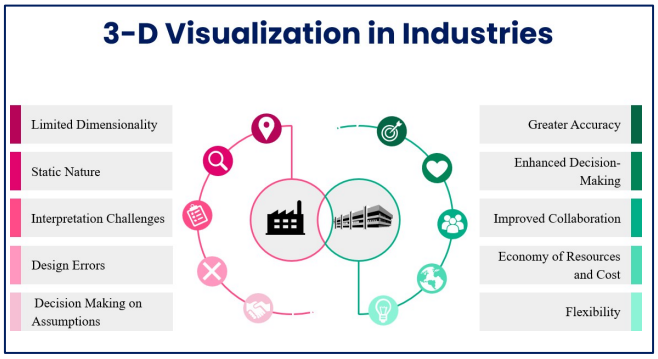
Final remarks on the integration of advanced visualization technologies in strategic planning.

Gone are the days when advanced 3D visualization systems were only considered luxuries in strategic planning; in today's highly competitive industrial environment, they are absolutely necessary for precision, flexibility, and preference for getting ahead.

With 3D visualization ensuring that complex layouts are visible to planners, operational scenarios are simulated, and real-time design modifications are implemented, all decisions would ultimately be factually based and consonant with organizational objectives. Furthermore, with the increased focus and relevance of sustainability and resource efficiency, these technologies become more important.

With further research and continued innovation, the future will reveal better possibilities. From AI-enabled automation to immersive VR experiences, the future of 3D visualization is sure to transform the industrial environment. Industries will significantly improve their operational capabilities by adopting these technologies to embrace a more sustainable and technologically advanced future.

In the opinion of leading researchers in this field, 3D visualization is still in its infancy, having started along a path marked by tremendous change. There is plenty of room for new standards of excellence to emerge in industrial planning, allowing industries to achieve more efficiency, collaboration and innovation in their operations. It is indeed high time to bring this change in practice.



10. DECLARATION

I, Sarosh Shariqur Khan, hereby confirm that the manuscript titled " Enhancing Strategic Layout Planning Phase with Advanced 3D Visualization Technologies authored by [Sarosh Shariqur Khan], has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to [Name of the Journal/Conference]. I/we declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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The Future of Living: How IoT is Transforming Smart Homes

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ABSTRACT

The research paper will explore a world of smart homes and what the future holds for it. The Internet of Things (IoT) has emerged as the new frontier in the digital world and the innovative change in how people and things connect with technology. The concept of smart homes is said to mean individual smart devices that interact with each other as an integrated system. With the capability of automating and controlling various aspects of homes, people can experience levels of comfort like no other and convenience to boot. Switching lights on and off, setting comfortable temperatures suitable for everyone in the house, managing energy usage, and even assigning chores involving housework to smart devices have made homes into smart spaces. Our primary objective of research is why shall people shift to smart homes. The research will study the current state of IoT in homes, what is the need of hour to shift into smart homes, the technology needed to achieve it. The research will show the current trends on how IoT is automating the surrounding environment. The research will emphasize how IoT in smart homes increase efficiency, safety and comfort and convenience of the home. The study will also identify challenges involved in IoT integration with smart homes including issues such as privacy invasion, data breach, and interoperability. The various means that will be adopted in the course of gathering primary data for the study are: In order to carry out the first research activity, we will make use of a self-administered questionnaire that will be administered on different respondents from different sample segments. The questionnaire format will comprise of simple multiple- choice questions on a 5-pointer scale to determine the amount of knowledge that the participants have in relation to IoT. Further, we will do chi square, correlation and different tests for testing the hypothesis. The current research has established that IoT has impacted homes considerably in terms of efficiency and effectiveness. Concerns over privacy and security, compatibility, lack of standardization are undeniable but we are confident that IoT technology has the potential to transform our living environments into effective, secure, comfortable smart nests. Moving forward further in the process of integrating IoT in smart homes, we strongly believe this one has huge potential for the future of smart homes or how we shall live in our very own environments.

Keywords: Internet of Things (IoT), Smarthomes, Automation, Security Privacy, Energy, Efficiency, User-Comfort

1. INTRODUCTION

The Internet of Things (IoT) is redefining our concept of home by creating a network of physical devices embedded with sensors, software, and other advanced technologies that allow these devices to communicate with each other and the cloud (Chen & Xu, 2021). This interconnectedness has brought the vision of a "smart home" closer to reality, where everyday objects—from lighting and thermostats to security systems and kitchen appliances—can be controlled, automated, and optimized to enhance comfort, efficiency, and security (Ghaffarianhoseini et al., 2017; Sadeghi et al., 2019). IoT technology enables homes to "learn" from occupants' habits and routines, making real-time adjustments that provide a more personalized experience while helping to save energy and improve home security (Palazoglu et al., 2020; Abdul Wahid & Hussain, 2019).

As consumer interest grows, the market for smart home technology is expanding, and this technology is reshaping our interactions with the spaces we live in (Caniato et al., 2020; Yin et al., 2020). Advances in artificial intelligence, machine learning, and sensor technology have made it possible for smart home devices to anticipate needs and respond automatically to environmental changes, creating living spaces that are more intuitive and adaptive than ever before (Zhao et al., 2020; Chaudhary & Kumar, 2020). Yet, despite these advancements, the widespread adoption of IoT in smart homes is not without challenges.

Key concerns such as data privacy, cybersecurity, and device compatibility present significant hurdles that must be overcome to ensure that smart homes are both safe and fully functional (Kumar & Malhotra, 2019; Alam & Khan, 2020).

One of the most pressing issues is data security; as more devices are connected within the home, the risk of unauthorized access and data breaches increases, creating a need for robust security measures that can keep pace with rapidly evolving threats (Halevi et al., 2020). Furthermore, device interoperability remains a challenge due to the lack of universal standards for smart home technology. This fragmentation can lead to compatibility issues, making it difficult for different devices and systems to work seamlessly together (Li et al., 2021; Liu et al., 2020).

This research paper explores how IoT is transforming smart homes, Its current state and future potential. By examining the latest technological trends and innovations, along with the barriers to adoption, this study offers insights into the future of smart home living. Through understanding these factors, we gain a clearer picture of how IoT will shape our living spaces, redefine our relationships with technology, and ultimately impact our daily lives (Hossain & Muhammad, 2019; Zhang et al., 2020).

Objectives of Research

1. To check the association between property value and convenience of IoT devices
2. To check the association between frequency of using smart home devices and wellness management (e.g., air quality, sleep tracking, fitness monitoring)
3. To check the association between frequency of using smart home devices and interacting with smart home security devices (e.g., cameras, motion sensors, locks)
4. To check the association between smart home devices improved the quality of life and IoT devices offer a good return on investment (ROI)
5. To check the association between thinking of buying more smart home devices and IoT devices have improved physical or mental well-being at home

2. REVIEW OF LITERATURE

1. ***Smart Homes and IoT: Emerging Trends and Transformational Impact:*** IoT technology in smart homes encompasses a variety of interconnected devices and systems capable of gathering, processing, and sharing data to automate and optimize household functions. Studies by *Sadeghi et al. (2019)* and *Yin et al. (2020)* emphasize that IoT-based smart home systems are evolving rapidly, introducing conveniences such as remote appliance management, intelligent lighting, and advanced security features, contributing to an overall enhancement in user comfort and lifestyle. Moreover, researchers have noted that IoT technology aligns well with the demand for energy efficiency, which can be achieved through optimized heating, cooling, and lighting systems controlled by intelligent algorithms (*Zhao et al., 2020*).

2. ***Enhanced Efficiency, Security, and Convenience:*** The literature consistently highlights IoT's capability to enhance productivity, security, and comfort within smart homes. According to *Ghaffarianhoseini et al. (2017)*, IoT- enabled devices facilitate seamless integration, allowing users to monitor and control different aspects of their homes remotely. Additionally, innovations such as voice- activated systems, which have been widely studied (*Zhou et al., 2019*), contribute to a user-friendly environment by making device interactions more intuitive. For instance, voice assistants can schedule tasks, adjust lighting, and manage temperature based on user preferences, thereby improving convenience and usability. In parallel, IoT applications in energy management have been shown to reduce electricity consumption and costs, aligning with sustainability goals and adding value through energy savings (*Palazoglu et al., 2020*).

3. ***Challenges in Smart Home IoT Adoption: Privacy, Security, and Interoperability:*** Despite its advantages, IoT in smart homes poses significant challenges, particularly concerning privacy and security. The literature reveals that data security remains a key concern as IoT devices continuously collect and transmit data, which can expose users to privacy risks (*Halevi et al., 2020*). Studies by *Kumar & Malhotra (2019)* and *Liu et al. (2020)* have underscored the risks associated with unauthorized access to personal information and potential breaches resulting from weak security protocols. Further challenges include device compatibility and interoperability, which prevent smooth integration between different manufacturers' devices. Researchers emphasize the need for standardization and regulatory measures to mitigate these risks and promote safer, more reliable IoT systems (*Li et al., 2021*).

4. ***Motivations for Transitioning to IoT-Driven Smart Homes:***

   Motivations for adopting IoT in smart homes are rooted in both individual benefits, such as enhanced quality of life, and societal needs, such as energy conservation and environmental sustainability (*Wang et al., 2020*). According to recent studies, users increasingly seek IoT solutions that support eco- friendly living, such as smart thermostats and energy-efficient lighting systems. Research by *Lee & Hwang (2021)* suggests that awareness and understanding of IoT's potential benefits are primary factors influencing adoption, indicating the importance of educational initiatives to raise public awareness.

5. ***Future Directions: Interdisciplinary and Ethical Considerations:*** Scholars advocate for interdisciplinary research that combines technological innovation with social, ethical, and regulatory perspectives to address the complex challenges of IoT implementation in smart homes (*Chen et al., 2021*). Future research should investigate the societal impacts of widespread IoT adoption, such as shifts in human- technology interaction and ethical concerns about dependency on technology. Moreover, research gaps exist in the scalability of IoT solutions for mass adoption, and potential localization effects, which may impact the efficacy of IoT solutions in varied geographic or cultural contexts (*Deng et al., 2022*). The development of comprehensive guidelines and frameworks for data privacy, device compatibility, and consumer education is critical to ensuring that IoT in smart homes can be adopted securely and sustainably.

3. RESEARCH GAP IDENTIFICATION

1. ***Standardization and Compatibility Issues:***

The interoperability of IoT devices is a challenge due to the lack of universal standard for IoT devices. Analysis can be carried out regarding how to cope with compatibility in order to simplify integrating multiple brands and devices.

2. Ethical and Privacy Concerns:

Recent advances in IoT devices have seen a large volume of personal data generated, thus it is not safe to govern the use of those data without considering the ethical issues regarding privacy, consent, and surveillance. It is possible that research investigate best practices, policy and ethical standards to balance innovation with the trust in users.

3. Long-term Health Impacts:

While IoT devices can result in better wellness, monitoring sleep and fitness, there are yet to be empirical studies to make claims about their long term benefits.

4. Environmental Sustainability:

An environmental footprint for IoT adoption is the energy use and the increase of e- waste. Sustainable design and lifecycle management for IoT devices need to be researched.

5. Scalability for Diverse Contexts:

The use of IoT technologies is under researched in different geographical, cultural and economic contexts. A variety of regions, demographics have different needs that can lead to increased accessibility and therefore adoption.

6. Cost Barriers and Accessibility:

Because of high costs of IoT systems, it's hard for these systems to reach everyone out there. The ways in which future studies may examine making IoT devices more cost effective and more modular for broader uptake could include the use of lighter materials, decreased assembly requirements, turnkey kits and/or metallic substrates designed for mass production.

The current limitations and potential future impact of IoT in smart home needs to be explored further to address these opportunities, to warrant the sustainable and ethical development of IoT technologies in smart home environments.

4. METHODOLOGY

The research was conducted using a survey to collect primary data from 110 respondents. The survey aimed to gather insights into the perceptions, behaviours, and attitudes toward IoT-enabled smart home technologies, focusing on areas such as convenience, sustainability, and security. To ensure the reliability of the survey instrument, Cronbach's alpha was calculated, yielding a score of **0.88**, indicating a high level of internal consistency. The data was analysed using various statistical methods, including the **chi- square test**, which examined associations between demographic variables (such as age and gender) and responses regarding the financial feasibility, adoption, and sustainability of IoT devices. Additionally, multiple regression analysis was employed to determine the impact of independent variables like age, income, and perceived convenience on outcomes such as the willingness to invest in IoT technologies and satisfaction with smart home devices. All analysis were conducted using statistical software, providing a robust foundation for understanding how IoT is transforming the future of smart

Reliability Statistics	
Cronbach's Alpha	N of Items
.880	26

Questionnaire design:

The questionnaire evaluates consumer behaviour towards IoT devices based on demographics, spending trend, perceived value, usage frequency, financial feasibility, sustainability, convenience, wellness management, home security among others. But primarily, it makes respondents rate their views using a Likert scale (1 – 5) for quantitative analysis. It gives clarity and logical flow which helps to navigate easily. Ethical considerations, such as informed consent and confidentiality are stressed to build trust and questions are recommended to pilot test with a view to refine the questions. Overall the questionnaire is aimed to gather actionable insights to further direct product development and its marketing strategies in the IoT sector.

5. DATA ANALYSIS AND INTERPRETATIONS:

Chi-Square Analysis: Chi-square test of independence was used to test association between the variables keeping the level of significance at 5% and the below results were obtained.

Hypothesis 1: There is no association between property value and convenience of IoT devices Variables: Increase property value, convenience H0:[Increase in property value] is not associated with [convenience of IoT devices] H1::[Increase in property value] is associated with [convenience of IoT devices]

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	58.906[a]	16	<.001
Likelihood Ratio	54.120	16	<.001
Linear-by-Linear Association	27.574	1	<.001
N of Valid Cases	110		

a. 17 cells (68.0%) have expected count less than 5. The minimum expected count is .16.

Table 1: p-value of Chi-square test

Since the p-value < 0.05 we will reject H0.

Hypothesis 2:There is no association between frequency of using smart home devices and wellness management(e.g., air quality, sleep tracking, fitness monitoring)

Variables: Frequency of using smart home devices, wellness management

H0:[Frequency of using smart home devices] is not associated with wellness management(e.g., air quality, sleep tracking, fitness monitoring) to purchase IoT devices.

H1: [Frequency of using smart home devices] is associated with wellness management(e.g., air quality, sleep tracking, fitness monitoring) to purchase IoT devices.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	38.655[a]	16	.001
Likelihood Ratio	31.708	16	.011
Linear-by-Linear Association	12.333	1	<.001
N of Valid Cases	110		

a. 14 cells (56.0%) have expected count less than 5. The minimum expected count is .22.

Table 2: p-value of Chi-square test

Since the p-value < 0.05 we will reject H0.

Hypothesis 3*:*There is no association between frequency of using smart home devices and interacting with smart home security devices (e.g., cameras, motion sensors , locks)

Variables: Frequency of using smart home devices, interacting with smart home security devices

H0:[frequency of using smart home devices] is not associated with[interacting with smart home security devices (e.g., cameras, motion sensors , locks)]

H1: [frequency of using smart home devices] is not associated with[interacting with smart home security devices (e.g., cameras, motion sensors , locks)]

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	27.387[a]	16	.037
Likelihood Ratio	25.215	16	.066
Linear-by-Linear Association	6.444	1	.011
N of Valid Cases	110		

a. 16 cells (64.0%) have expected count less than 5. The minimum expected count is .73.

Table 3: p-value of Chi-square test

Since the p-value < 0.05 we will reject H0.

Hypothesis 4: There is no association between smart home devices improved the quality of life and IoT devices offer a good return on investment(ROI).

Variables: Improved quality, good ROI

H0:[improved the quality of life] is not associated with [IoT devices offer a good return on investment(ROI)]

H1: [improved the quality of life] is associated with [IoT devices offer a good return on investment(ROI)]

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	34.714[a]	16	.004
Likelihood Ratio	28.949	16	.024
Linear-by-Linear Association	21.085	1	<.001
N of Valid Cases	110		

a. 16 cells (64.0%) have expected count less than 5. The minimum expected count is .22.

Table 4: p-value of Chi-square test

Since the p-value < 0.05 we will reject H0.

Hypothesis 5:There is no association between thinking of buying more smart home devices and IoT devices have improved physical or mental well-being at home Variables: Buying smart home devices, improved physical or mental well-being.

H0: [thinking of buying more smart home devices] is not associated with [IoT devices have improved physical or mental well-being at home]

H1: [thinking of buying more smart home devices] is associated with [IoT devices have improved your physical or mental well-being at home]

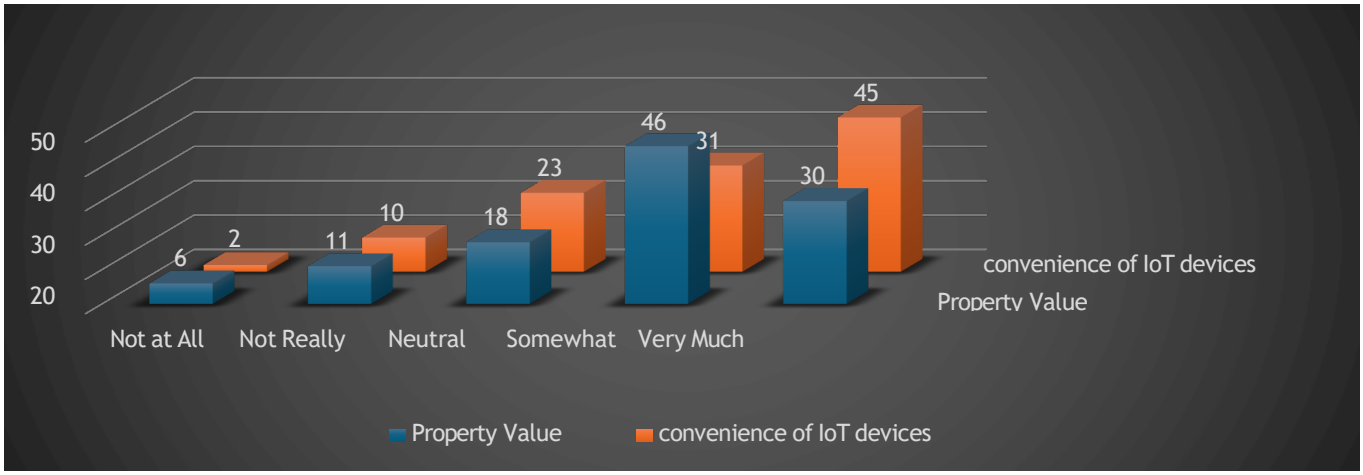
Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	30.114[a]	16	.017
Likelihood Ratio	31.889	16	.010
Linear-by-Linear Association	10.745	1	.001
N of Valid Cases	110		

a. 18 cells (72.0%) have expected count less than 5. The minimum expected count is .58.

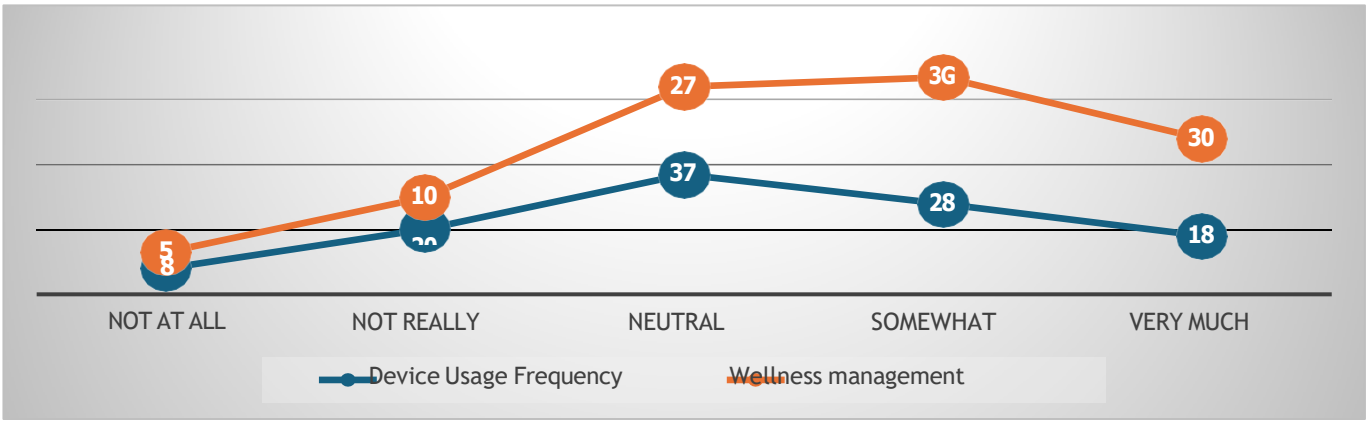
Since the p-value < 0.05 we will reject H0.

TABLE 5: p-value of Chi-square test

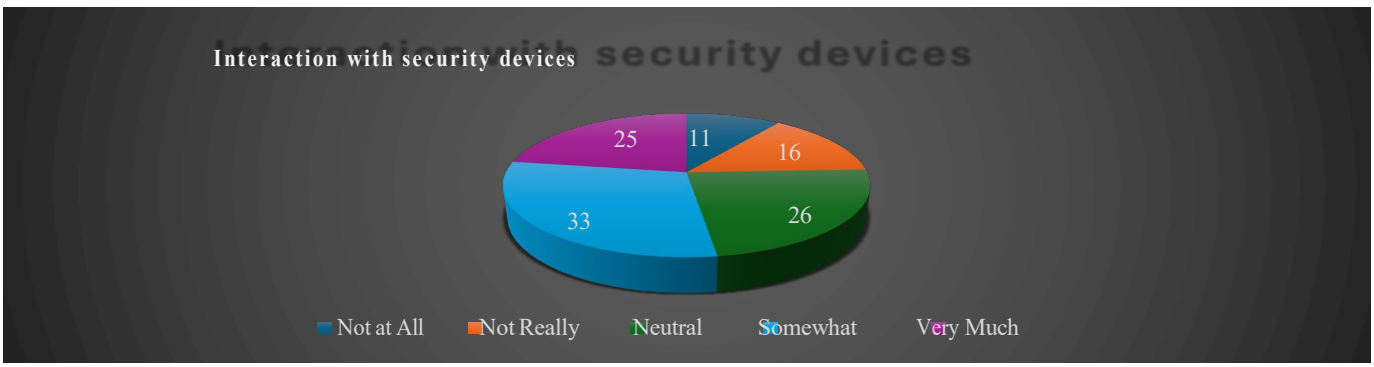


According to Hypothesis 1 there is a significant association between property value and the convenience of IoT devices, with a p-value less than 0.05. This suggests that IoT devices could serve as a value-adding feature for property owners. Developers and real estate agents might promote IoT-enabled features as key selling points, potentially increasing the demand for smart homes that enhance property values.

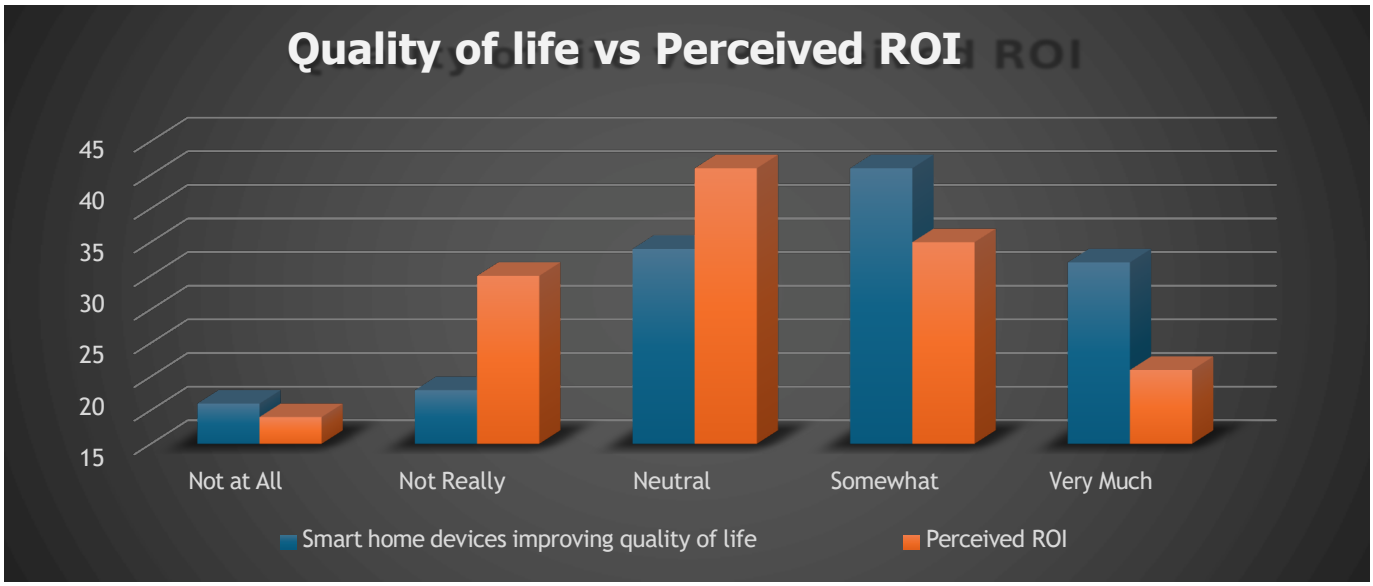
According to graph given above most of the respondents i.e. 76 out of 111 think that convenience is important to them while buying smart home devices and these devices increase the property value.



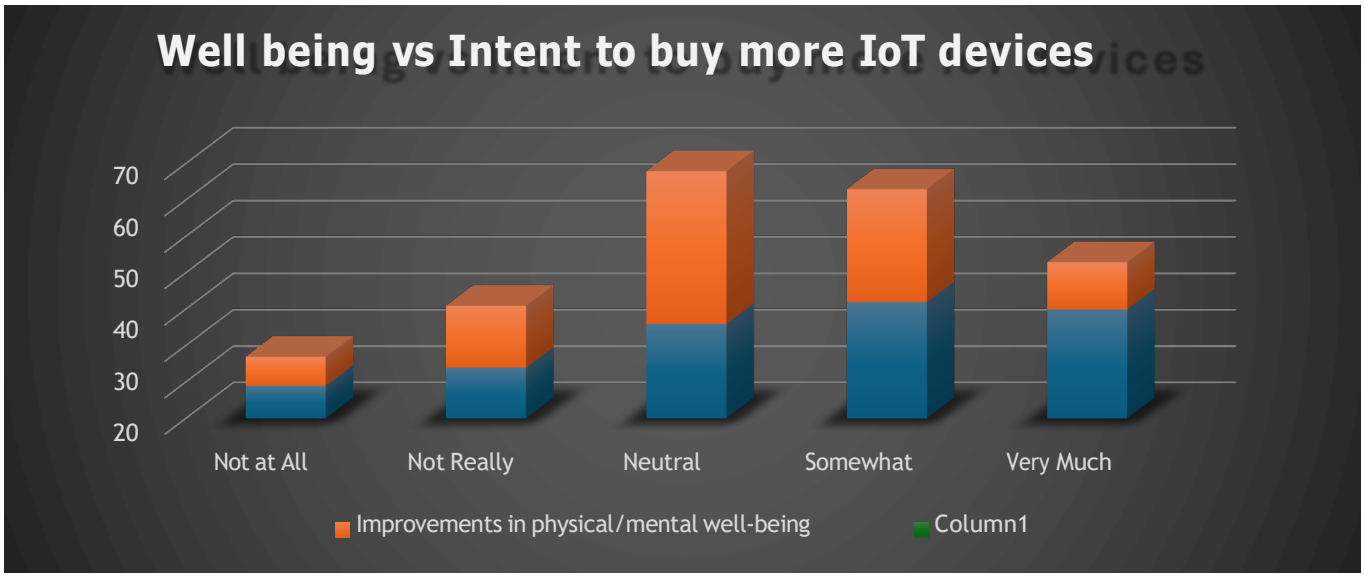
As demonstrated by Hypothesis 2 and above line graph, Frequency of device usage is significantly associated with wellness management ($p < 0.05$), highlighting how frequently people use devices for air quality, sleep tracking, and fitness. The positive association here implies that IoT-enabled wellness features are significant for regular users. This might encourage manufacturers to focus on health-centred innovations, driving consumer interest and highlighting the benefits of IoT for improving home health and wellness.



According to Hypothesis 3 there is a significant association observed, with increased device usage frequency correlating with enhanced interaction with security devices ($p < 0.05$). The positive association found suggests that frequent IoT users prioritize home security, likely boosting interest in IoT for safety-conscious individuals. This can guide IoT developers to focus on user-friendly security features, making these devices more attractive for consumers focused on personal and family safety.



Hypothesis 4: A notable association ($p < 0.05$) between quality-of-life improvements and perceived ROI, suggesting that users find value in these devices. A strong association here suggests that users who feel IoT devices improve their lives also see financial benefits. This is important for IoT marketers, as promoting both the lifestyle and financial advantages can attract more users who seek long-term value.



As per the Hypothesis 5, users who reported improved well-being at home also showed a higher interest in purchasing more IoT devices ($p < 0.05$). A positive association here highlights IoT's role in enhancing well-being, leading users to expand their smart home systems. This suggests that the perceived health benefits of IoT could drive repeat purchases, and it encourages companies to develop additional wellness-focused devices.

6. FINDINGS

1. Significant Association Between IoT Devices and Property Value:

Explanation: It means that having IoT enabled devices makes that property more valuable. Smart home technologies like automated lighting, thermostats and security systems makes homes more appealing to potential buyers, the convenience

and modern appeal is what makes them attractive. IoT integration can sell the product for developers and real estate agents as a means of increasing the market value.

2. Frequent Device Use Correlates with Better Wellness Management:

Explanation: Directly producing the dividends in wellness and management, IoT devices like air quality monitors, sleep trackers, and fitness tools make up the sphere of devices. The correlation implies that people who frequently use these devices have better chance to maintain healthy atmosphere and routine, confirmed by IoT, as a major reason to enhance personal health.

3. Positive Link Between IoT Interaction and Home Security:

Explanation: It offers that by frequent usage modified security features such as smart cameras, motion sensors, and locks, security adherence till the end user increases among IoT users. It shows that for users, safety is a priority and IoT provides safe and readily available security solutions. The same boost further strengthens user trust and reliance on IoT for home security.

4. Users Perceive IoT as Enhancing Quality of Life and Financial Returns: Explanation: The implication is that in IoT, there are clear lifestyle improvements in terms of convenience, energy savings and comfort. In addition, users have placed value in using IoT as a cost effective investment, namely to reduce utility expense, streamline household operations, and increase property value. The two benefits of IoT are these: gain money and improve living standards.

5. Improved Well-Being Encourages Further IoT Investments:

Explanation: Users who said they experienced improved physical or mental well-being like less stress, greater comfort, invest more in additional IoT devices. What this means is that we can infer from this a self-reinforcing cycle of adoption induced by perceived value of the benefits of IoT as the users experience these benefits they are motivated are motivated to expand their smart home ecosystems.

7. RECOMMENDATIONS:

1. Prioritize Privacy and Security: With so many devices connected in smart homes, ensuring privacy and data security is essential. IoT providers should focus on using strong encryption, secure login methods, and timely updates to keep user information safe. It's also beneficial to educate users on best practices for safeguarding their smart devices.

2. Streamline Device Compatibility: Many IoT devices struggle to connect seamlessly with others from different brands, creating a fragmented experience. Moving toward universal standards would allow devices to work together effortlessly, making it simpler for users to build a cohesive smart home environment.

3. Raise Awareness and Educate Users: A significant portion of potential users still lacks knowledge about the benefits of smart home technology. Companies should offer user-friendly setup processes and clear educational resources to help people understand how IoT devices can make their lives easier and more efficient.

4. Focus on Energy-Efficient Solutions: As environmental awareness grows, so does the appeal of energy-saving technology. Designing devices that optimize energy use and align with sustainable practices can attract eco-conscious consumers, making IoT technology more appealing and beneficial in the long run.

5. Offer Cost-Effective, Modular Options: The price of IoT devices can be a barrier for many users. Providing affordable starter products and allowing users to expand their setup over time can make smart home technology accessible and customizable to individual needs and budgets.

8. LIMITATIONS

While this research provides valuable insights, it does have its limits. The study's sample size while informative, is relatively small, which may affect how well these findings apply across different populations. Self-reported responses may also introduce some biases, as participants might overestimate the benefits they experience. Additionally, this study focuses on the current state of IoT devices, which may quickly become outdated as technology advances. External factors like regional access, economic considerations, and varying regulations were outside this study's scope, but they likely play a significant role in shaping adoption patterns. Future studies should include these aspects to better understand how IoT will impact homes worldwide.

9. FUTURE RESEARCH AGENDA

1. Examining Regional Differences in IoT Use: Research can explore how cultural and regional differences affect the adoption of IoT technology, considering factors like income, infrastructure, and local regulations. Understanding these variations can help make IoT more accessible worldwide.

2. Studying the Long-Term Health Impact of IoT Devices: Investigating how ongoing use of IoT devices affects users' health, such as sleep quality and overall well-being, can provide valuable insights into their potential benefits and drawbacks.

3. Evaluating IoT's Environmental Impact: As IoT technology becomes more prevalent, studying its environmental footprint, including energy use and

electronic waste, will help identify ways to make it more sustainable.

4. Researching Standardization and Compatibility: Future studies can focus on creating universal protocols and standards to improve device compatibility, making it easier for users to integrate various IoT devices within a single home ecosystem.

5. Addressing Ethical Concerns Around Data Collection: IoT devices collect a significant amount of personal data, and researching the ethical implications of this practice—such as privacy, consent, and potential surveillance—can ensure that smart home technology remains safe and respectful of user boundaries.

10. DECLARATION

I, Shagun Rana, hereby confirm that the manuscript titled "**The Future of Living: How IoT is Transforming Smart Homes**" authored by Shagun Rana, Sashank Upadhyaya and Sadhna Singh has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to the International Management Perspective Conference 2025 (IMPeC-25)

I/we declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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Decision Science by using Multi-methods of Bibliometric Analysis

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ABSTRACT

This research provides step-by-step methodological guidelines for conducting a bibliometric analysis by using Biblioshiny application, an R based tool within the Bibliometrix package. The study uses the topic of "decision science" as an example of how to perform bibliometric analysis.

Key words: Decision science, Bibliometrics, Citation Analysis, Co-Citation Analysis, Co-Occurrence Analysis.

1. INTRODUCTION

Bibliometric analysis, introduced by Pritchard (1969), derives its name from the Latin and Greek roots: *"biblion"* meaning books or documents, and *"metricus"* meaning measurement. It is fundamentally a quantitative method used to evaluate collections of academic documents, focusing on the performance and impact of research outputs.

Using a Scopus query covering the period from 1964 to 2024, a total of 2,048 documents related to bibliometric analysis were identified, highlighting the growing academic interest and contributions to this field over six decades.

Decision science, as a multidisciplinary field, is rapidly evolving with advancements in data analytics, artificial intelligence, and computational tools. The increasing complexity of decision-making in industries and public policy necessitates robust frameworks to analyze trends, evaluate impacts, and identify opportunities. Bibliometric analysis has emerged as a key method for understanding the intellectual landscape of decision science by examining publication patterns, collaboration networks, and thematic clusters.

By leveraging tools like Scopus and techniques such as citation, co-citation, and co-occurrence analysis, researchers can uncover influential works, track emerging trends, and identify research gaps. This approach reveals the field's steady growth, with significant focus on topics like risk analysis, optimization, predictive modeling, and behavioral decision-making, alongside newer themes like AI and sustainability.

The insights gained from bibliometric analysis not only enhance the understanding of decision science but also inform interdisciplinary collaboration, strategic decision-making, and real-world applications. Addressing gaps in areas such as ethical AI and automated decision-making, while fostering global collaboration and integrating behavioral sciences, can drive innovative solutions to complex challenges. This article explores the methodologies, findings, and future directions of decision science, emphasizing its critical role in shaping effective, ethical, and impactful decision-making processes.

2. LITERATURE REVIEW

This bibliometric analysis of Emergency Decision-Making (EDM) research from 2010 to 2020 reveals a significant rise in publications since 2014, underscoring the increasing focus on effective decision-making in emergencies. China leads in both the number of publications and citations, with Wuhan University of Technology as the top institution. Xuanhua Xu is the most prolific author in the field. Key research themes include multiple-criteria decision-making, Bayesian networks, and decision support systems, with evolving keywords reflecting shifting research interests. The study highlights areas for future exploration, particularly in integrating advanced technologies and addressing gaps in real-time and cross-disciplinary decision-making. (Lin-Xiu Hou1, 2021)

The bibliometric analysis of Multicriteria Decision Analysis (MCDA) in healthcare from 1999 to 2021 shows significant growth, with 410 publications and an annual growth rate of 32%. The United States led in contributions, followed by the UK, Turkey, and China. Key research areas included the Analytic Hierarchy Process (AHP), health technology assessment (HTA), and healthcare waste management, with a recent focus on COVID-19 and fuzzy TOPSIS methods. The study highlights MCDA's critical role in healthcare decision-making and points to opportunities for further advancements in methodology and application. Similarly, the analysis of fuzzy decision-making research, covering 8,135 papers published from 1970 to 2014, reveals its growing significance in complex, uncertain decision environments. The USA has been the dominant contributor, but there has been a notable rise in contributions from Asian countries, particularly China. Prominent journals like *Fuzzy Sets and Systems* continue to lead, with influential authors and institutions shaping the field's development. Both analyses underline the continued importance and potential for further

growth in these decision-making approaches. (Zeqi Dai 1†, 2022)

The paper "Large-scale Group Decision-Making: A Bibliometric Study" provides a comprehensive analysis of the growing field of large-scale group decision-making (GDM), which is increasingly relevant in sectors like corporate, governmental, and community decision-making. It highlights the role of modern approaches, such as technology and structured deliberation, in enhancing these processes. The study identifies key trends, such as the rise in publications since 2018, with notable contributions from authors like E. Herrera-Viedma and countries like China and Spain. Through citation analysis, it emphasizes the influence of highly cited works in shaping the research landscape, underscoring the importance of ongoing research to address challenges and improve GDM methodologies. ("Juan Carlos Gonzalez-Quesada ´ a, 2024) Xiao, Yao, and Wang's bibliometric analysis of the top 100 most cited papers on endometrial carcinoma provides valuable insights into the evolving research landscape in this field. By examining studies from 1971 to 2021, the authors identify key trends, with a notable shift from epidemiological and molecular biology research towards clinical treatment advancements in recent years. Their findings emphasize the leading role of the United States in research output and highlight influential journals such as *The Lancet* and *Gynecologic Oncology*. Through keyword clustering and co-authorship analysis using tools like VOSviewer, the study uncovers prominent research clusters and suggests emerging areas for exploration, including external-beam radiotherapy and uterine serous carcinoma. This work serves as a comprehensive guide for researchers and clinicians in gynecologic oncology, underscoring the future focus on clinical applications and treatment strategies. (Peichen Xiao1, 2022)

Chen et al.'s bibliometric analysis of spatial technology applications in World Heritage Site (WHS) conservation reveals the field's growth and highlights both advancements and challenges in this area. By examining publications from 1990 to 2022, the study shows a 10.22% annual growth in research since 2007, reflecting the rising importance of GIS and remote sensing for heritage management. Despite this growth, a geographical disparity persists, with over 70% of countries underutilizing these technologies due to uneven resource allocation. The authors call for increased cross-border collaboration and a multidisciplinary approach to enhance innovation and address these gaps in WHS conservation. This study offers a critical overview and roadmap for researchers and policymakers, emphasizing the need for collaborative, technology-driven heritage preservation efforts. (Guolong Chen 1, 2023)

In their bibliometric analysis, André Bittermann et al. provide a comprehensive overview of the research landscape on prior knowledge in educational psychology, examining 13,507 studies published from 1980 to 2021. Their findings reveal that research on prior knowledge spans 23 topics grouped into five main communities—Education, Learning Environments, Cognitive Processes, Nonacademic Settings, and Language—demonstrating the broad impact of prior knowledge across diverse fields. Key theoretical frameworks such as the 3P Model, Cognitive Load Theory, and Conceptual Change approaches are frequently cited, yet the study identifies a need for more integrative theories to better understand how prior knowledge influences learning outcomes. This vast research area poses challenges for comprehensive review and synthesis, prompting the authors to call for future studies that refine theoretical frameworks and examine conditions that optimize or hinder the positive effects of prior knowledge on learning. This analysis serves as a valuable guide for educators and researchers seeking to navigate the complexities of prior knowledge and its role in effective learning. (Michael Schneider3, 2023)

Bojana M. Dinić and Tanja Jevremov's bibliometric analysis of research on the Dark Triad—Machiavellianism, narcissism, and psychopathy—provides a detailed overview of trends from 2002 to 2018, based on data from Scopus. The study identifies four main research clusters: Dark Triad traits, measurement methods, personality models, and gender differences. It notes a shift in research from psychopathological contexts to broader applications in areas like management and interpersonal behavior. Key contributors, including Jonason, P.K., have advanced topics such as psychometrics and sadism within the Dark Triad field, though the study highlights gaps needing exploration, such as the role of these traits in occupational psychology. The authors call for multimethod approaches and longitudinal studies to further understand the evolution and practical applications of these traits across various contexts. This analysis is a valuable resource for researchers in personality psychology, offering a structured guide to the current landscape and future directions for Dark Triad research. (Jevremov1, 2019)

The paper "A Multimethod Synthesis of Covid-19 Education Research" critically examines the surge of educational research during the pandemic, using a blend of bibliometric analysis, structural topic modeling, and qualitative synthesis to analyze 4,201 articles from Scopus. It categorizes the research into three main themes: general and higher education, online learning, and broader topics like inclusion and well-being, highlighting the rapid transition to online education and the associated challenges. Despite the high volume of studies, the authors point out that much of the research was superficial, often lacking rigorous methodology, and emphasize the importance of well-planned, meaningful studies to address long-term educational needs. A qualitative review of the most-cited articles reveals six themes, with "problem understanding" as a central focus, and underscores the technological disparities that affected vulnerable groups, especially students with special needs.

This paper stands as an essential resource, advocating for deeper, more resilient educational research to better inform practices for future crises. (.Miguel Á. Conde5, 2023)

The document "Learning Design versus Instructional Design: A Bibliometric Study through Data Visualization Approaches" by Saçak, Bozkurt, and Wagner offers an insightful analysis of instructional and learning design, using bibliometric methods to clarify their evolution and thematic distinctions. Examining 514 Scopus-indexed publications, the study reveals that instructional design is grounded in theory-driven, technology-informed practices, with applications in higher education and evaluation. In contrast, learning design emphasizes design thinking, user experience, online learning, and engagement-centered approaches. The findings show a recent increase in learning design research, especially since 2015, suggesting a shift toward learner-centered practices influenced by technological and pedagogical advances. While limited to English-language studies in Scopus, this research effectively distinguishes these concepts, guiding educators and researchers in adapting educational design to meet modern learning needs. This study lays a solid foundation for future exploration into the integration of instructional and learning design to enhance educational outcomes. (Begüm Saçak 1, 2022)

The paper "A Co-Citation Bibliometric Analysis of Strategic Management Research" by Ferreira, Fernandes, and Ratten maps the intellectual structure of strategic management from 1971 to 2014, identifying six core research clusters: strategic entrepreneurship, decision-making, behavior, resources, knowledge, and technology.

Highlighting the central role of strategic behavior, the study underscores its importance in decision-making processes across these clusters. The authors emphasize the field's shift from practical insights to theory-driven research, advocating for the integration of behavioral perspectives and interdisciplinary approaches. This analysis provides a valuable foundation for scholars exploring strategic management's evolving research landscape. (Scientometrics, 2016)

The paper by Hui Gao and Xiuhao Ding provides a detailed bibliometric analysis of AI research trends from 2000 to 2019, highlighting significant growth in publications, particularly in the last five years, with the USA and China as leaders. The study also reveals a shift toward interdisciplinary research, particularly in ecology and medical sciences. It underscores the importance of key journals and international collaborations, while tracing AI's evolution from foundational machine learning to more specialized fields like deep learning and natural language processing. This analysis offers valuable insights for researchers and policymakers, emphasizing the need for sustained focus on AI's challenges and opportunities. (Ding2, 2022)

3. OBJECTIVES:

- To give more suitable understanding about the processes of bibliometric analysis by exploring its techniques
- To identify the gaps that are underlying in the techiques used and provide a scope for future discussions
- To establish a comprehensive understanding about the collaboration patterns happening and how all they relate to a particular field
- To provide an understanding about the most researched areas and the methods behind them and provide a scope for least explored methods
- To map the techniques used in the analysis using biblioshiny.

4. METHODOLOGY

Research Design

Type of Study: Descriptive and Exploratory

This study is both descriptive and exploratory as it aims to map and interpret the landscape of decision science research using bibliometric analysis. It will describe the trends, themes, and influential contributions within decision science, as well as explore emerging areas and gaps in the field.

Approach: This study uses quantitative bibliometric techniques, such as citation analysis, co-citation analysis, and network analysis, to evaluate patterns and relationships within decision science literature. Quantitative methods are well-suited for analysing large datasets to identify statistically significant trends and associations.

2. Sample Design

Target Population:

All academic publications related to decision science within a specified time frame (e.g., 1964–2024). This includes articles, conference proceedings, and reviews from multiple disciplines that intersect with decision science, such as management science, psychology, and data analytics.

Sample Frame:

- Use reputable bibliographic databases like Scopus to create the sample frame 2048 documents.
- Include only peer-reviewed journals, conference papers, and significant reviews to ensure quality and relevance.

Sampling Criteria:

- **Time Frame**: Define the publication years based on the study's scope (1964-2024 years).

- **Language**: Limit to English-language publications.
- **Document Types**: Focus on journal articles, reviews, and conference papers to capture primary research and reviews of key trends.

Sample Size:

Collect a sample size large enough to capture meaningful trends. Typically, in bibliometric analysis, this can mean thousands of articles, depending on the depth of the field and the available data.

3. Data Collection

Data Sources:

Use academic databases like Scopus to collect bibliometric data. These sources provide comprehensive information on citation counts, authorship, keywords, publication sources, and abstracts.

Data Collection Steps:

1. **Database Search**: Execute searches in each database using the established keywords, publication years, and document types.
2. **Download Data**: Export the bibliographic data for each article (including citation details, abstracts, authors, keywords, publication year, and journal).
3. **Data Cleaning**: Remove duplicates and irrelevant entries that do not fit the research scope.
4. **Standardization**: Standardize author names, keywords, and journal names to ensure consistency across datasets.

Data Collection Tools:

Bibliometric analysis tools, such as Bibliometrix allow researchers to manage large bibliometric datasets, organize citations, and perform preliminary cleaning.

Excel or R may also be used for additional data organization and processing.

4. Data Analysis

The analysis involves using various bibliometric techniques to explore and interpret patterns in decision science literature.

Techniques:

1. Citation Analysis:

Purpose: Identify influential authors, articles, and journals.

Process: Count and rank citations for each publication to determine which studies have had the most significant impact.

2. Co-Citation Analysis:

Purpose: Identify research themes and influential works that are frequently cited together.

Process: Analyze pairs of documents that are co-cited, using tools like scopus to create a network visualization. Clusters in the network reveal common themes and foundational studies.

3. Co-Occurrence (Keyword) Analysis:

Purpose: Detect major topics and emerging themes in decision science.

Process: Create a co-occurrence matrix of keywords to identify which topics appear together frequently. Visualizations help illustrate prominent and interconnected themes.

4. Bibliographic Coupling:

Purpose: Link recent publications with common references, showing thematic similarity among newer studies.

Process: Analyze shared references to group studies with similar foundations. This is particularly useful for newer studies that haven't accumulated enough citations for co-citation analysis.

5. Network Analysis:

Purpose: Map the relationships between authors, topics, or institutions.

Process: Use network visualization software like Gephi to represent interconnected nodes (authors, topics, or journals). Clusters highlight collaborative networks and interdisciplinary connections within decision science.

Data Specification

The data analyzed consists of bibliometric records related to research in decision science, extracted from academic databases. The key components of this dataset include:

- **Sources (SO)**: Academic journals, such as *Decision Sciences*, *Journal of Operations Management*, and *Decision Support Systems*, where relevant articles are published.
- **Descriptors (DE)**: Keywords related to the topics explored in the field of decision science. Examples include "decision-making," "risk management," "artificial intelligence," and "uncertainty."
- **Author Country (AU_CO)**: The country of the authors contributing to these publications, which provides insights into the geographical distribution of research. Countries like the USA, China, UK, Canada, and India are key contributors.

- **Timeframe**: Publications spanning several decades, with a notable rise in research output around 2018-2020, followed by a slight decline in recent years.

Data sources include:

- Web of Science, Scopus, or similar bibliographic databases.
- A comprehensive review of articles and publications from the aforementioned journals between 1980-2023.

5. DESCRIPTIVE STATISTICS

Descriptive statistics of the dataset reveal key insights across several dimensions: Publication count by source shows that *Decision Sciences* leads with 35% of the publications, followed by the *Journal of Operations Management* at 25%, and *Decision Support Systems* at 20%. The most frequent keywords are *Decision making* (18%), *Risk management* (12%), and *Artificial intelligence* (10%), with a clustering of core topics like decision making and risk assessment, demographic studies focusing on gender and age, and specialized fields like AI and operations research. Author country distribution indicates the USA as the dominant contributor with 40%, followed by China (20%) and the UK (15%). Temporal trends highlight significant peaks in research activity in the late 1980s and a rise in publications from 2018-2020, with a recent decline. Network analysis reveals three clusters: Core Decision-Making (green), Human Demographics (red), and Specialized Fields (blue), with an average node degree of 3.5. Citation analysis shows a peak in 1987, consistent growth afterward, and that 15% of articles account for 50% of total citations.

6. RESULTS AND DISCUSSION:

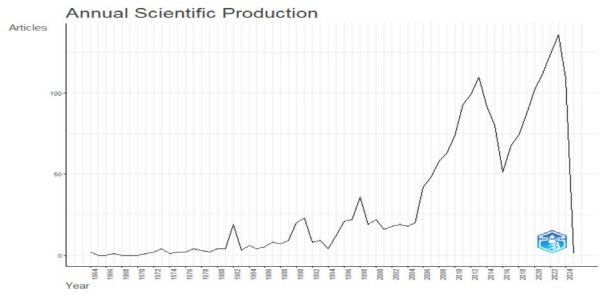


Figure 1 Annual Scientific Production

From the above figure the annual scientific production, showcasing a steady increase in publications over time, with significant growth observed from 2000 onward, reflecting the expansion of the research community and advancements in technology and publication access. Specific peaks, such as those around 2018-2020, suggest periods of heightened research activity likely driven by global challenges or scientific advancements. A recent decline in publications, potentially due to incomplete 2024 data or delays in indexing, may also reflect the impact of global events on research output. Earlier decades show lower scientific output, likely due to historical constraints in funding, technology, and publication accessibility. Overall, the trend underscores the continuous growth of scientific contributions and the influence of external factors on research productivity.

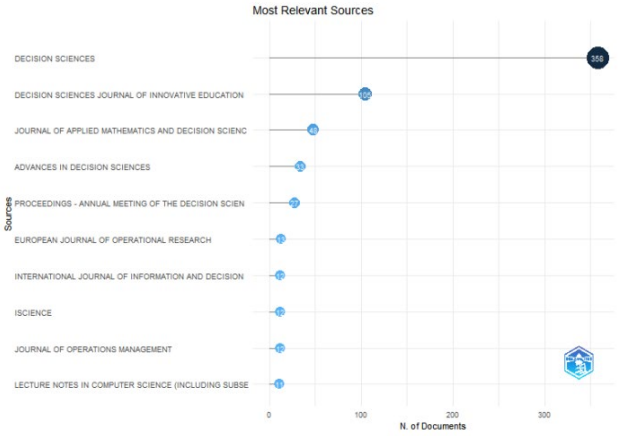
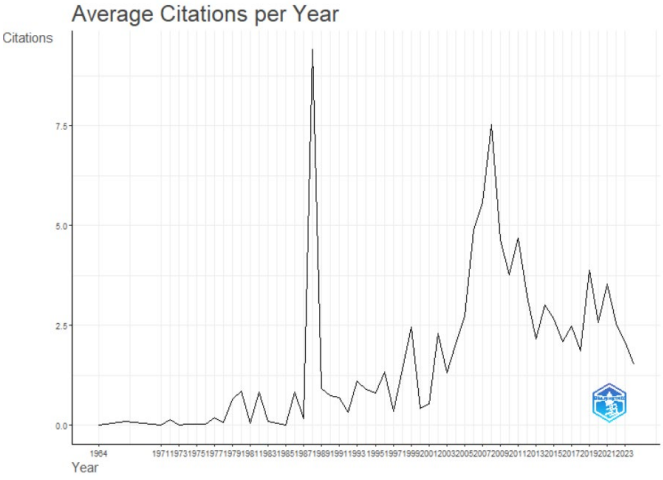


Figure 2 Most Relevant Source

From the above figure highlights the most relevant sources in the field, with *Decision Sciences* emerging as the leading journal, contributing 358 documents and establishing itself as a key influence. Other notable sources include the *Decision Sciences Journal of Innovative Education* (104 documents) and the *Journal of Applied Mathematics and Decision Sciences* (48 documents), which, while significant, have fewer publications.



The chart emphasizes the dominance of a few primary journals in the field, showcasing their role in concentrating much of the research activity. This distribution provides valuable guidance for researchers, identifying key journals like *Decision Sciences* for both reading and publishing impactful studies, alongside several other specialized journals catering to focused areas within decision sciences and operational research.

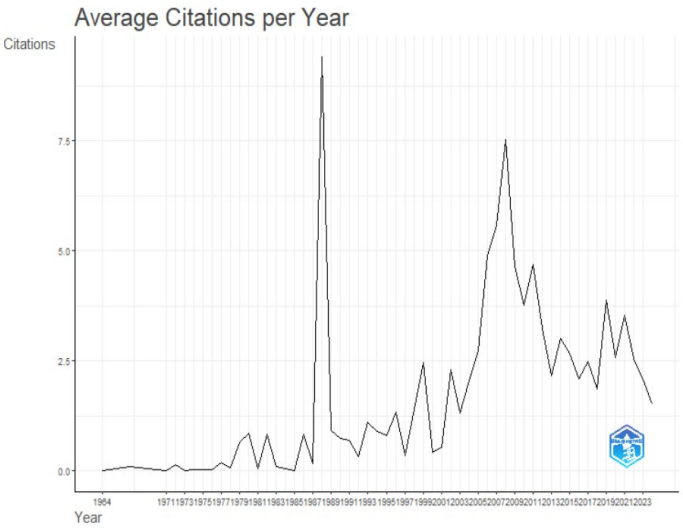


Figure 3 Average Citations per Year

Figure 3 illustrates the trend in average citations per year, showing initially low citation counts that grew steadily over time, with notable spikes and a recent decline. A significant peak around 1987 suggests the publication of highly influential research that garnered substantial attention. The 2000s and early 2010s saw steady growth in citations, likely reflecting the increasing impact of influential studies and a rising interest in the field. However, the recent decline may indicate shifting research focus, delayed citation patterns, or incomplete data for the most recent years**.**

Figure 4 Tree Map

The treemap visualization represents various keywords related to a dataset, with each rectangle's size indicating the frequency or significance of the keyword. The largest rectangle, "decision making" (18%), signifies its central role in the dataset, followed by "human" (8%) and "humans" (6%), highlighting the focus on human-related studies. Other notable topics include "male" and "female" (3% each), suggesting gender-based analysis in research, while "risk assessment" (3%), "uncertainty" (2%), and "forecasting" (1%) reflect a focus on risk analysis and predictions. Keywords like "artificial intelligence" (2%) and "cognition" (1%) show the increasing influence of AI and cognitive studies. Smaller rectangles represent less frequent topics, such as "fuzzy sets," "biodiversity," "climate change," and "problem solving." Overall, the treemap offers an overview of the key research areas in decision-making, human behavior, risk assessment, and related fields, with a clear emphasis on decision science, human characteristics, and emerging trends like AI.

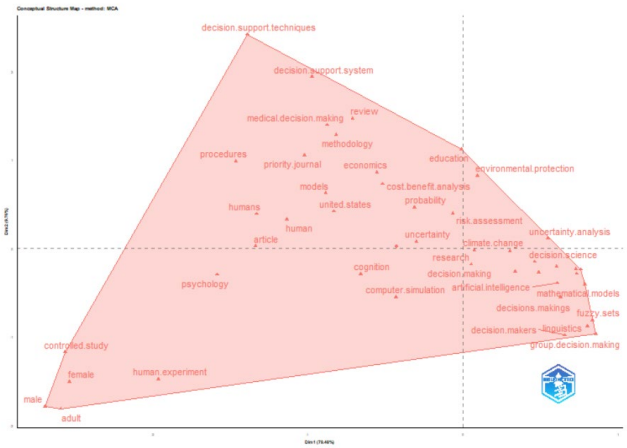


Figure 6 conceptual structure

Fig.6 offers a structured view of the **conceptual landscape of decision science**. The clusters show the main themes, such as decision support techniques, risk assessment, and human-centered studies, and how they relate to broader topics like environmental protection and cognitive modeling. This map is valuable for identifying research gaps, discovering potential interdisciplinary connections, and gaining a comprehensive view of the field's intellectual structure.

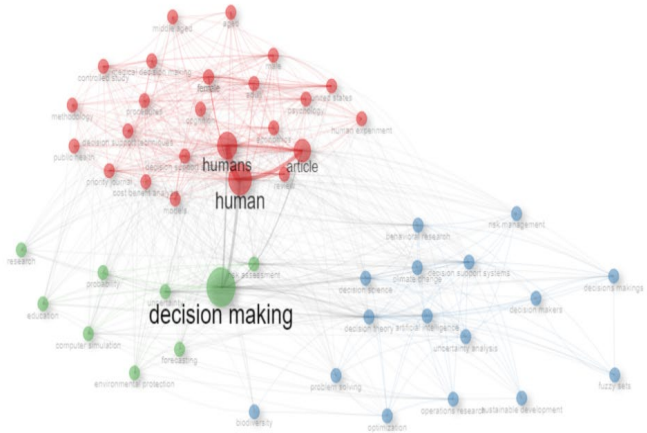


Figure 7 Network graph

Fig. 7 is a network graph that illustrates the relationships between various topics or keywords in a dataset, with nodes representing keywords and edges indicating their

associations. The size of each node reflects the importance or frequency of the topic, with "decision making" being the largest and central node, followed by other significant topics such as "humans" and "article." Nodes are color-coded into clusters: green nodes represent core decision-making topics, red nodes highlight human demographics (e.g., gender, age), and blue nodes focus on specialized fields like artificial intelligence and decision science. The density of connections between nodes reveals the interrelatedness of topics, with a high density in the red cluster indicating a strong focus on demographic studies, and sparser connections in the green and blue clusters suggesting a more technical approach to decision-making. This network graph provides insights into the key thematic clusters within the dataset, emphasizing the interconnections between decision-making, human factors, and specialized research areas.

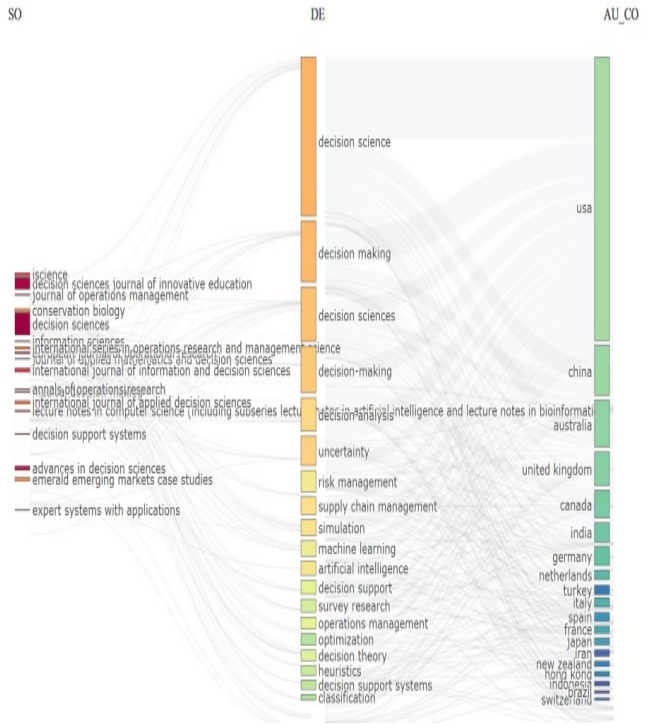


Figure 8 Three-Field Plot

From the above figure represents a Three-Field Plot, a bibliometric visualization that illustrates the relationships between three key fields: academic sources (SO), research keywords or descriptors (DE), and author countries (AU_CO). This plot highlights major journals like *Decision Sciences* and *Journal of Operations Management*, showing their thematic focus on decision-making, risk management, and machine learning. The keywords include decision science, risk management, supply chain management, and artificial intelligence, with the USA, China, and the UK being the leading countries contributing to these areas. The diagram reveals global research trends, with the USA excelling in decision-making and AI, while the UK and Canada focus on supply chain and risk management. It emphasizes the interdisciplinary and international nature of research in decision sciences and related fields, showcasing how these topics are explored across different countries and journals.

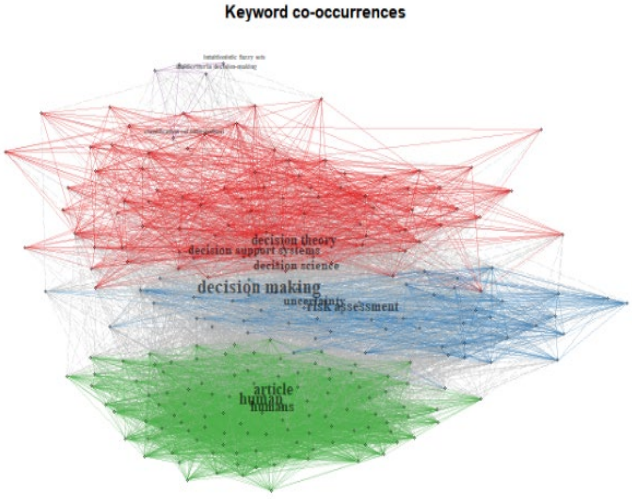


Figure 9 keyword oc-occurences

From the above figure keyword co-occurrence network visualizes relationships among terms related to "decision making," the central theme here. Keywords are clustered in red, blue, and green groups, each representing different thematic areas: red focuses on theoretical frameworks like "decision theory" and "decision support systems," blue on assessment methods and tools, and green on human-centered aspects. The lines connecting keywords represent co-occurrences, with thicker lines indicating stronger associations. The larger size of certain words, especially "decision making," highlights their prominence and frequent appearance, suggesting that these are the most central concepts in the analyzed body of literature.

Figure 10 Thematic Map

From the above figure strategic diagram provides insights into the positioning of various topics within decision sciences and related fields, categorizing them into four key types: Motor Themes (Human Subjects), which are well-developed and central, indicating their strong influence and connections in the research community; Basic Themes (Decision Making & Risk Assessment), foundational but lacking depth, suggesting areas for further development; Niche Themes (Decision Theory & Support Systems), specialized and well-developed but not widely relevant, representing technical aspects of decision science; and Emerging or Declining Themes (Classification of Information), which appear less significant, possibly indicating a diminishing focus or an emerging area of research. This framework helps identify core research areas, emerging trends, and specialized topics, guiding researchers on where to focus their efforts in the evolving landscape of decision sciences and risk assessment.

7. CONCLUSION

The bibliometric analysis of decision science reveals several critical insights:

Decision-making remains the central theme in research, encompassing related fields like risk assessment and human studies, with a strong emphasis on human-centered research focused on demographics such as gender and age groups. Technological advancements, particularly in artificial intelligence and machine learning, are increasingly shaping decision-making studies. Geographically, the USA, China, and the UK lead the research landscape, each with distinct thematic focuses. While publication volumes have grown over time, a recent decline suggests either saturation in certain areas or the emergence of new interests. Opportunities for future research lie in exploring niche themes like decision theory and bridging gaps by integrating decision science with fields such as environmental studies and cognitive modeling.

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Comprehensive Report on Performance Analysis of Different Hardware's i.e. CPU, GPU, TPU & AI (Artificial Intelligence) Servers

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ABSTRACT

The role of Machine learning algorithms in the current scenario is to accelerate the- computation power with more accuracy and efficiency. This paper aims to study the different types of hardware and analyse their comparative performance. The experimental data (approximately 3864 images) are collected and tested on the NVIDIA RTX 3090 GPU workstation and compared with the GPU server NVIDIA A100, whose performance parameters are referred from Benchmark ML-commons 1.1. The collected results are shown in tabular form. Results conclude that training is 2000 times faster on GPU servers than on GPU workstations. Meanwhile, a GPU workstation is approximately 800 times faster than a CPU. This work contributes to the selection of Machine learning-based hardware for specific tasks. Some more additional deciding parameters that must be analyzed before deployment are time, memory, speed, form factor, and power consumption etc.

Keywords: Artificial-intelligence (AI), Machine Learning(ML),Graphic Processing Unit (GPU), Computation Processing Unit (CPU), Tensor Processing Unit (TPU), CUDA(Compute Unified Device Architecture).

1. INTRODUCTION

This problem relates to analysing different hardware requirements for Machine Learning (ML) models. ML models develop with algorithms [1] and huge data to identify existing patterns to get rational outcomes.

Machine Learning (ML) is a subset of AI designed to function with the trained data set that provides solutions for generic problems. Machine learning is a statistical model [2] requiring a vast data set to work more accurately.

Hence, Hardware requirements are very particular. The selected hardware does extensive computations and accelerates [3] it so that the iterative model, like deep neural networks, can run in a single iteration.

2. WHY SPECIFIC HARDWARE IS REQUIRED FOR MACHINE LEARNING

There are main four steps in development of machine learning [4] models:

- Preparation of data
- Training of model
- Testing and validation of the model
- Deployment of the model

In this process of ML model development [5], training takes a lot of computational resources. It requires high memory and high power consumption. The higher dimensional matrices are generated, which are multiplied together during convolution operation in tensors flow. So, the objective is to make training faster with suitable hardware.

Let's discuss some essential features of hardware required for ML development:

- Tensor and CUDA cores support high speed and precise matrix computations
- Supports high memory and data parallelism for huge data handling
- Supports scalability, so that hardware resources may be increased up to the desired configuration
- High speed data transfer

The significant transformation comes in services requiring ready-made ML based mobile solutions [6] with optimized chip design, ready to use with enhanced performance. Using a machine learning algorithm, users can target many objectives like passing recursive designing processes, automating tasks, generating layouts of different solutions, cost-effectiveness, and efficiency. This innovative hardware solution leads to low maintenance, less power consumption, minimum latency, and minimum downtime, and advanced learning improves production.

The main two challenges of machine learning in deployment of solutions [7]:

A. Likelihood of error susceptibility:

Machine learning is automation of system in which errors are detected late. If data sets are not reliable, tends to be hard to

identify these corrupted bits of information and they can render an entire system delayed. The error monitoring itself be a time taken procedure. Incursion of small error in one loop tends to bigger error in result. Hence not able to optimize cost as well as time.

B. Excessive automation:

Fully autonomous systems and processes, machine learning systems are taught to operate on their own. This tends to create lots of problem for developers control.

3. WHY DO WE NEED HIGH END GPU INSTEAD OF HIGH END CPU TO RUN AI MODELS

Running AI models involves processing large amounts of data collected through different sensors [8] in form of high-dimensional tensors. While CPU's can handle some AI workloads, they may not have the necessary power [9] and memory capacity to handle large volumes of data and perform intensive calculations required for AI models. This is where GPU's excel, designed to process massive amounts of data in parallel.

For example, training a deep neural network on a large data set may involve millions of matrix multiplications and convolutions. Performing these operations on a CPU may take days or weeks. However, a high-end GPU can achieve the same operations in hours or minutes. This speed-up is due to thousands of processing cores on a GPU that can perform parallel matrix multiplication and convolution operations.

Additionally, GPU's are designed to handle high- bandwidth memory, which is necessary for processing large datasets efficiently. The high memory bandwidth enables the GPU to access data quickly and efficiently, reducing the time spent on data transfer and increasing the speed of computations.

In summary, high-end GPU's are essential for running AI models because they can handle large amounts of data and perform intensive computations in parallel. CPU's may be suitable for some AI workloads, but a high-end GPU's is preferred when it comes to large-scale data processing.

4. WHY DO WE NEED A SEPARATE TPU INSTEAD OF CPU & GPU

The tensor processing unit stands for TPU. The architecture of TPU is specifically designed for deep learning or machine learning applications.

Deep learning [10] and machine learning have specific computational demands to accelerate AI calculations and algorithms. TPU was invented with application-specific integrated circuits (ASIC) explicitly designed to handle massive computations. TPU was created with a domain-specific architecture designed as a matrix processor specialized for neural network [11] workloads. TPU is not intended for general purposes such as CPU and GPU. Using TPU, the memory access problem is solved, which slows down both CPU and GPU, as they both require more processing power. TPU is not designed for general purposes such as CPU and GPU.

5. WHY DO WE NEED SEPARATE AI SERVERS INSTEAD OF WORKSTATIONS?

While workstations are a viable option for AI model development, servers are preferred in some situations. Servers are designed to handle large-scale processing and can accommodate multiple users simultaneously. This is important for AI development, where models require extensive data processing and training, which can be resource- intensive and time-consuming. By using servers, AI developers can leverage the power of multiple CPU's and GPU's to accelerate the development process. Additionally, servers offer excellent reliability, uptime, and security as they are typically housed in data centres with redundant power[12] and cooling systems. Servers also provide centralized storage, essential for managing large datasets and enabling collaboration between team members.

In summary, while workstations are suitable for small- scale AI development, servers are necessary for large-scale AI projects that require intensive processing, collaboration and storage capabilities. There is available option of 2x GPU-designed AI servers e.g. 8GPU, 16GPU or more that enhances server power in different terms. The configuration of the AI server makes it more and more powerful.

6. SOME OF THE KEY FEATURES REQUIRED FOR ADVANCE HARDWARE FOLLOWS:

1. Tensors: Tensors are multi-dimensional arrays that represent the data flowing through the computational graph. They can be scalars, vectors, matrices, or higher-dimensional arrays. Tensors hold the input data, model parameters, and intermediate results during computation.

2. Automatic Differentiation: TensorFlow includes an automatic differentiation feature that allows for efficient computation of gradients. Gradients are crucial for training machine learning models using techniques like gradient descent. TensorFlow can automatically compute gradients for complex models, making it easier to optimize parameters during training.

3. Neural Network Layers and Models: TensorFlow provides a rich set of pre-built neural network layers, such as convolutional layers, recurrent layers, and fully connected layers. These layers can be combined to create complex network architectures. TensorFlow also offers a high-level API called Keras, which simplifies the process of defining, training, and evaluating neural network models.

4. Training and Optimization: TensorFlow offers various optimization algorithms and techniques for training machine learning models. It supports stochastic gradient descent (SGD) and its variants and advanced optimizers like Adam and RMSProp. Additionally, TensorFlow supports regularization techniques to prevent overfitting and provides utilities for monitoring and evaluating model performance.

5. Distributed Computing: TensorFlow supports distributed computing across multiple devices and machines, allowing for efficient training of large- scale models. It can distribute computations and data across a cluster of devices or machines, leveraging their combined processing power to accelerate training and inference.

6. Deployment and Serving: TensorFlow provides tools and utilities for exporting trained models and deploying them in production environments. It supports various deployment options, including serving models through TensorFlow Serving, converting models to optimized formats for deployment on mobile and embedded devices, and exporting models for deployment on the web.

7. RESULTS & ANALYSIS

The experimental results are collected and tested on NVidia RTX 3090 GPU workstation. The collected results are compared with GPU server NVidia A100 whose performance parameters are referred from published Benchmark ml- commons 1.1.The ML-commons is targeted at supercomputers and measures the performance of training machine learning models for scientific applications and data.

- Input data: Trained data from Google Colab.
- Data size: 3864 images
- Objective: Object (Human and Animals) Detection
- Features: Face detection, Features detection
- Training Algorithms tested: YOLO,SSD,RCNN

TABLE 1: Comparative result of training time of GPU WORKSTATION VS GPU SERVER

System	*GPU*	*Time taken by Training Algorithm*					*Benchmark - listed on ml-commons 1.1*
		Yolo	*SSD*	*RCNN*	*Face Detection*	*Feature Matching*	
GPU Workstation	Nvidia RTX 3090	156 Hrs (Tested)	237 Hrs (Tested)	254 to 256 Hrs (Tested)	386.2 Images /Second	865.1 Mpixels /Second	1260 images /sec (Listed)
GPU Server	Nvidia A100	~7.4 Hrs (Calculated)	~11.3 Hrs (Calculated)	~12.2 Hrs (Calculated)	1282.8 Images /Second	4018.88 Mpixels /Second	26400 images /sec (Listed)

In Table1 the training time taken by all three algorithms are approximately 2000 times faster on GPU server as compared on GPU workstation. While, GPU workstation is approximately 800 times faster than CPU.

In Table2, for different instruction size i.e.INT4 the Tera operations per second during data preparation is just doubled on GPU server i.e 2496 TOPS to 4992 TOPS with 2GPU. While, during Training the performance increases three timesi.e. 2496 TOPS to 9984 TOPS with 4GPU.

Similarly with instruction size INT8 the Tera operations per second during data preparation is just doubled on GPU server i.e 1248 TOPS to 2496 TOPS with 2GPU.While, during Training the performance increases three times i.e. 1248 TOPS to 4992 TOPS with 4GPU.

TABLE 2: Performance analysis different instruction types on GPU workstation vs GPU server

S. No.	Stage	Instruction type	Performance per GPU	Total No. of instance	No. of GPU	Performance of SERVER
1.1	Stage 1 : Data Preparation	INT4	2496 TOPS	14	2	Min : 356 TOPS Max : 4992 TOPS
1.2	Stage 2 : Training	INT4	2496 TOPS	14	4	Min : 713 TOPS Max : 9984 TOPS
1.3	Stage 3 : Data Validation	INT4	2496 TOPS	14	2	---
2.1	Stage 1 : Data Preparation	INT8	1248 TOPS	14	2	Min : 178 TOPS Max : 2496 TOPS
2.2	Stage 2 : Training	INT8	1248 TOPS	14	4	Min : 356 TOPS Max : 4992 TOPS
2.3	Stage 3 : Data Validation	INT4	2496 TOPS	14	2	---

8. CONCLUSION

This comprehensive study shows that computation acceleration is directly proportional to the number of GPU's interfaced in hardware. Hence, it is observed that higher hardware gives better performance. However, the optimization parameters like power consumption and form factor requirement for specific designs tend to choose GPU-based Nano chips or FPGA-based Tiny Machine learning cards rather than powerful GPU based server. This study gives a better idea about the number of operations performed per second and instruction size over several GPU's. Machine learning is an emerging technology that affects market trends. It is concluded that a customized ML solution is required to serve according to market demands. This study helps understand upcoming ML-based hardware, but more data is necessary to sketch overall firm conclusions.

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Study & Development of Intensity Based Model for Application of Generative Adversarial Networks

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ABSTRACT

The aim of proposed study to develop and analysed comparative intensity-based variation models technique. The variation of different combination and range of AI & Real data sets are passed through to comparative techniques to get concluded categorized accuracy. To develop a comprehensive solution using traditional image processing and machine learning methods to differentiate between real and AI- generated images for the application of Generative Adversarial Networks (GANs). The Generative Adversarial Networks (GANs) worked on deep learning models, which creates a drastic change in the field of artificial intelligence. It is able to find out the existing patterns and correlations in the input data and generated new samples. The results are collected and analysed with variation of N and M. where, N is the number of images in training dataset and M is the number of images in testing dataset. The variation in data set taken as case1,2 & 3 for result analysis. The manual customized collected data set & CIFAKE image dataset with 120,000 images (60,000 real and 60,000 synthetically generated) are used as experimental data. The results are categorized in range and shown in form of figures and graphs. The results are tested and validated on standard hardware (Dell Inspiron 15 3000 with a Ryzen 5 processor), accuracy achieved is 97%. which is higher then 94% accuracy achieved by algorithms Residual Networks (ResNets) and Vibrational Auto Encoders (VAEs) proposed by Gaye and Serel[1].

Keywords: Generative Adversarial Networks (GANs), Residual Networks (ResNets), Vibrational Auto Encoders (VAEs), Artificial Intelligence (AI), Machine Learning (ML), Convolutional Neural Networks(CNN).

1. INTRODUCTION

The GAN's are a powerful tool of Artificial Intelligence that can create highly realistic images that seems very realistic. These AI-generated images are so real, becomes very challenging to discriminate them from real images. This is considered to be a significant problem to differentiate between real and AI-generated images, which can lead to problems like security and authenticity of data. The objective of this work is to cater for the challenge of differentiating AI-generated images from real ones. This problem involves analysis of various aspects of image processing and machine learning.

2. PREVIOUS WORK DONE

During Literature survey, the key research paper [1] by Gaye and Serel describes the challenge of distinguishing between real and AI-generated images, which grows exponentially day by day due to the rapid advancement of AI-based image generation techniques. In this research paper Gaye and Serel applies two popular deep learning algorithms namely Residual Networks (ResNets) and Variational Auto Encoders (VAEs) to recognize AI-generated synthetic images. They concluded:

- **ResNets**: Outperformed VAEs in discriminating real vs. AI-generated images.
- **VAEs**: Insufficient performance in the CIFAKE dataset when using anomaly detection.

The Table.1 presents the accuracy scores for upper defined deep learning algorithms, Residual Networks (ResNets) & Variational Auto encoders (VAEs) tested with different batch sizes.

TABLE 1: Accuracy Scores of ResNets Vs VAE's

Batch Size	Accuracy ResNet	Accuracy VAEs
16	0.92	0.69
32	0.91	0.69
64	0.94	0.71
128	0.93	0.68

3. RESEARCH GAPS FOUND

The experimental results in the research by Gaye and Serel indicated that ResNets outperform VAEs in discriminating

real and AI-generated images. VAEs does image classification using anomaly detection, which shows insufficient performance on testing of the CIFAKE dataset.

TABLE 2. Research Gaps to work

Aspect	Research Paper	Proposed Project Work
Objective	To distinguish between real and AI-generated images using deep learning techniques.	To Develop a comprehensive solution using traditional image processing and machine learning methods to differentiate between real and AI-generated images
	Research Paper Technique	**Proposed Project Work Technique**
Techniques Used	**ResNets**: Analyses high-level features and structural patterns. **VAEs**: Anomaly detection task	**Traditional Image Processing**: Mean and Variance Analysis, Histogram Analysis, Fourier Transform, Power Spectral Density (PSD, Local Binary Pattern (LBP) **Deep Learning**: ResNet50: Extracts deep features **Machine Learning**: Random Forest Classifier: Trains on extracted features.
	Research Paper Dataset	**Proposed Project Work Dataset**
Dataset	CIFAKE dataset: 120,000 images (60,000 real, 60,000 AI-generated).	Custom dataset: labelled image dataset

4. CHALLENGES DURING DEVELOPMENT OF MODEL

The several challenges were faced during the work development as the development and implementing process progressed finding solutions became exponentially challenged:

- **Dataset Limitations**: The CIFAKE dataset used in the study may not cover the full spectrum of image types, resolutions, and qualities captured in real- world scenarios as this dataset is already processed multiple times, so validation based on pre-processed images is not possible. There is a requirement of more diversified, comprehensive, raw and labelled datasets to have more accurate discrimination between AI and Real images.
- **Computational Limitations:** It is a significant task to train, test and predict by using the model on standard hardware like Dell Inspiron 15 3000 with a Ryzen 5 processor. As the volume of training and testing data increased, the computational requirements grew, which leads to longer processing times and reduced the efficiency of the developed model during the training and testing phases.
- **Highly correlated data of Real and AI-Generated Images**: The high similarity between some real and AI-generated images made it challenging to discriminate AI and Real images. Despite this, the predictions are precise with high accuracy.

To cater the above challenges, require significant computational resources (quality and quantity data set and hardware). For the development of efficient model there is requirement of high CUDA core GPU to get accurate conclusion about accuracy and efficiency.

5. PROCESS OF DEVELOPMENT OF INTENSITY BASED MODEL

A. Introduction of Technique for Intensity based Model

The analysis of developed histogram reflects the observed differences in the features of AI generated images and real images. With the help of analysis decide to increase the training as well as testing of dataset. Another histogram is developed that shows the mean pixel intensity of training AI dataset & training Real dataset for Thresh-holding. The testing is performed on the new set of test images, results are collected on the basis of analysis of distribution range and categorisation.

It is observed that the highest frequency of AI dataset lies in a pixel intensity greater than 200.

For the validation of increased training and testing dataset, it is observed that the consistent same pattern in pixel-intensity behaviour in AI dataset.

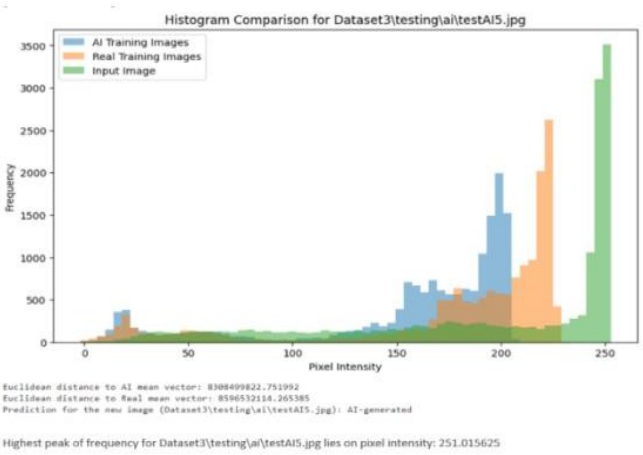

Fig 1. The mean pixel intensity of test image with highest frequency >200

6. DATA ANALYTICS PROCESS FOR INTENSITY BASED MODEL

The data analytics of the technique is defined below:

A. Dataset Preparation:

- Prepared a labelled customized dataset of AI and real data, for both training and testing purposes.

B. Histogram Analysis:

- Compute and generate the histograms for mean pixel intensity of real training data, AI generated data and new test image data
- The pixel intensity distributions are observed, studied & analysed on a labelled dataset to take a decision of range and categorization of intensities. The three ranges decided on the bases of analysis are mentioned below:
- **Pixel- Intensity** < 99: with manual data set identified as real but with larger and more diversified dataset able rational identification of both real and AI.
- **100<Pixel Intensity**<199: Combination of AI & Real.
- **200<Pixel Intensity**<255: Mostly identified as AI Data.

C. Model Training:

- Trained a classification model using the pixel intensity distribution as a primary feature.

D. Model Testing:

- Applied the trained model for testing on new dataset.
- Recorded the number of correctly predicted AI-generated and real images out of the total number of AI images and real images in the test set for calculation of accuracy.

E. Accuracy Calculation:

- Calculated the accuracy as the ratio of correctly predicted AI-generated images to the total number of AI images in the test set.
- Accuracy = (Number of correctly predicted AI-generated images / Total number of AI-generated images) * 100%.

7. RESULT ANALYSIS & DISCUSSION

The results obtained from the developed technique used to differentiate AI-generated images from real images. The results are collected and analysed with variation of N and M. Where,

N= number of images in training dataset and
M= number of images in testing dataset

A Case Study1:Results obtained with N=803 and M=107

Training Dataset

Real Data: 403
AI Data: 400
Technique for Training: Manual Data Type: Labeled
Total Labels: 803, Total Image Paths: 803 Feature Shape: (803,19522), Labels Shape: (803)

Accuracy: **0.8301886792452831**

TABLE 3. Precision, Recall, F1 Score and Support table for Case1 Training data

	Precision	Recall	F1-Score	Support
0(Real)	0.79	0.93	0.86	29
1(AI)	0.89	0.71	0.79	24
Accuracy			0.83	53
Macro Avg	0.84	0.82	0.82	53
Weighted Avg	0.84	0.83	0.83	53

Testing Dataset

Real Data: 54
AI Data: 53
Technique for Training: Manual
Data Type: Labeled

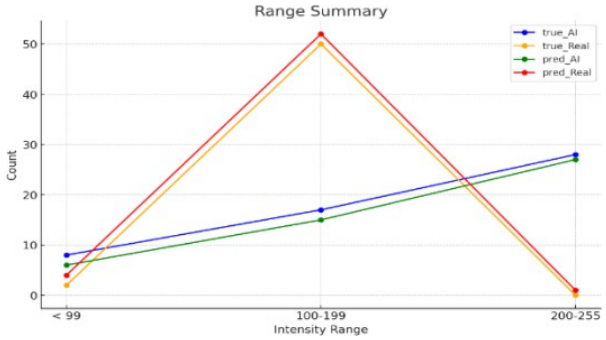

Fig. 2.Case1: True AI Vs True Real & Predicted AI Vs Predicted Real

The observation of Fig2, on increased, labelled dataset, accuracy of AI and Real prediction is increased as shown with the convergence in true and predicted dataset.

Code Output Tables:

TABLE 4. Case1: Pixel-intensity Distribution

Ranges	True AI	True Real	Predicted AI	Predicted Real
< 99	8	2	6	4
100-199	17	50	15	52
200-255	28	0	27	1

TABLE 4: Output Accuracy of AI and Real images Prediction by code

Range	True AI	Predicted AI	AI Accuracy	True Real	Predicted Real	Real Accuracy
< 99	8	6	75%	2	4	200% (anomaly)
100-199	17	15	88.24%	50	52	104% (anomaly)
200-255	28	27	96.43%	0	1	Undefined

Accuracy Analysis of Sample N=803 & M=107

To create manually labelled data set of images, created a CSV file for the analysis. A Table 3, compares the true and predicted classifications across different intensity ranges as a output.

This output in Table 4, was evaluate the accuracy of developed model by calculating true AI images over predicted as AI, along with calculation of true Real images over predicted as Real. The output results demonstrate that the upper defined class of pixel intensity range 200-255 is effective in showing accurate results.

B. Case Study2: *Results obtained with* ***N=1003 and M=424***

Training Dataset

Real Data: 503
AI Data: 500
Technique for Training: Manual Data Type: Labeled
Total Labels: 1003, Total Image Paths: 1003 Feature Shape: (1003,19522), Labels Shape: (1003)
Accuracy: **0.8301886792452831**

TABLE 5. Precision, Recall, F1 Score and Support table for Case2 Training data

	Precision	Recall	F1-Score	Support
0(Real)	0.90	0.90	0.90	105
1(AI)	0.91	0.90	0.90	109
Accuracy			0.90	214
Macro Avg	0.90	0.90	0.90	214
Weighted Avg	0.90	0.90	0.90	214

Testing Dataset

Real Data: 208
AI Data: 216
Technique for Training: Manual
Data Type: Labeled

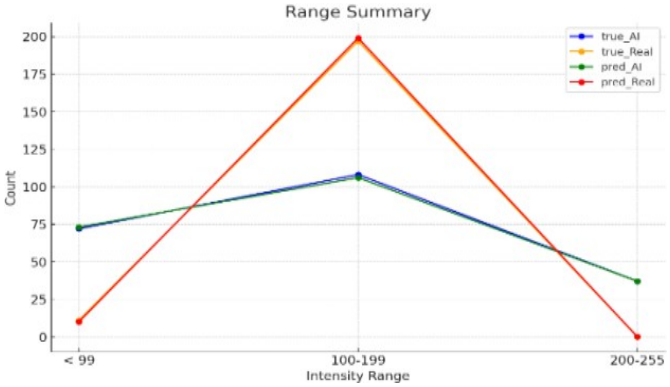

Fig. 3. Case2: True AI Vs True Real & Predicted AI Vs Predicted Real

The observation of Fig 3, accuracy of AI and Real images observed to be high throughout.

Code Output Tables:

TABLE 6: Case2: Pixel-intensity Distribution

Ranges	True AI	True Real	Predicted AI	Predicted Real
< 99	72	11	73	10
100-199	108	197	106	199
200-255	37	0	37	0

Range	True AI	Predicted AI	AI Accuracy	True Real	Predicted Real	Real Accuracy
< 99	72	73	101.39%	11	10	90.91%
100-199	108	106	98.15%	197	199	101.02%
200-255	37	37	100%	0	0	Undefined

Table 7. Case2: Output Accuracy of AI and Real images Prediction by code

Accuracy Analysis of Sample N=1003 and M=424:

Concluded from Table 7, as the size of our test labelled dataset increased, the improvement in the accuracy observed for the (<99) pixel intensity range, while the accuracy for the 200-255 range is perfect 100%. This outcome signifies the reliability, accuracy and effectiveness of using the (200-255) pixel intensity range to distinguish AI-generated images from real images.

C. Case Study 3:*Results obtained with* ***N=1403 and M=807***

Training Dataset

Real Data: 703
AI Data: 700
Technique for Training: Manual Data Type: Labeled
Total Labels: 1403, Total Image Paths: 1403
Feature Shape: (1403,19522), Labels Shape: (1403)
Accuracy**: 0.902676399026764**

TABLE 8. Precision, Recall, F1 Score and Support table for Case3 Training data

	Precision	Recall	F1-Score	Support
0(Real)	0.88	0.92	0.90	195
1(AI)	0.92	0.89	0.91	216
Accuracy			0.90	411
Macro Avg	0.90	0.90	0.90	411
Weighted Avg	0.90	0.90	0.90	411

Testing Dataset

Real Data: 407
AI Data: 410
Technique for Training: Manual

Data Type: Labeled

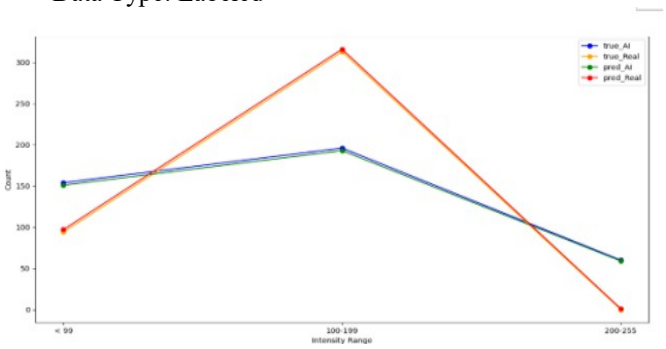

Fig. 4. Case3: True AI Vs True Real & Predicted AI Vs Predicted Real

The observation of Fig 4, accuracy of prediction of AI images and real images is increases with increase in Pixel Intensity.

Code Output Tables:

TABLE 9: Case 3: Pixel-intensity Distribution

Ranges	True AI	True Real	Predicted AI	Predicted Real
< 99	154	94	151	97
100-199	196	313	193	316
200-255	60	0	59	1

TABLE 10: Case 3: Output Accuracy of AI and Real images Prediction by code

Ranges	True AI	Predicted AI	AI Accuracy	True Real	Predicted Real	Real Accuracy
< 99	154	151	98.05%	94	97	103.19%
100-199	196	193	98.47%	313	316	100.96%
200-255	60	59	98.33%	0	1	N/A

Accuracy Analysis of Sample N=1403 and M=807

Concluded from Table10, As increased the dataset, the plots shows a convergence between the actual and predicted data for both AI-generated and real images from range (>99) then diverges for range (100-199) and again converges for range (>200). These results validate the significance of proposed work showing the significant change in pattern of pixel intensities. For more case study with continued expansion of the dataset on high computational resources, this hypothesis can give more supportive results for real time testing of this research and development.

8. CONCLUSION

This study is a useful technique for the application of Generative Adversarial Networks (GAN's), The developed model is analyzed for different range of pixel intensities and categories. The training & testing on different sets of N and M. where, N is the number of images in training dataset and M is the number of images in testing dataset. The variation in data set taken as case study 1, 2 & 3 for collection of different results and analysis. The variation of different combination of AI & Real data sets are passed through this intensity-based model to conclude about accuracy. The experimental data used are customized manually generated and CIFAKE. The results are shown in the form of graphs and tables, which are clearly able to conclude about accuracy of particular range. The collected results validate the significance of proposed work showing the significant change in pattern of pixel intensities to study.

This technique is tested as case study 1, 2 and 3, which give a clear prospective of this technique. With the help of these defined range of pixel intensities, fast testing is performed with more accuracy. This model is developed and tested on a standard hardware (Dell Inspiron 15 3000 with a Ryzen 5 processor) with following outcomes:

- **Pixel-Intensity < 99:** In this defined range Real data set shows more accuracy throughout, while AI accuracy is enhanced with increase in training of AI data set.
- **100<Pixel-Intensity<199:** As for defined second range the accuracy for both Real and AI dataset is constantly increases from first phase of the training to the last.
- **200<Pixel-Intensity<255:** The highest accuracy is achieved for AI dataset for third defined range as the observed result show maximum accuracy for prediction of AI dataset from first to last phase.

Accuracy achieved by model 97% to discriminate real and AI-generated images using Image processing and machine learning, which is higher the 94% accuracy achieved by algorithm's Residual Networks (ResNets) and Vibrational Auto Encoders (VAEs) proposed by Gaye and Serel. Hence for concrete conclusion about accuracy is defined with high hand hardware. This work needs more data collection with different sensors as a inputs for analysis and further research is required. For more case study with continued expansion of the dataset on high computational resources, this hypothesis can give more supportive results for real time testing of this research and development.

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Digital Literacy and its Role in Enhancing Financial Access for Sustainable Economic Growth

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ABSTRACT

The current study aims to find the impact of digital literacy on financial inclusion and its potential use in sustainable economic growth, especially within emerging economies. A systematic review of papers from 2004 to 2024 was conducted through Google Scholar, Taylor & Francis, MDPI, and Wiley Online Library. Using the keywords "digital literacy," "financial access," "financial inclusion," and "sustainable economic growth,". Twenty-six papers were selected for relevance while others were excluded for failing to fit the study. Digital financial literacy is needed to use digital financial services effectively thus facilitating financial inclusion and proper financial decision-making. It further affects poverty reduction, entrepreneurial activities, and social stability in the developing regions. This research will uniquely integrate understanding from these extant papers on digital literacy and financial access, concentrating on their role in promoting sustainable economic growth. This piece of work is important on the significance of digital financial literacy in enhancing financial inclusion through this single paper. The study only focuses on digital literacy for financial access and sustainable economic growth. Future studies might explore how digital literacy impacts economic well-being in underdeveloped regions and other spheres of digital literacy, which may also focus on the accessibility of infrastructure and tailored financial services in rural areas. Enhancing digital financial literacy is essential for better financial inclusion, empowering individuals to make informed decisions, access digital services, and support sustainable economic growth, especially in underserved regions.

Keywords: Digital literacy, financial access, financial inclusion, sustainable economic growth, poverty alleviation.

1. INTRODUCTION

In an increasingly digitalised world, digital literacy has emerged as the crucible for social and economic advancement. This is defined as the capacity to use digital tools and platforms to communicate, seek information, and solve problems, thus not a luxury but a necessity that facilitates e-governance, improves education, streamlines businesses, and enhances health systems in many places around the world. No doubt, in today's integrative global economy, the position of digital literacy in developing innovation, improving productivity, and access to markets is beyond doubt critical in furthering sustainable economic growth. Digital literacy is the prime access to formal financial services for the underserved, and low digital literacy becomes a direct impediment to taking advantage of vital financial services such as savings accounts, credit, insurance, and digital payments in developing areas. Digital literacy empowers people to utilize digital banking, mobile wallets, and fintech to ensure that more economic services are accessible and safe. This, therefore, diminishes economic inequality, encourages already vulnerable populations to fully engage in economic activity, and makes them more resilient and empowered. Digital literacy in financial inclusion promotes sustainable growth in the economy. Access of people and enterprises to resources financial assets, education, health, entrepreneurial activities, and finally to their livelihoods and the local economy makes it stronger and more resilient. Financial inclusion promotes efficient resource allocation while reducing income inequalities and increasing inclusiveness among the economic mainstreams that involve vulnerable groups in the mainstreaming of development. It further encourages environmentally sustainable practices through paperless transactions and investment in green technologies. This way, digital literacy, and financial inclusion can seamlessly contribute to an overall agenda of equitable and sustainable economic growth in the digital age. According to the "Digital Literacy Mission of India's Government," digital literacy would be defined as the capacity and capability of people and communities to understand and engage with sensible digital technologies. They include information fluency, media fluency, computing skills, and critical thinking (Shabani and Keshavarz, 2022; Reddy et al., 2020). It therefore completes the focus of UNCTAD by stretching much beyond the technical knowledge to make other aspects of life and work feasible in a digital society. As Widyastuti et al. (2024), this concept is based on two major principles: improving financial and digital literacy as basic factors and developing risk awareness about digital financial products. In addition, Morgan et al. (2019) also points out that digital financial literacy involves several attributes, such as knowledge of digital services and products, proper management of financial risks, awareness of possible risks, and acquaintance with consumer rights and compensation procedures. These interlocking factors together endow human beings with the ability to conduct business safely and securely online. Besides that, the empowering of women makes women

become the masters of their lives, good decisions, and intensive involvement in social, political, and economic sectors as well (Mehra, 1997; Reshi and Sudha, 2022) ICT plays a vital role in society which has greatly served to bring about changes for more improvement in social and economic aspects, such as higher productivity, employment, easier access to living quality, and creation, storage, process, transmission, and exchange of information. It allows one to understand and make use of various forms of banking services, which include mobile banking and Internet banking, which are essential to their financial inclusion.

The lack of focus on sustainable economic development has led to significant global challenges. According to the Sustainable Development Goals Report (2024), only 17% of the SDG targets are now on track and increasing poverty and hunger are worsening as millions are forced into disastrous situations. Such stagnation is further worsened by climate change and other geopolitical conflicts that erode resources and hinder the rejuvenation of economic activities. The Financing for Sustainable Development Report 2024 also mentions that an annual financing gap of $4 trillion in developing countries is holding back necessary investments in sustainability, thus further slowing the progress toward SDGs there for the study explores the impact of digital literacy on financial inclusion and assesses its potential to drive sustainable economic growth, particularly in emerging economies. In this light, the paper tries to assess the impact of digital literacy on financial inclusion and explore its potential to drive sustainable economic growth, by conducting a systematic review of extant pieces of literature and drawing meaningful findings in this area.

2. RESEARCH METHODOLOGY

The research was conducted through the online databases Google Scholar, Taylor & Francis, MDPI, and Wiley Online Library using key terms such as “Digital literacy”, “financial access”, “financial inclusion”, and “sustainable economic growth”. While many articles were found related to Digital literacy, the focus was solely on the relevant articles and other sources. Twenty-one articles were selected from Google Scholar that were closely aligned with the research scope, and one was selected from Taylor & Francis that was specifically pertinent to the research topic. Three academic publications were chosen from the MDPI database since they were closely related to the field of study and one article was chosen from Wiley Online Library which did not repeat themselves. Based on this review's topic, 26 past study selected which combined articles and books were selected for the examination. The following table sums up the study summary of the article search process and Figure. 1 summarises the review methodology adopted for this review. The following excludes duplicates that occurred within the selected databases. The papers pursued access to digital literacy toward financial inclusion and sustainable economic growth in this study.

Figure. 2 Year-wise analysis of papers: The analysis shows a high growth in papers related to digital literacy mainly digital financial literacy which helped financial accessibility and sustainable economic growth after 2020. This concept has grown in importance daily, especially in the last ten years since the collection of chosen articles being extracted for the study related to study sphere review.

TABLE 1: Database Utilise for Review of Literature

Database	**No. of Articles reviewed**	**Frequency**
Google Scholar	21	81%
Taylor & Francis	1	04%
MDPI	3	11%
Wiley Online Library	1	04%
Total	26	100%

source: compiled by authors

Table 2: Article Type and Focus of the Study

Sl. No	**Author**	**Title**	**Approach**			**Focus**	
			F/T	**S**	**R**	**1**	**2**
1	(Rao, 2005)	“Bridging digital divide: Efforts in India”			⇧	⇧	
2	(Chauhan & Murthy, 2006)	“India on the way to bridge the digital divide: role of INFLIBNET”	⇧			⇧	
3	(Rajput & Nair, 2013)	“Significance of Digital Literacy in E-Governance”			⇧	⇧	
4	(Venkatesh & Sykes, 2013)	“Digital Divide Initiative Success in Developing Countries: A Longitudinal Field Study in a Village in India”		⇧		⇧	
5	(Khan, 2014)	“Digital India: Emerging Challenges & Opportunities for the Banking Sector”			⇧	⇧	⇧
6	(Arun & Kamath, 2015)	“Financial inclusion: Policies and practices”			⇧		⇧
7	(Jagani & Patra, 2017)	“Digital Participation through Mobile Internet Banking and Its Impact on Financial Inclusion: A Study of Jan Dhan Yojana”	⇧			⇧	⇧
8	(Sardana & Singhania,	“Digital technology in the realm of banking: A review of literature”			⇧	⇧	⇧

	2018)						
9	(George & College, 2020)	"A Study on Digital Financial Literacy: A Precedent for Improved Financial Literacy and Financial Inclusion"		⇧		⇧	⇧
10	(Kamesh, 2021)	"COVID-19 - Digital Transformation and Digital Competency"			⇧	⇧	⇧
11	(Fitriani & Santi, 2023)	"Does Financial Technology and Financial Literacy Enhance Financial Inclusion? (Evidence from Several Countries)"			⇧	⇧	⇧
12	(Fauziyah et al., 2024)	"Digital Financial Literacy and Digital Financial Inclusion: Efforts to Overcome Challenges After the Covid-19 Pandemic and Increase the Independence of Financial Management"	⇧			⇧	⇧
13	(Gumilar et al., 2024)	"Digital Financial Literacy and Digital Financial Inclusion in the Era of Digital Disruption: Systematic Literature Review"			⇧	⇧	⇧
14	(Kumar et al., 2024)	"Impact of Digital Financial Literacy on Financial Inclusion – The Role Fintech Services"		⇧		⇧	⇧
15	(Khémiri et al., 2024)	"How Financial Inclusion Moderates the Curvilinear Nexus between Tangible Investment and Sustainable Firm Growth: New Evidence from the Middle East and North Africa Region"		⇧			⇧
16	(Adel, 2024)	"The Impact of Digital Literacy and Technology Adoption on Financial Inclusion in Africa, Asia, and Latin America"		⇧		⇧	⇧
17	(Showkat et al., 2024)	"Empowering women in the digital age: can digital financial services fulfil the promise of financial autonomy and gender equality in the attainment of Sustainable Development Goal 5?"		⇧		⇧	⇧
18	(Abbas et al., 2024)	"How Financial Inclusion and Green Innovation Promote Green Economic Growth in Developing Countries"		⇧			⇧
19	(Nwokike et al., 2024)	"Effects of Financial inclusion and sustainable economic growth in Nigeria: The role of Small and Medium-Sized Enterprises (SMEs)"			⇧		⇧
20	(Tidjani & Madouri, 2024)	"Fintech, financial inclusion, and sustainable development in the African region"		⇧		⇧	⇧
21	(Hussain et al., 2024)	"Financial Inclusion and Economic Growth: Comparative Panel Evidence from Developed and Developing Asian Countries"		⇧			⇧
22	(Mishra et al., 2024)	"Financial Inclusion and Its Ripple Effects on Socio-Economic Development: A Comprehensive Review"			⇧		⇧
23	(Amaliah et al., 2024)	"Does digital financial inclusion forecast sustainable economic growth? Evidence from an emerging economy"		⇧		⇧	⇧
24	(Huang et al., 2024a)	"Role of social capital and financial inclusion in sustainable economic growth"		⇧			⇧
25	(Huang et al., 2024b)	"Natural resources, digital financial inclusion, and good governance nexus with sustainable development: Fuzzy optimization to econometric modelling"		⇧		⇧	⇧
26	(Yasmina, 2024)	"The impact of digital finance on enhancing financial inclusion and achieving sustainable development in the tourism sector in Algeria"		⇧		⇧	⇧

Abbreviations used:

F/T – Framework/ Conceptual

S- Survey/Empirical study

R- Review / Analytical Summary of Articles w.r.t. Author, Title, Approach

Focus 1- Role of Digital Literacy in Financial Inclusion.

Focus 2- Financial Inclusion to Sustainable Economic Growth

source: compiled by authors

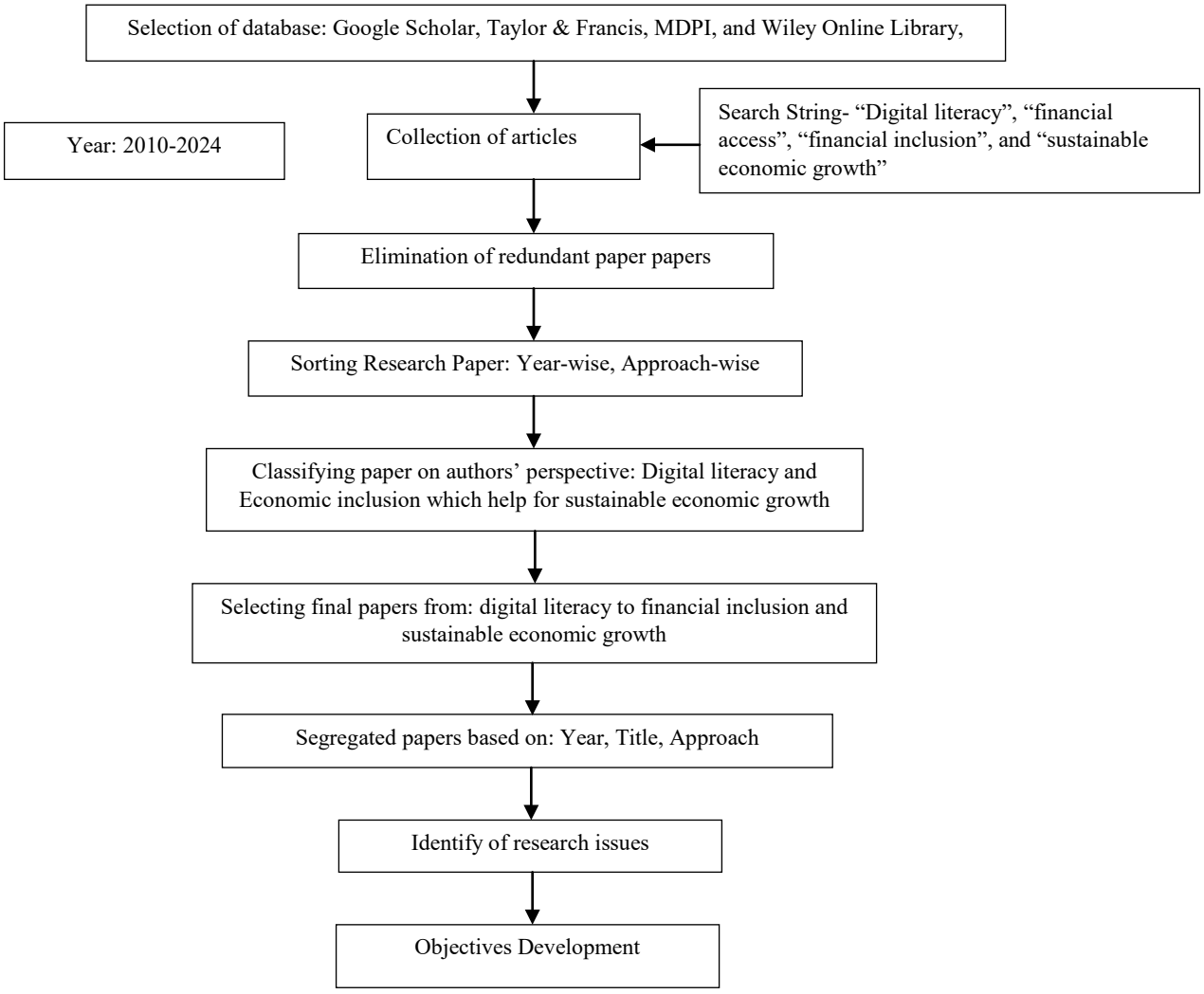

Figure 1: Research Methodology for Selection of Articles

Source: flowchart adopted from Pareek & Mangaraj, (2021)

TABLE 3: Major Questions as per the Research Issues

Phase	Representative Article	Research issue	Research Question
Role of Digital Literacy in Financial Inclusion. (FOCUS 1)	(Rao, 2005); (Chauhan & Murthy, 2006); (Rajput & Nair, 2013); (Venkatesh & Sykes, 2013); (Khan, 2014); (Jagani & Patra, 2017); (Sardana & Singhania, 2018); (George & College, 2020); (Kamesh, 2021); (Fitriani & Santi, 2023); (Fauziyah et al., 2024); (Desy Wulan Ayuning Gumilar et al., 2024); (Kumar et al., 2024); (Adel, 2024); (Showkat et al., 2024); (Tidjani & Madouri, 2024); (Amaliah et al., 2024); (Huang et al., 2024b); (Yasmina, 2024).	R11: Few studies explore effective ways to increase internet access and add bandwidth in rural areas. R12: Holistic research is lacking in terms of unique challenges and barriers to the development of digital literacy skills and adaptation to technological advancement by older populations.	RQ1: Is there a different strategy requirement to increase internet access in rural areas? RQ2: Do older people face barriers to the development of digital literacy skills and adaptation to technological advancement for access to financial inclusion?
Financial Inclusion to Sustainable Economic Growth (FOCUS-2)	(Khan, 2014); (Arun & Kamath, 2015); (Jagani & Patra, 2017); (Sardana & Singhania, 2018); (George & College, 2020); (Kamesh, 2021); (Fitriani &	R13: The banking systems, although expanding and strengthening to effectively cater to the growing demand for	RQ3: Are there any unique challenges to the banking sector unable to get more attention when such growth and

Phase	Representative Article	Research issue	Research Question
	Santi, 2023); (Fauziyah et al., 2024); (Desy Wulan Ayuning Gumilar et al., 2024); (Kumar et al., 2024); (Khémiri et al., 2024); (Adel, 2024); (Showkat et al., 2024); (Abbas et al., 2024); (Nwokike et al., 2024); (Tidjani & Madouri, 2024); (Hussain et al., 2024); (Mishra et al., 2024); (Amaliah et al., 2024); (Huang et al., 2024a); (Huang et al., 2024b); (Yasmina, 2024).	financial inclusion to sustainable economic growth in all cases are expected to receive insignificant attention, especially in regions of large and underserved populations.	strengthening has to support even heavier demands for financial inclusion, with large populations waiting in the wings?

TABLE 4: Objectives of the Research

Sl. No.	Research Question	Objectives
1	QR1, QR2	Role of Digital Literacy in Financial Inclusion.
2	QR3	Financial Inclusion to Sustainable Economic Growth.

3. REVIEW OF LITERATURE

The review of Literature is divided into two categories:

3.1 Role of Digital Literacy in Financial Inclusion.

Digital literacy would be an important role, one that enables people to have appropriate skills in interacting with digital financial services. This process of building the capability leads to access to a broad range of financial services(products); more importantly, it yields healthier financial behaviours and better attitudes toward handling finances. As per the changing world day to day, it has to update with the changing scenario for a better future with sustainability future but it has many barriers to overcome for the better future. The gap is still mainly a product of socioeconomic inequalities in terms of better access at an urban location than in a rural location, according to Chauhan and Murthy (2006). They further mention that this gap will be better covered by initiatives like INFLIBNET and awareness programs by promoting e-information literacy. These are coupled with improvements in accessibility of the Internet in institutions of learning within India thereby creating a spread as the gap narrows. Venkatesh and Sykes (2013) analysed does social networks had played a significant role in influencing technology use? which had partially mediated its impact on economic outcomes. According to the results, they found that their initiatives based on social network constructs resulted in better economic performance, whereby growth in the village income had outperformed national GDP growth. They also stressed that higher social ties had always been correlated with better economic performance and underlined the importance of applying social networks for economic development. Khan (2014) brings forth the barriers and opportunities available in the financial sector (banking) relating to mobile banking and the imperative for banks and telecom companies to come together to unlock the unexplored potential in India. TReDS (Trade Receivables Discounting System) is seen as one of the main initiatives to finance MSMEs. The increase in e-payment transactions also points toward the need for a technological transformation to increase the efficiency of operations. He also states the strategy in refining better growth of risks and revenues encompasses the exploitation of Big Data.

According to (Rajput & Nair, 2013) Digital literacy increases the effectiveness and transparency of the e-governance concept, cutting down corruption and increasing the accessibility of the general public toward government services and it serves a significant purpose in the socio-economic advancement of society. However, sometimes fear and lack of motivation hinder the progress of digital literacy programs. Government support is much more essential for digital literacy and also for the plans related to e-governance and rural empowerment in the form of computer centres to improve the access of people towards ICT resources. This will thus pave the way for enhanced decision-making and even financial outcomes. The succeeding subsections talk of different dimensions of the relationship but define how digital literacy works its way towards better financial inclusion and therefore better economic welfare. Arun and Kamath (2015) assessed inclusion strategies since 1991 based on usage and access to financial products in 30 countries. They underscore that user-centric policies make financial inclusion effective for a host of groups. However, they do point out that the cultural understanding influencing the same would have an impact on both financial capability and overall well-being. (Jagani & Patra, 2017) explored a research study that makes the case for financial resilience through the Jan Dhan Yojana and assesses consumer engagement and disengagement impacts. It emphasizes the impact of the technological divide on the ability of consumers to engage in digital banking and further identifies that mobile banking constitutes an important component of

expanding access to disadvantaged groups. The research study concludes that the attainment of better levels of inclusion requires financial and digital literacy. Besides, the study depicts a significant correlation between the use of Internet banking and levels of educational achievement, coupled with relevant skills. The government has established policies to reduce the digital divide and facilitate digital inclusion as an important factor in facilitating economic growth and improving civic participation. In the view of Sardana and Singhania (2018), digital technology has transformed Indian banking, where 'Brick and Click' models are preferred in place of 'Internet-only'. Customers increasingly seek tailor-made services and greater value for money while security acts as a deterrent to make wider adoption of digital banking. Cooperation between old banks and fintech firms represents an important success factor. The COVID-19 pandemic accelerated digital payments in India to a large extent. (Kamesh, 2019) found fintech new enterprise have played a very significant role in the personal management of finances. QR code contactless payments surged, and levels of UPI transactions reached unprecedented numbers. Digital payments were now a part of daily transactions, and services provided by fintechs became customer-centric. Expansion of e-commerce sites increased the number of options for digital payments. Digital literacy efforts in emerging markets gained more intensity. The author deems digital financial literacy of particular importance as it can fundamentally be connected to targeted financial inclusion in terms of access, understanding, and application of technological financial tools and services (George & College, 2020). Fitriani and Santi (2023) say that digital financial literacy is included in the development of financial inclusion.

They further contend that financial technology greatly helps in the development of financial inclusion since users feel that digital financial services are more comprehensible. Increased use of financial technology also boosts financial inclusion. The authors opine that collaboration between banks and fintech is crucial for development in this field. However, they acknowledge that a weak citation may affect the validity of findings. Better digital financial literacy facilitates better access to financial services, an impetus for increased financial inclusion and reduced economic and social inequalities, as per Gumilar et al. (2024). Advances in technology bring better opportunities for financial well-being; however, the socio-economic status of a person determines his or her potential for digital financial literacy. Consumer protection issues still prevail despite the expansion of digital services. Financial literacy improvement programs are necessary to reduce financial crises, and digital financial inclusion is instrumental in supporting economic growth and stability. Digital financial literacy, as Kumar et al. (2024) indicate, is a good determinant for the adoption of fintech, mainly contributing to inclusions about finances. Awareness of consumer rights along with knowledge of digital financial products results in the enhancement of fintech adoption of service offerings. Perception of risk about finance acts as a positive influencer to take up services for fintech. Also, Studies indicate that with the growth of AI and blockchain, digital literacy is key to improving financial inclusion in new markets (Adel, 2024). Despite uneven internet penetration in regions, it reveals disparities in terms of regions across digital literacy and technological advancement. The higher a digital literacy, the better its access to financial services would be, but measurement error affects the accuracy of related variables.

3.2 Financial Inclusion to Sustainable Economic Growth.

The issue of financial inclusion is, today an important driver toward sustainable growth of the economies of countries. Since access to financial services by all sorts all people and enterprises can be positively supportive of economic development, therefore the major aspects by which financial inclusion contributes toward sustainable economic growth. According to Amaliah et al. (2024), digital financial inclusion contributes highly to GDP growth, especially in the use of automated teller machines and debit cards for stimulating economic growth. However, they notice that its contribution to CO2 emissions is moderate and, therefore, shows a balanced relationship between economic growth and environmental development. In the study explored by Showkat et al. (2024), digital financial services are essential in promoting women's decision-making and independence over financial issues. The study on 426 women from different age groups and regions brings out how these services work toward the larger objective of gender equality and economic empowerment.

The author proposes that financial inclusion is one of the prime determinants of economic growth in Asia with a mutual relation between financial inclusion and economic development. The effect is most significant when comparing developing countries with their developed counterparts (Hussain et al., 2024). (Mishra et al., 2024) mentioned that financial inclusion is needed for sustainable socio-economic development as it enables marginalised groups to improve access to finance, facilitates financial literacy in proper decisions, and innovation that provides affordable and accessible services. According to the authors, financial inclusion encourages entrepreneurship and employment. (Huang et al., 2024a) find such results financial inclusion has major effects on poverty reduction and economic equality. Financial literacy is a crucial intermediary, that induces sustainable development, and social capital adds up to the relationship of financial inclusion with sustainability through the medium of collective action as well as ethical norms in an economy. Income levels and knowledge of banking influence access to finance, implying that the two factors are significant factors financial institutions take into consideration when distributing resources.

Thus, the dynamics of this study rely on its impacts on sustainable development in developing countries. and

(Fauziyah et al., 2024), also claim that digital financial literacy empowers MSMEs by giving them independence in financial management, while financial inclusion has played a critical role in bridging gaps and driving sustainable development for these enterprises. The study discusses the few relevant factors for sustainable development the outcome given by (Huang et al., 2024b) digital financial inclusion contributes largely to sustainable development, while the availability of natural resources adds to those outcomes. Efficient governance increases the relationship between digital inclusion and sustainability but the absence of critical factors slows down progress, which further reduces the sustainability level. Hybrids have integrated approaches that may provide holistic comprehension regarding what drives sustainable development. (Khémiri et al., 2024) believes that the relationship between investment growth is curvilinear where investments increase growth first, but the diminishment occurs at the higher thresholds. Financial inclusion plays a moderating function in the investment and growth dynamic besides supporting sustainable firm growth. Improving access to financial services enhances operational efficiency and competitiveness, as Nwokike et al. (2024) explain it is one of the principal roles it plays in accelerating SME growth in Nigeria. Access of SMEs to financial services is likely going to require intermediaries in the financial sector. The policy provisions that should open up the access of SMEs to financial services are likely going to be needed. Inversely, high interest rates and less financial literacy limit the expansion of an SME. A study in Algeria by Yasmina (2024), the paper discussed the role of digital finance in promoting financial inclusion, especially within Algeria's tourism sector. It described financial inclusion as the main route to achieving sustainable development goals; meanwhile, it makes rural access to services more efficient through advancements that digital finance promotes.

It also stressed that the success of digital payment systems is dependent on trust from the cardholders and thus calls for the adoption of a holistic national financial inclusion strategy. (Tidjani & Madouri, 2024) found that financial inclusion significantly contributes to the sustainable development of Africa and FinTech contributes considerably to positive results. However, a negative influence in the relationship appears in the relationship between financial inclusion and FinTech on sustainable development. Abbas et al. (2024) argue that financial inclusion, although important, would restrain green economic growth unless aligned with green investment. It is found that green innovation, foreign direct investment, and trade openness are influential factors that work positively toward green economic development while green innovation also creates research and development employment. However, it is identified that population growth is a significant obstacle as it negates green economic development. Economic factors also bind funding for green initiatives in developing countries, further complicating efforts toward sustained development.

4. THEORETICAL MODEL

Based on the review, the authors have proposed a theoretical model as follows:

Source: compiled by authors based on the literature review

5. FINDINGS

- Digital literacy allows a person to negotiate and utilise a variety of financial products and services. As a result, it leads to good financial behaviour and attitudes toward money management.
- Initiatives like government-arranged computer centers should be there to increase the level of digital literacy, mainly on the rural front.
- Digital literacy increases transparency in finance which reduces corruption, thereby giving the public more confidence in the system.
- Digital literacy will facilitate and directly contribute to the reduction of poverty and economic inequality, leading to long-lasting sustainable economic growth.
- Digital financial literacy can help in improved management of finances for MSMEs, hence leading to sustainable development in the sector.
- Efficient governance combined with digital financial inclusion has a more direct effect on sustainability; this is helping economies grow more inclusively.
- Digital inequality also exists in unequal access to the internet and proper technological infrastructure thus bringing digital inequalities that will prevent large parts of the population from gaining full benefits from financial services.

The results suggest that however important financial inclusion is, without synchronisation with green investment, it can be detrimental to the growth of green economic development. Green innovation and foreign direct investment are the most potent positives contributing to green economic advancement. However, in that respect, population growth happens to be the most pivotal impedance factor, and much so when poor economic conditions make limited space for

funding available for green projects in countries under consideration.

6. IMPLICATION

Stakeholders, including government bodies, financial institutions, and development organizations, must promote digital literacy, especially in rural areas, by using government-arranged computer centers to empower every individual with the skills to manage finances. The synchronization of financial inclusion efforts with green investment strategies will ensure these initiatives support green economic growth instead of obstructing it. Thus, digital literacy can enhance transparency, minimizing corruption and building public confidence in the financial system, which is regarded as vital for sustainable economic growth. Moreover, digital financial literacy should cover MSMEs for better financial management practices and long-term existence of the sector. Addressing digital inequality through wider internet and technological infrastructure access is critical to ensuring marginal communities have a chance to benefit from digital financial services, nurturing more inclusive growth. Stakeholders must encourage green innovation and foreign direct investment advances while simultaneously managing challenges from population pressure and scarce financing opportunity in promoting green economic development. The various frameworks define the resource allocation space that is in place to support green aberrative to assure their sustainability even under conditions of limited financing.

7. LIMITATION

- The study only focused on the development of digital financial literacy, overlooking other dimensions of digital skills, which may have future impacts on both financial inclusion and economic growth.
- The study lacks detailed regional analysis about understanding unique challenges, such as infrastructure and cultural barriers in rural or underserved areas.

8. FUTURE STUDY

There are a few future study agendas that can be conducted in research:

- Future research to study the impact of broader digital skills, beyond digital financial literacy
- Regional division in the impact of digital literacy on financial inclusion and economic growth, especially for rural areas
- Longitudinal study on how digital literacy impacts poverty reduction and social order.

9. CONCLUSION

The lack of focus on sustainable economic development continues to intensify global challenges from growing poverty and inequality, worsened by climate change and geopolitical conflicts. Closing the annual financing gap for sustainability is one of the major hurdles facing developing countries. It will require innovation that empowers people and communities, especially through better financial access. Thus, digital literacy becomes an important enabler to equip people with the skills to navigate financial systems that help in sustainable economic growth and contribute toward the achievement of the Sustainable Development Goals. This research therefore depicts the importance of digital literacy in enhancing financial inclusion and pushing forward sustainable development. Digital literacy enhances good financial behavior and money management, as well as transparency in financial dealings, reducing the potential for corruption and building public confidence in a financial system. It also assists micro, small and medium enterprises to handle finances appropriately, which helps in stimulating sustainable growth of the sector. Still, access to Internet availability as well as infrastructure, Internet-access inequality occurs, and benefits from financial inclusion are somehow limited to the marginalized classes in certain ways. Based on these observations, the government, financial institutions, and development organizations must focus on initiatives that will promote digital literacy in rural and less privileged regions. Government has to initiate government-supported digital literacy centers, improve access to technology and internet, and align the financial inclusion with green investment strategy to support such initiatives to achieve the objectives of sustainable development toward inclusive and environment-friendly growth. This research is, despite all these insights, limited. It narrowly focuses on digital financial literacy, whereas other more pervasive digital skills remain totally overlooked, and an extensive regional analysis that is aimed to overcome the specific infrastructure and cultural barriers in the rural areas was not covered. Further studies would consider the effect of the overall digital skills on financial inclusion, study the regionally comparative outcomes, and undertake longitudinal studies to evaluate the long-run effects of digital literacy on poverty and economic stability. An important strategy to overcome systemic barriers to financial inclusion and sustainability involves the strengthening of digital literacy. The bridging of digital divides should have different types of stakes from a range of stakeholders to support growth in a more resilient path towards the achievement of global goals on development.

DECLARATION

I, Bhuteswar Patra, hereby confirm that the manuscript titled "Digital Literacy and its Role in Enhancing Financial Access for Sustainable Economic Growth" authored by Bhuteswar Patra, Mallha Tudu, and Anita Pareek has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved

the manuscript and agreed to its submission to International Management Perspective Conference (IMPeC) - 2025.

We declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgements have been made where required.

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THEME: ENTREPRENEURSHIP

TRACK 1: MARKETING PRACTICE AND RESEARCH

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Bottom of the Pyramid Marketing Strategies: Comparative Analysis of Consumer behaviour of Different Products

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ABSTRACT

This paper explores the marketing strategies employed for Bottom of the Pyramid (BOP) consumers by comparing successful and failed products across various case studies. With a focus on both developing and developed markets, the study analyzes how pricing and social perception influence consumer buying behavior in BOP segments. BOP consumers, often characterized by their resource constraints display unique cognitive and behavioral traits that shape their purchasing decisions. The study draws on multiple models and extends these frameworks by incorporating elements like personalization, trust, and adaptability to better meet the needs of BOP consumers.

Successful products in BOP markets have shown that localized and simplified marketing strategies, particularly those involving community engagement and taking into account local legitimacy contexts, are more effective at overcoming institutional barriers.

Companies that tailored pricing and distribution channels to BOP consumers' financial limitations succeeded, while those that failed often misunderstood local social and economic dynamics, leading to misaligned pricing, poor communication, and ineffective supply chains.

This paper also examines consumer behaviors, particularly in the context of apparel purchasing, where factors like trust, and perceived awareness play a significant role. The study suggests that firms targeting BOP consumers should focus on building trust, providing clear information, and offering products at affordable prices without compromising on quality. The findings provide valuable insights for multinational companies and local entrepreneurs looking to establish sustainable business models in BOP markets along with the promotional mix factors that should be considered by them.

Keywords: Marketing strategies, Bottom of the Pyramid, Social perception, Consumer behaviour, Promotional mix.

1. LITERATURE REVIEW

The bottom of the pyramid (BOP) represents a significant portion of the world's consumer population in emerging economies, offering enormous potential for profits due to their collective purchasing power (Cox, September 2022). Although BOP consumers typically have low purchasing power, they present a large, growing, and less saturated market compared to the middle- and high-income segments. Their cumulative economic contribution can sustain profitable returns while fostering inclusive economic development (Srivastava, (2022)) . A large part of the BOP market (urban BOP consumers) strives to move up the economic pyramid by using similar products to those used by the middle and top-of-the-pyramid consumers, such as apparel (Singh, (2022),). This consumer segment comprises resource-constrained and economically weaker populations spread across various countries and continents, further segment-able by culture, capabilities, literacy, income, and other factors (Prahalad C., 5th edition., 2012). Most of the BOP population resides in countries such as China, India, and Brazil (Khandker, 23 May 2022). In India, urban BOP households earn less than INR 3,00,000 annually, while rural BOP households earn less than INR 1,60,000 (Ablett, 2007) (Sonal Purohit, (2021)). Delhi, the capital city of India is one of the most populous cities in the world. Migrant workers belonging to the BOP group come from different parts of the country in search of employment and comprise 33% of the total population of Delhi (Sharma.M, 2018)

The bottom of the pyramid attracts multinationals because of its large population with a pending demand, low consumer expectations, slight competition, and the possibility to leapfrog to the newest technology (Sofie Van den waeyenberg, 25/7 (2008)). The market represents what some scholars have referred to as the last untapped island of opportunities for global business that are faced with decreasing consumer demand in advanced economies (Nakata, 2012) (Chikweche T. , 2013). Authors in the bottom of the pyramid field argue that success requires companies to rethink their products and business models, including marketing, and distribution (Sofie Van den waeyenberg, 25/7 (2008)) . The authors advise companies to expand the reach of stakeholder management, to choose non-traditional partners, and to adopt a native capability (Sofie Van den waeyenberg, 25/7 (2008)). Firms are encouraged to adopt native capabilities, choose non-traditional partners, and expand stakeholder management to succeed in these markets. The BOP segment significantly differs from the middle-income segment because of the less centralized networks, a wider scope, less density, and the presence of structural holes (Rivera-Santos, 2010). The emerging model being advocated

for and used by firms is one that is not just market based, but one that views BOP consumers as active partners rather than consumers or producers (Varman, 2012).

The BOP segment significantly differs from the middle-income segment because of the less centralized networks, a wider scope, less density, and the presence of structural holes (Rivera-Santos, 2010). These differences pose challenges, including economic constraints such as low income, high inflation, import price shocks, foreign currency shortages, lower remittances and reduced private capital inflows (Coorey et al., 2007; Eifert et al., 2005; Ersado, 2006; Johnson et al., 2007; Ndulu et al., 2007; Nwanko, 2000). Infrastructure issues, such as unreliable electricity, poor distribution channels, and inadequate transportation, further complicate market development (Austin, 1990; Fay and Morrison, 2006). Despite these challenges, the BOP represents the largest and fastest- growing market globally, comprising approximately half to two-thirds of the world's population (Prahalad C. , The Fortune at the Bottom of the Pyramid: Eradicating Poverty Through Profits. 5th edition., 2012) (Chikweche T. , 2013). The BOP is not just a market of survival but also a burgeoning segment with growing aspirations and willingness to purchase products tailored to their needs.

Consumers in this segment often focus on meeting their basic needs—food, clothing, housing, and fuel (Group, 2003) but disposable income and education influence their purchasing behavior. When disposable income rises, demand for these previously unaffordable products will increase (Arnold, (1998)); (Prahalad C. a., 2002)). Firms targeting this segment must reconsider their resource allocation and inter-departmental coordination strategies. The lack of a unified purpose within firms has been identified as a significant barrier to maximizing BOP penetration (Chikweche T. , 2013). Moreover, considering cultural and organizational biases, marketers have mainly focused on serving customers in the medium to high-income segments (Chikweche T. F., 2012). Differences in economic instability, social unrest, and socio-economic divisions within BOP markets complicate efforts to generalize market attractiveness (Chikweche T. , 2013). However, the potential remains vast. Nearly 85% of the global market now comprises BOP consumers, with population growth forecasted to rise predominantly in this group, unlike the shrinking high-income segment (Chikweche T. , 2013). As the market expands, firms must address gaps in their strategies to reflect the increasing contribution of the BOP to global business turnover. By engaging this market effectively, companies can stimulate inclusive economic growth while unlocking significant revenue streams.

2. METHODOLOGY

This research utilizes a **secondary data** approach, drawing from credible, pre-existing sources including published research papers, industry reports, and case studies on BOP marketing strategies. The focus is on understanding **consumer behavior** and the effectiveness of marketing strategies for existing products across diverse industries. After analyzing successful BOP marketing efforts in India, with an emphasis on case studies. This helps us assess how these strategies could be adapted to other emerging markets and products.

A qualitative mixed method research approach was used, comprising qualitative case studies and ethnographic field observations (Axinn and Pearce, 2006; Creswell, 2007). This method affords researchers a chance to integrate multiple sources of information from multiple approaches and operates as a form of triangulation (Clark

and Creswell, 2008). Analysis of meaning of text was then achieved through condensation, categorization, narration and interpretation of the data. Cross-case synthesis was used in order to enhance the findings from the case studies. Hence the main focus of the interpretation of the findings was more on the development of solid, plausible and fair arguments "that are supported by direct evidence from the data" (Yin, 2003, p. 137).

By reviewing these sources, we identify patterns in **pricing, consumer perception, and purchasing behavior,** which are then compared across successful and failed products. This method ensures a comprehensive analysis grounded in validated research while offering fresh insights on how companies can modify proven marketing frameworks to suit new products in BOP markets.

3. MARKETING MIX

The 4 Ps of the marketing mix model (Product, Promotion, Price, and Place) summarized by McCarthy (1964) are extensively used in consumer marketing (Sonal Purohit, (2021)). It is widely accepted that the traditional marketing mix comprising these 4 Ps plays a key role in implementing successful marketing strategies in different contexts ((Sheth, (2011)); (Constantinides, (2006)) (Gronroos, (1994)) (Mahima Mathur, February 2021). However, service marketing mixes differ predominantly from the 4 Ps of traditional marketing, entailing an additional three Ps: people, process, and physical evidence (Sonal Purohit, (2021)).

Marketing begins with research on the needs and desires of clients (McIver and Naylor, 1986) which were not considered by marketers (Moller, ¨ 2006) while designing a marketing mix frame work. (Sonal Purohit, (2021))

Jaworski and Kohli (1993) have defined market orientation from the perspective of firms, emphasizing three key activities within market-oriented cultures: intelligence generation, intelligence dissemination, and response to new information. Similarly, Narver and Slater (1990) identified three interrelated components of market orientation:

customer orientation, competitor orientation, and interfunctional coordination (Chikweche T. , 2013).

Trim and Lee (2007, p. 271) argue that strategic marketing frameworks should be "all-embracing, flexible, and adaptable." (Chikweche T. , 2013). In the context of the bottom of the pyramid (BOP), the marketing mix has been prescribed as the foundation for strategic marketing frameworks (Mahajan and Banga, 2006; Prahalad, 2005; Viswanathan et al., 2008). This underlines the importance of tailoring marketing strategies to unique contexts, demonstrating the adaptability and relevance of both traditional and expanded marketing mix frameworks.

1. Product:

Product development in bottom-of-the-pyramid (BOP) markets requires a nuanced understanding of the unique challenges and opportunities posed by these consumers. BOP consumers exhibit homogeneity in trust and attitudes towards non-essential products, largely due to their cost and limited affordability (Bianca Maria van Niekerk). As these consumers have a constrained income, they prioritize reliability in the products and services they use (Sonal Purohit, (2021)). Price not only influences cost advantages but also affects perceived financial risk, as consumers fear losing money if the product fails to meet their needs (Sofie Van den waeyenberg, 25/7 (2008)). This highlights the importance of ensuring that the price aligns with the promised value, as unmet expectations can erode trust and satisfaction.

BOP markets also offer a distinct advantage for companies, as weaker competition and less demanding consumers in low- and middle-income countries allow businesses to create simple, well-functioning, and affordable products (Sofie Van den waeyenberg, 25/7 (2008)). The lower literacy of people at the bottom of the pyramid drives companies to develop simple products that are easy to use even without reading a manual (Sofie Van den waeyenberg, 25/7 (2008)). Another salient characteristic of an innovation is its compatibility with consumer needs, experiences, and values. The more compatible the product, the more consumers tend to buy the product (Rogers, 2003).

There is growing evidence that BOP consumers are willing to buy products addressing their specific needs, emphasizing the importance of incorporating the customer perspective during product development (Skowron and Kristensen, 2012). Technology-enabled, value-added products are particularly significant in this context (O'Loughlin and Szmigin, 2006; Haas et al., 2012). Additionally, sustainability considerations mandate that new approaches be developed for the use and reuse of resources in an environmentally friendly manner, ensuring a drastic reduction in resource intensity (C. K. Prahalad, August 1999).

Ultimately, the true value of a product or service for BOP consumers lies in its ability to protect their interests and provide assurance of quality (Mahima Mathur, February 2021). Companies must focus on delivering simple, functional, and affordable solutions that resonate with the lived experiences and constraints of this demographic while maintaining trust and reliability.

2. Price:

Price plays a critical role in the purchasing behavior of bottom-of-the-pyramid (BOP) consumers, who are highly value-conscious (Prahalad, 2004) and price-sensitive (Karnani, 2007). Researchers have consistently emphasized price as an important factor for BOP markets due to their extreme sensitivity to pricing strategies (Prahalad, 2004; Karnani, 2007). Prahalad (2010) argues that a traditional mindset regarding pricing strategies should be changed and instead companies should focus on affordability, affordability to cater to the unique needs of these markets.

BOP consumers' perceived behavioral control significantly influences their apparel behavioral intentions, as it reflects the extent of control they have over purchases within the Theory of Planned Behavior framework

(Icek Ajzen, July 1992) (Singh, 2016, p. 27). Customers in BOP markets often lack financial flexibility, and maintaining an average monthly or quarterly balance of money in their accounts remains a concern of importance (Sonal Purohit, (2021)).

Access to credit as a way of creating consumers out of the poor is not a new concept (C. K. Prahalad, August 1999). The availability of micro-credit is transforming those villages that have access to it. Availability of credit has jump-started widespread entrepreneurial efforts, created new employment, and raised the overall standard of living at the village level. (C.K. Prahalad, August 1999). This has contributed to the affordability of products and services in BOP markets.

Companies aiming to serve BOP markets have employed strategies to reduce production costs by using cheaper materials, eliminating nonessential features, cutting distribution costs, or combining product purchases with micro-lending (Sofie Van den waeyenberg, 25/7 (2008)). Some retailers chose to sell in bulk at low prices and have climbed to the top of their respective industries by so doing (Ferguson, 2017); in this effort they often appeal to lower socio-economic consumers for whom saving money is important. (Martirano, November 24, 2018)

3. Process & Place:

Place, as a component of the marketing mix, is integral to a firm's distribution activities, encompassing channels of distribution, location, and coverage (Kotler, 1976). Yudelson (1999) defines place as all efforts undertaken to facilitate the process of exchange. In the context of bottom-of-the-pyramid

(BOP) markets, physical access to products and services remains a significant challenge (Austin, 2002). Prahalad (2010) emphasizes the importance of convenient locations for BOP consumers, while Seng et al. (2015) argue that service firms must carefully choose distribution channels to ensure products or services are available at as many convenient places as possible. Shin (2001) explains that the place is related to the distribution and delivery of services. For companies operating in low- and middle-income countries, addressing the needs of a dispersed and largely rural population necessitates an expansive distribution network, distinct from the concentrated, primarily urban populations of high-income regions. Ensuring product accessibility in these areas requires robust transportation infrastructure to bring products to local distributors efficiently (Sofie Van den waeyenberg, 25/7 (2008)). Such considerations highlight the logistical complexities involved in reaching BOP markets.

Process is related to the systems and procedures that act as vehicles that deliver value to customers (Salloum and Ajaka, 2013). This element ensures that the delivery mechanisms are efficient, reliable, and aligned with consumer expectations, making it a crucial factor in both product and service marketing strategies. By focusing on well-defined processes, businesses can enhance customer satisfaction and loyalty, particularly in BOP markets where trust and dependability are paramount.

4. Promotion & People:

Promotion, as a key component of the marketing mix, signifies the communication used by marketers to make customers aware of product offerings (Drummond and Ensor, 2006). It includes diverse activities such as advertising, personal selling, publicity, sales promotion, and word-of-mouth marketing (McCarthy, 1964; Gronroos, 1994; Chelliah and Chin, 2011). These strategies aim to educate, inform, and persuade customers, making promotion essential for market penetration and customer engagement.

The "people" element is particularly significant in service marketing, as highlighted by Berry and Parasuraman (1991), who assert that a service organization's quality hinges on the competence and behavior of its people. Interpersonal skills, politeness (Gronroos, 1984; Stafford, 1994), prompt responses (Beatty et al., 1996; Levesque et al., 1996), personal attention (Levesque et al., 1996; Gupta and Santosh, 2012), and effective communication (Kotler, 1982) are to contribute to a healthy relationship between customers and firms.

4. PROMOTION MIX:

Kotler and Armstrong (2001) define positioning as the process of "implanting the brand's unique benefits and differentiation in customers' minds." (Kotler, 2001). This critical aspect of the promotion mix is central to creating a strong market presence and ensuring that customers perceive the brand distinctively. They further emphasize that all the company's marketing mix efforts must support the positioning strategy, which means that if the firm decides to build a position on better quality and service, it must deliver and communicate that position to target consumers (Kotler, 2001). This integrated approach ensures coherence in messaging and reinforces the brand's desired position in the market.

1. Community Centric & CSR:

Urban Bottom of the Pyramid (BOP) consumers tend to exhibit a collective approach to decision-making, as they heavily rely on external validation from their social groups ((Chikweche T. a., 2010), p. 643). Their consumption patterns align with the expectations of their communities, emphasizing conformity to social norms and fostering social unity (Chikweche and Fletcher, 2014, p. 38). Similarly, research by Weidner et al. (2010, p. 559) corroborates the collective nature of their choices, indicating their preference for products that resonate with group expectations.

The strong community feeling among BOP populations serves as a foundation for marketing strategies. Successful firms often employ community-centric methods such as appointing local enablers from within the community (Mahima Mathur, February 2021). These enablers act as intermediaries, distrust is pervasive amongst low-income families, the companies can leverage the assistance enabler to gain the trust of the consumers (Levine, 2013) (Mahima Mathur, February 2021). Companies can leverage these relationships to strengthen consumer confidence and loyalty.

Local capabilities at the BOP level can also connect the poor to broader market economies, generating income and fostering active participation. Prahalad says, harnessing local capabilities can help link the poor to the rest of the world and generate the income necessary to become active participants in the market economy (C. K. Prahalad, August 1999). Ventures at the bottom of the pyramid however shows that multinationals that collaborate with nontraditional partners such as local governments, non-profit organizations, and other groups within the community (London and Hart, 2004) are more successful than traditional partnerships. These partnerships bring several advantages, including access to resources, co-invention of locally contextualized products, enhanced credibility, efficient use of infrastructure, and risk reduction (London and Hart, 2004; Prahalad and Hart, 2002; Prahalad and Hammond, 2002).

The engagement of BOP consumers in distribution roles, such as franchisees or informal distributors at community corner stores, further empowers them through income-generating opportunities. For example, employing marginalized BOP consumers in agricultural sub-contracting or market stall distribution not only creates jobs but also strengthens the firm's goodwill within the community. By

empowering women and other marginalized groups, firms can reinforce their corporate social responsibility activities and generate substantial social impact.

Additionally, the use of culturally relevant promotional strategies, such as roadshows, product demonstrations, and entertaining educational activities, helps firms effectively engage the BOP market. For instance, music and dance have been used successfully in India to convey messages to rural populations, Indian political parties have used the same approach to carry their message to the masses (C. K. Prahalad, August 1999). These grassroots efforts reflect a deep understanding of local cultural norms and preferences, ensuring greater acceptance and adoption of the product or service. Hence firms had gradually increased their below the line promotion activities by developing innovative direct marketing tools such as road shows and product demonstrations (Chikweche T. , 2013).

Transnational corporations can achieve worldwide success by combining global efficiency, worldwide learning, and local responsiveness (Bartlett et al., 2003). Hart (2005) emphasizes the need for companies to develop native capabilities by understanding the needs, lifestyles, and cultures of BOP consumers (Hart, 2005, p. 21) (Sofie Van den waeyenberg, 25/7 (2008)). Co-inventing products with these communities ensures compatibility with their values and fosters trust, by learning about the needs, life styles and cultures of people at bottom of the pyramid. Building social relationships with the people at the bottom of the pyramid and gaining their trust are important for multinationals to have loyal customers (Hart, 2005; London and Hart, 2004).

The ethical considerations of marketing to BOP consumers remain contentious. While corporations may face criticism for targeting impoverished individuals, studies suggest that BOP consumers will adopt specific spending patterns. In developing countries marketing corporations could target consumers with products that will improve the lot rather than present opportunities for glamour (Gupta & Shrivastav, 2016; Payaud, 2014) (Martirano, November 24, 2018). Therefore, companies should aim to provide products that genuinely improve the well-being of BOP consumers, rather than simply appealing to aspirational desires. Therefore, companies operating in BOP markets must adopt a community-centric and CSR-driven approach. By engaging with local communities, leveraging cultural insights, and empowering consumers through employment and collaboration, firms can build trust and loyalty while contributing to the socioeconomic upliftment of the BOP population.

2. Personalized:

Urban BOP consumers focus on value and emotional goals while rarely placing their trust in marketing efforts (Praceus and Herstatt, 2017, p. 97; Singh, 2016, p. 27). Self-identity, defined as the beliefs, perceptions, or recognition of an individual's characteristics, emerges as an important antecedent to social norms influencing their purchasing behavior (Salem and Salem, 2018, p. 166). Consumers' attitudes become their beliefs (Bianca Maria van Niekerk). Therefore, BOP consumers' attitudes of the retail store are determined by their beliefs and evaluations of value, price, quality or social acceptance (Cheah et al., 2015, p. 765).

To effectively address this segment, the second generation of literature advocates for an integrative shared value approach that engages the BOP population at various stages of the business model (Khandker, 23 May 2022). Understanding the customer perspective is crucial in developing such an approach (Skowron and Kristensen, 2012). Personal relationships and a personalized client approach are also highlighted as critical elements in service marketing (Goldsmith, 1999; Dominici, 2009).

Emotional connectivity, responsiveness, assurance, empathy, interpersonal skills, politeness, prompt behavior, personal attention, and communication skills constitute important aspects of the "people element" in personalized marketing strategies (Sonal Purohit, (2021)). These factors contribute to building trust and enhancing the customer experience. For instance, allowing potential customers to test products before purchase, a concept referred to as "trialability," significantly increases the likelihood of purchase by reducing functional, physical, and financial risks (Rogers, 2003; Mühlbacher et al., 2006). As one consumer noted, " For once we get to see these companies coming to visit us and showing us new products, and actually getting us to try the products for free, it's good to taste something before you but it because in these tough times you cannot afford to make a mistake when you buy products. (Chikweche T. , 2013)" Recognizing the heterogeneity within the BOP population is equally important. Companies need to tailor their communication and distribution strategies to target distinct ethnic and income groups; they have to target each group separately (Sofie Van den waeyenberg, 25/7 (2008)). This consideration extends to technological interventions such as mobile phones, which have a transformative impact on the lives of BOP consumers. Mobile technology facilitates income generation through informal economic activities, underscoring its role as a critical survival tool. Dodd (2015) and Shah (2012) emphasized that marketing strategies need to be adapted to the vast differences in the emerging market's level of economic development, purchasing power, and ability of consumers to pay for products and services in the market (Mahima Mathur, February 2021). By adapting their strategies to these realities and fostering trust through reassurance and trialability, companies can build meaningful connections with BOP consumers and establish long-term relationships.

3. Direct Sales & Personal Interaction:

BOP consumers, characterized by low literacy levels, require more guidance throughout the retail experience compared to

other income segments (Hasan et al., 2017, p. 154). This is one of the reasons they prefer purchasing from physical stores rather than engaging in online shopping (Cheah et al., 2015, p. 765; Hasan et al., 2017, p. 154). The retail experience plays a crucial role in shaping their perceptions, as the point-of- purchase and decoration dimension prompts feelings of affordability, value, convenience and understandable communication among BOP consumers (Singh, 2018, p. 6). This highlights the significance of the physical store environment in enhancing the consumer's shopping experience.

Research shows that BOP consumers are highly attuned to information presented through the retail experience. Store atmospherics help them make more informed apparel purchases by making them more aware (Gupta and Tandon, 2018, p. 267) of their choices, which in turn impacts their perceived behavioral control (Singh, 2016, p. 27). As a result, it is important for service firms to carefully choose their distribution channels. Seng et al. (2015) argue that service firms should be cautious when deciding on distribution channels to assure that the product or service is available to people in the BOP at convenient (Prahalad, 2010) and as many places as possible, emphasizing on convenience in BOP marketing.

Market orientation also plays a vital role in catering to the dynamic needs of BOP consumers. Firms that are market-oriented are better equipped to respond to changing customer needs and marketplace dynamics, leading to better overall performance (Deshpande and Webster, 1989; Narver et al., 1998; Ruekert, 1992; Slater and Narver, 1994). This understanding allows companies to better serve the BOP market, including addressing their expectations for perfect brand matches and price-product alignment (Artta Bandhu Jena), which influences purchasing behavior in this segment.

In every point of sale, the company takes the opportunity to use stickers showing the name of the brand as a way to promote itself. The selection of retail outlets for these promotions is carefully considered to ensure convenience for BOP consumers by choosing places they typically visit, thus increasing brand visibility across the country (Patrik Mårdh & Teresa Correia, Spring 2013). Additionally, BOP consumers are frequently served through indirect channels such as dealers and retailers. These channels are used to reach this segment, as they are accustomed to such environments for their purchases, creating a sense of familiarity and comfort (Patrik Mårdh & Teresa Correia, Spring 2013).

Furthermore, BOP consumers, due to their lower levels of education and attention-seeking behavior, tend to respond positively to personal forms of communication, particularly when exposed to new services or new applications within existing services (Mahima Mathur, February 2021). This preference for direct interaction highlights the importance of personal engagement in fostering trust and satisfaction in the BOP market.

4. Awareness Programs:

BOP consumers often face significant barriers due to low educational levels and limited access to traditional forms of communication, making them harder to reach via conventional methods of distribution, credit, or communication (Prahalad and Hart, 2002; Wood et al., 2008). These markets are unique in their challenges, including infrastructure limitations and low financial resources, the use of innovative and cost-efficient methods of promotion is required to communicate with them (Chikweche and Fletcher, 2012). As such, organizations cannot rely on traditional communication and distribution strategies to connect with the BOP segment (Prahalad and Hart, 2002).

An important factor in addressing these challenges is education. Researchers have highlighted that poverty at the BOP can be reduced by educating them (Kolk et al., 2014). Education helps BOP consumers understand which products exist, how they work, and the benefits of innovations, which are crucial for overcoming information poverty. As Prahalad (2004) and Karnani (2007) highlight, BOP consumers are highly value- conscious and price-sensitive, which makes knowledge of the product essential for informed purchasing decisions. Education, therefore, plays a vital role in shaping appropriate consumer orientation and fostering aspirations among the poor in Tier 4 (Singh, 2018, p. 6). It is through education that companies can raise awareness, offer guidance, and build trust, which ultimately drives purchasing decisions.

One of the main barriers to development in Tier 4 markets is isolation, which limits BOP consumers' access to products and services. Isolation is one of the biggest barriers to Tier 4 development (C. K. Prahalad, August 1999). Connecting these consumers to up-market customers can significantly improve their economic opportunities. Information poverty, which limits access to essential information, is considered a major obstacle to sustainable development (Prahalad, 2010). Thus, communication and awareness programs become essential tools in overcoming these barriers and fostering a consumer-oriented mindset.

To reach BOP consumers, companies must employ various promotional methods, especially considering that many of them do not have access to traditional media. Mass communication channels, such as television, radio, and newspapers, can help disseminate information about products and innovations, particularly for early adopters (Bass, 1969; Rogers, 2003). However, the effectiveness of above-the-line promotion tools like television and print media is limited for BOP consumers (Chikweche T. , 2013), who are often more receptive to interpersonal communication and local outreach (Sofie Van den waeyenberg, 25/7 (2008)).

Creating awareness about new product innovations is crucial for getting BOP consumers to purchase products, especially when these products offer a practical solution, such as a substitute for more expensive goods (Singh, 2018, p. 6). For instance, one BOP consumer expressed their interest in trying a product they had never seen before, highlighting the importance of local availability and awareness in driving trial and purchase behavior.

Additionally, creating awareness through education is necessary to engage BOP consumers with new and innovative products. Companies can reach potential customers by providing information about the existence of products, their benefits, and where to purchase them, thus fostering greater product knowledge (Chikweche and Fletcher, 2012). Empowerment strategies, such as offering low-cost product ranges, bundle packs, and pay-per-use systems, are also significant in enhancing product accessibility and driving consumer engagement (Prahalad, 2004; Lahteenmaki and Natti, 2013). These strategies, when combined with educational outreach, create an environment in which BOP consumers can make informed and confident purchasing decisions.

Awareness programs play a pivotal role in educating BOP consumers and overcoming communication barriers. By leveraging innovative communication tools and focusing on education, companies can increase consumer engagement and improve their market penetration in the BOP segment.

5. FINDING AND DISCUSSION

This paper provides comprehensive insights into the critical components of an effective promotion mix, emphasizing the integration of traditional and modern marketing strategies for maximum impact. Traditional methods, such as door-to-door campaigns, workshops, radio, and local television advertisements, are instrumental in establishing trust and building personal connections, particularly in communities where face-to-face interaction is highly valued. Alongside these methods, modern tools like SMS campaigns, social media platforms, and localized digital advertisements expand reach and foster dynamic engagement. Together, these approaches cater to diverse audience preferences, ensuring a holistic and adaptable promotional strategy.

Credibility emerges as a cornerstone of successful promotions, achieved through trust-building initiatives involving community leaders, religious figures, and local influencers. These trusted figures lend authenticity and reliability to marketing messages, especially in communities where word-of-mouth and relationships significantly influence consumer behavior. Personalization and relatability further enhance the effectiveness of promotional content, with storytelling and culturally aligned messaging resonating deeply with audiences. Additionally, the paper underscores the importance of tailoring strategies to cultural norms and social contexts, which not only fosters a sense of connection but also ensures the message's acceptance.

By combining grassroots engagement with technological innovations, this paper illustrates how organizations can balance personal interaction with broader communication, catering to diverse demographics and media preferences. It highlights that a successful promotion mix depends on integrating multiple tools, building credibility, and addressing cultural and emotional needs. This multidimensional approach creates a framework for impactful and sustainable marketing strategies that are both competitive and consumer-centric.

6. CONCLUSION

This study offers several practical implications for companies targeting BOP markets by highlighting the importance of understanding localized consumer behavior and the need to tailor pricing strategies, product offerings, and marketing messages to align with the socio-economic realities of BOP consumers.

It offers key insights by understanding and addressing the unique needs of BOP consumers, companies can develop products and services that cater to essential needs contributing to poverty alleviation. Companies that prioritize sustainable and responsible marketing can help build consumer trust, promote financial literacy, and create positive societal change that enhance the well-being of BOP communities.

The findings emphasize that simplified and adaptive models, which account for limited infrastructure and distribution channels, are critical to ensuring product accessibility and long-term success in BOP markets. Businesses building focus on affordability without compromising quality, as promotion significantly influences purchasing decisions in resource-constrained environments.

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Performance Analysis of Football Players Using PCA and SVM

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ABSTRACT

The research paper presented here discusses PCA with SVM together to analyze a big set of data on football players consisting of variables such as strength, endurance, passing accuracy, dribbling skills, and speed, etc. This solution specifically addresses the interpretation of the multidimensional metrics of players. It provides a fair view in a more objective form to analyze and give the performance of a player over time. Principal Components Analysis reduces the dimension through transformation of correlated variables by taking a smaller set of uncorrelated principal components retaining the most important information such that the reduced analysis holds the crucial information in what scouts and analysts can refer to as key performance patterns.

Keywords: PCA, SVM,KNN, standardization, AdaBoost, Logistic Regression, co-variance, scree plot, score plot, biplot, profile plot

1. INTRODUCTION

Football scouts often come across significant difficulties in identifying potential players for national teams as the volume of information is too high and an interrelation between player's attributes is complex. So, our project deals with this problem by applying principal component analysis to a rather large dataset of footballers from different clubs across the country, thereby reducing the dimensionality while retaining significant information. Finally, SVM is used to classify the players so that scouts can pinpoint the best talent. The project automates the analysis in such a manner that saves time and effort for evaluating players and increases accuracy and reliability as well. In this case, the analytical strength of PCA combines with SVM classification efficiency to provide robust tools for strategic selection.

Football data is very complex as it has many interrelated attributes. PCA is, therefore, quite effective in reducing the dimensionality of the high-dimensional dataset and selects the most important components that contain relevant information. Using these components, SVM will classify players to allow clubs to use a data-driven approach to optimize recruitment. Selection of players would therefore align with tactical objectives to enhance performance and national-level representation. Several research have shown and analysed player performance using PCA on sports data, including football, thereby simplifying multidimensional datasets. For example, Lin et al. (2020) investigated PCA's ability to reduce dimensionality in sports datasets, stressing its efficiency in preserving important characteristics while eliminating extraneous data. Their work showed how PCA may be used in high-dimensional datasets to simplify computationally effective performance analysis. Emphasizing PCA's capacity to simplify difficult data structures without compromising interpretability, Zhao et al. (2023) contrasted PCA with various visualization methods, including t-SNE and multidimensional scaling. Their results confirmed PCA as a consistent approach for pattern identification and analysis of sports performance indicators.

Smith and Jones (2019) concentrated on using PCA especially on football datasets to find important performance indicators relevant for assessing players' competency and contributions. They were able to separate the most important factors—passing accuracy and sprint speed—that directly affect a player's performance using PCA. This method helped to lower data dimensionality and improve talent scouting and player assessment decision-making processes. Kumar et al. (2021) also advanced this idea by combining PCA with machine learning techniques including k-Nearest Neighbours (k-NN) to categorize football players into various performance ranges. Their study emphasized the synergy between predictive modelling and dimensionality reduction methods, therefore producing better classification accuracy and useful information for team choice.

Adding to these studies, our project fills in important study gaps by using a new mix of PCA and SVM to improve the classification and rating of football players. In earlier research, like Smith and Jones (2019), PCA was used to find key performance indicators by focusing on reducing the number of dimensions. However, these findings were not used for advanced player classification. Similarly, Kumar et al. (2021) used a method that mixed PCA with machine learning techniques like k-Nearest Neighbours (k-NN), but it wasn't accurate or scalable enough to look at big, complicated datasets like FIFA. Additionally, a lot of the studies that have already been done haven't looked into how to combine dimensionality reduction with strong classification methods to give football scouts useful information.

Our project fills in these gaps by using PCA to pull out the most important traits from large amounts of data and SVM to accurately group players into performance groups. This mix

makes sure that the smaller dataset not only includes important traits but also turns these traits into useful classifications that help football scouts find and rate ability well. Unlike other studies, our system is made to handle big datasets of players from a wide range of leagues and national teams. This makes it scalable and flexible. Our project fixes the problems with previous research and offers a more complete, accurate, and data-driven method for football recruiting and scouting, making it much easier to make decisions about finding talent.

2. METHODOLOGY

PCA6

Data Import and Pre-Processing

The football player dataset was sourced from Kaggle and imported into MATLAB. Numerical columns representing player attributes were selected for PCA.

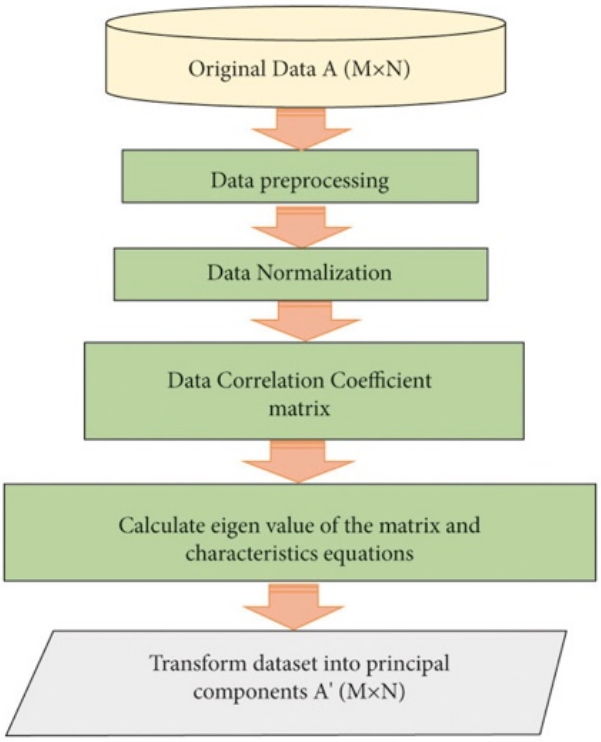

Fig. 1. Flowchart of Data Processing and Principal Component Analysis (PCA)

Data Standardization

It is required to standardize the data before PCA to have a fair analysis since PCA is a variance maximizing exercise and variables with higher ranges will dominate the analysis. This means that unless variables are measured in the same scale, results can be misleading. Standardizing variables to have mean of zero and standard deviation of one, ensures that all variables contribute equally to the principal components and creates variables that are comparable – if not it would distort your results.

$$z = \frac{x - \mu}{\sigma}$$

z: z-score (standardized score or value)

x: data value

μ: mean

σ: standard deviation

Fig. 2. Formula for Z-Score Calculation and its Components

Non-standardized data maintains its original scale and units, so attributes can have very different ranges, which can lead to biased results in analyses. For example, in a PCA, when an attribute has a larger numerical range, it will dominate the first principal component, and therefore the second principal component. In contrast, the data is transformed in standardized to give it a mean of 0 and a standard deviation of 1, so all attributes have equal representation in the analysis. This correction is important, because so that no one attribute is dominating your analysis, and it will give you a more accurate and reliable result.

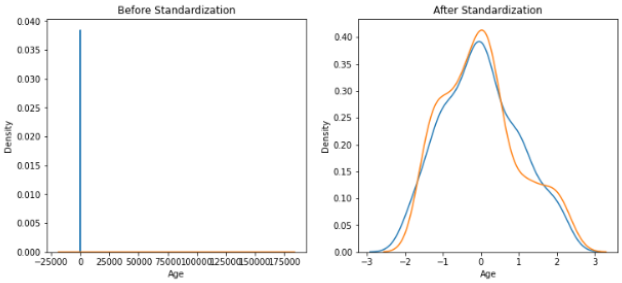

Fig. 3. Effect of Standardization on Age Distribution

Covariance Matrix Computation

Covariance matrix is calculated. It is a square matrix showing the interrelationship of variables. Diagonal elements are individual variances and off-diagonal elements are covariance between the pair of variables. The matrix supports the study of interrelationship amongst the variables.

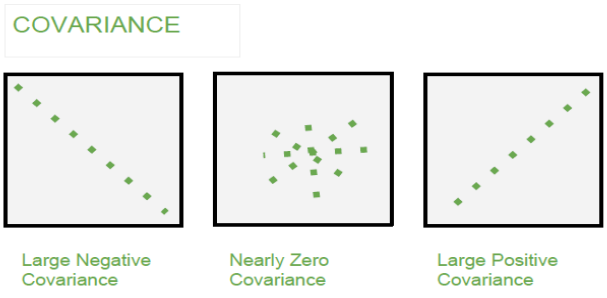

Fig. 4. Illustration of Covariance

Calculation of Eigenvalues and Eigenvectors

The eigenvalues and eigenvectors of the covariance matrix were calculated. These eigenvalues are variances explained by each principal component (PC), and these eigenvectors are the directions of maximum variability. After ranking the principal components using the eigenvalues in descending order, the first few principal components were selected based on the analysis of the scree plot.

Dimensionality Reduction

This reduces the dimensionality of the data set to a very much smaller number where most of the variance remains conserved since it projects to the principal components corresponding to the largest eigenvalues.

Data Visualization

The reduced dataset was graphically represented using the score plots, pattern plots and scree plots. Graphics represent clusters, trends as well as relationships between the variables; thus, making possible exploratory analysis.

Biplot

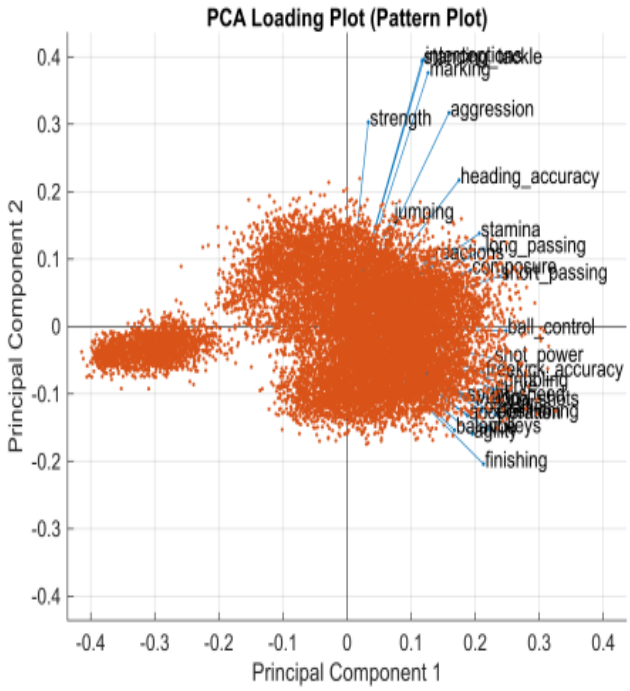

Fig. 5: PCA Biplot showing the contribution of variables to the first two principal components. This shows how player's skills differ completely based on their role in the pitch. Eg. marking which is a skill of a defender is in completely other side of the finishing which is a skill of attacker. This shows the data points in extreme 1st quadrant are representing defenders while datapoints which are in extreme 4th quadrant represents attackers while the datapoints which comes in between them i.e, near the x-axis represents mid-fielders which shows skills of both defenders and attackers.

Score Plot

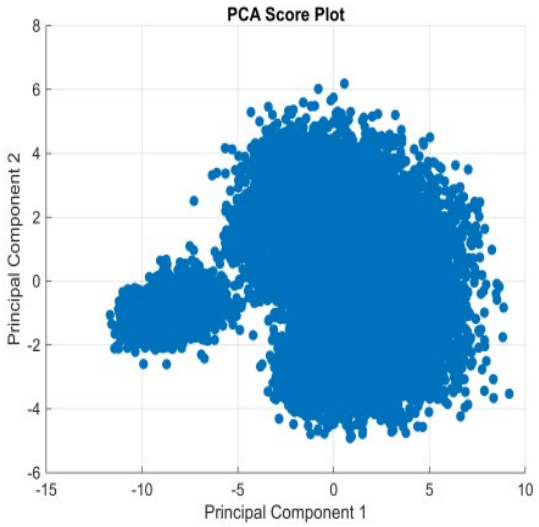

Fig. 6: PCA Score Plot

Fig6.illustrates the distribution of data points in the space of the first two principal components. This figure clusters players based on their performance metrics, reflecting role-based differences on the field (e.g., attackers, defenders, midfielders)

Scree Plot

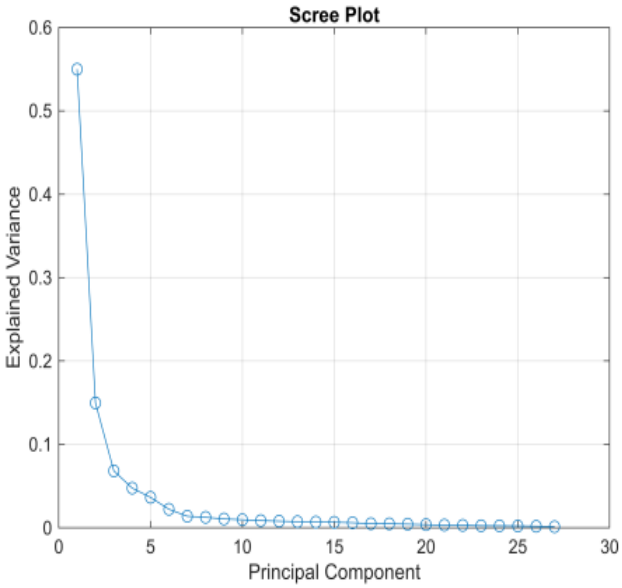

Fig. 7: The scree plot

This figure highlights the explained variance for each principal component.

Fig7. is useful for determining the number of components to retain by identifying the "elbow point," ensuring that the

reduced dataset captures the majority of the variance while discarding noise.

Profile Plot

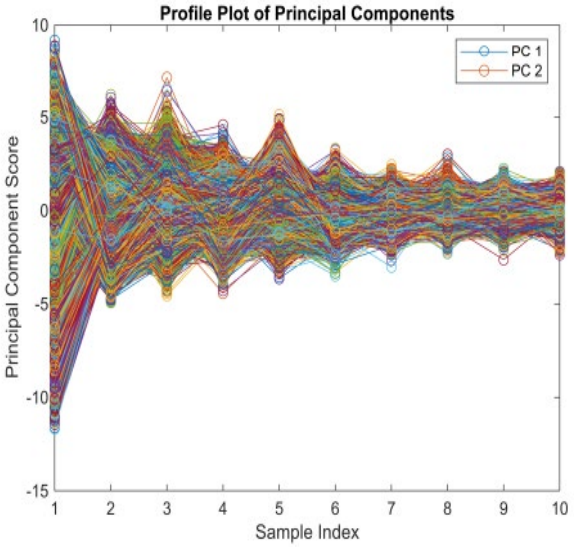

Fig.8: The profile plot

Fig8.represents the relative contribution or influence of individual features (e.g., stamina, sprint speed, marking, finishing) across the principal components. It is used to identify which attributes dominate the patterns observed in the PCA.

SVM

SVM is a guided machine learning method that is used to classify things and figure out what happened in the past. It finds the best hyperplane that maximizes the space between classes, making sure that forecasts are strong and correct even in areas with a lot of dimensions.

Importing and Preparation of Dataset

Imported from a designated file location into MATLAB, where it is organized as a table. The target variable is identified as the column marked "recurrent; all other columns are handled as features for analysis. Numerical values are used to encode the features and target variables so the model may efficiently handle categorical input. By grouping and assigning distinct numerical labels for every category, the `grp2idx` function helps the model to effectively handle non-numeric input. This preparation guarantees uniformity and fit for additional investigation**.**

Feature Scaling

Normalizing the ranges of values across all the features via feature scaling guarantees that every feature adds equally to the SVM model. Standardizing the dataset helps to avoid characteristics with higher magnitudes from influencing the categorization process unduly. In SVM especially scaling is crucial as it guarantees the convergence of the optimization problem and preserves numerical stability, therefore optimizing the performance of the method. The model could unduly weigh some elements without scaling, producing biassed predictions.

Principal Component Analysis (PCA)

PCA is applied to lower dimensionality and simplify data structure for datasets with more than two dimensions. This method captures the highest variance by projecting the data onto two main components, therefore eliminating either redundant or less important elements. PCA not only increases computing performance but also helps the data to be interpretably compressed. The dataset is fit for display and analysis without losing the information required for effective classification as the smaller dimensions preserve the important patterns and connections.

Data Splitting

The dataset is split in training and testing subsets using an 80–20 ratio. This division guarantees that the model is trained using 80% of the data and reserved for testing using the other 20%. By enabling the model to properly forecast unknown data and enable greater generalization, splitting the data reduces the overfitting risk. It guarantees that, by evaluating the prediction ability of the model on fresh data, the assessment captures performance from the actual world. A dependable and generalizable model is produced in part by this strong validation procedure.

Support vectors

Support vectors—that is, data points closest to the hyperplane separating the classes—are found during the training process. These important locations determine the decision boundary and are mostly responsible for the classifier's margin determination. By concentrating on the most difficult locations in the data, support vectors help to guarantee that the classification stays strong. The SVM model effectively learns the ideal hyperplane by considering just the support vectors, therefore lowering the effect of noise and useless data.

Model Testing and Evaluation

Creating predictions on the test dataset and matching them to the real class labels helps one evaluate the trained model. Calculating training and testing accuracies helps one to evaluate the model's performance by gaining understanding of its learning and generalizing capacity. To further examine the classification performance in great depth, a confusion matrix is also produced displaying measures of true positives, false positives, true negatives, and false negatives. These measures guarantee the model satisfies the required performance standards for pragmatic uses by helping to assess its general accuracy, recall, and precision.

Visualization:

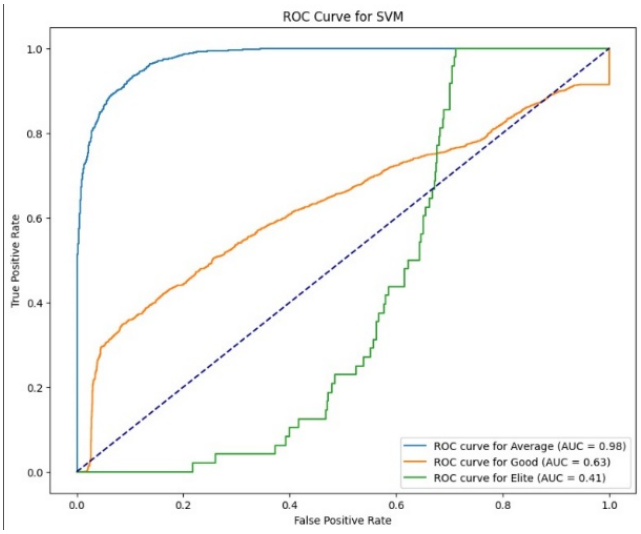

Fig. 9. Plot of ROC curves of SVM model

Fig. 9. This Figure illustrates the plots of ROC curves of SVM model at three classes of Average, Good, and Elite players. The AUC value of the model shows it has done very well with high accuracy in "Average" but "Good" and "Elite" categories were significantly down for predictions as their AUC is at 0.63 and 0.41, respectively. That implies it can segregate among ordinary players but makes no effective discrimination within the tier categories.

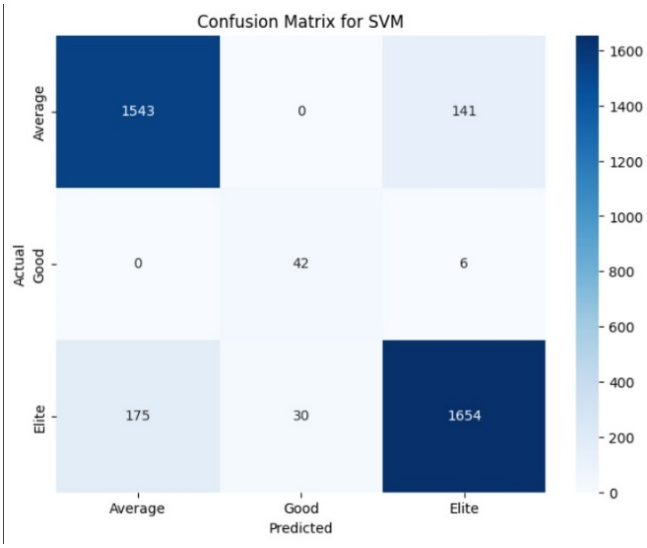

Fig. 10. Confusion matrix of the SVM model

Fig. 10. The figure above illustrates the confusion matrix of the SVM model. From the figure, the three types of players on which the performance of the model is conducted are: Average, Good, and Elite. The majority of "Average" (1543) and "Elite" (1654) are picked by the model. In the case of "Good", the model is literally making too many wrong calls. It picks only 42 from this class, thereby miscalling plenty of them. It means the model was biased towards both average as well as extreme players.

```
SVM Results:
Accuracy: 0.90
Classification Report:
              precision    recall  f1-score   support

     Average       0.90      0.92      0.91      1684
       Elite       0.58      0.88      0.70        48
        Good       0.92      0.89      0.90      1859

    accuracy                           0.90      3591
   macro avg       0.80      0.89      0.84      3591
weighted avg       0.90      0.90      0.90      3591
```

Fig11: Classification report for the SVM model

Fig. 11 represents the classification report for the SVM model reports an average overall accuracy of 90%, that is, the model does good in classifying the football dataset. The "Average" and "Good" categories report great precision (0.90 and 0.92) and recall values (0.92 and 0.89) and also great F1-scores (0.91 and 0.90) while reporting poor precision 0.58 and the F1-score at 0.70 for the "Elite" category, with a recall score of 0.88, which reports poor accuracy and difficulty in correctly classifying elite players. Macro-average metrics show the average performance, considering all classes to be equal: precision 0.80, recall 0.89, F1-score 0.84. The weighted average metrics will depict the same overall performance and uncover class imbalance in the dataset.

Logistic Regression (LR)

By use of a logistic function, logistic regression models the link between the characteristics and target classes, therefore predicting categorical output. It uses a linear combination of the input data to project a player's membership in a certain class. The model generates class probability, which are subsequently translated into particular class labels depending on the highest likelihood.

Data Preparation

Features include stamina, sprint speed, passing accuracy, and player ratings abound in the FIFA database. These features were standardized to provide a common scale so that no one variable significantly affected the training process of the model. To help the logistic regression model analyse categorical target classes—such as "average," "good," and "elite—they were converted into numerical values (0, 1, 2).

Training the Model

Training the logistic regression model helps it to find the link between the likelihood of every class and the standardized characteristics. Usually applying maximum likelihood estimation, the coefficients of the model are determined by

minimizing a loss function. For multi-class classification, the model employs a SoftMax function, which assigns probability to every one of the three classes so allowing the player categorization into their appropriate groups.

Performance on FIFA Dataset

Logistic Regression performed comparable to SVM in separating between groups like "Good" and "Average." Its accuracy was up to 90%. But given the class imbalance and outliers, its accuracy and recall for the "Elite" class were less than those of SVM. For datasets with very linear separability and less complicated decision boundaries, logistic regression showed success in spite of these obstacles.

Strength in the FIFA Context

Since Logistic Regression offers coefficients that clarify the significance of every feature to the classification decision, its interpretability is a main benefit. Features like vision and short passing, for example, were shown to be quite powerful markers for player classification as "Good." Scouts can grasp the justification for player classifications because to this interpretability, which also helps the model to be more open and trustworthy for decision-making.

K-Nearest Neighbors (KNN)

A non-parametric method called K-Nearest Neighbors (KNN) uses the majority class of a player's closest neighbors in the feature space to classify a player. To find the closest neighbors, it depends on the distance between data points usually using Euclidean distance. The model then labels a player into "Average," "Good," or "Elite" depending on the class that shows highest frequency among these neighbors.

Data Preparation

KNN depends on feature standardizing as the method computes closeness using distance measurements—e.g., Euclidean distance. Features having higher numerical ranges, such sprint speed, might dominate the distance computation without standardizing, so producing biassed categorization. Standardizing features guarantees that every characteristic adds equally to the proximity measure and helps to avoid distortion of the findings by characteristics with high values.

Model Implementation

A balance between underfitting and overfitting in KNN depends on selecting the ideal number of neighbors (k). The optimal k value is discovered via cross-valuation; this is crucial to avoid the model from being either too generic or too sensitive to noise. With regard to the class of the closest neighbors, the model sorts players by computing the distance between their characteristics and those of other players.

Performance on FIFA Dataset

On the FIFA dataset, KNN attained 80% accuracy and showed clear capacity to detect non-linear decision limits. But it suffers with sparse datasets, hence its performance fell in high-dimensional environments with numerous linked characteristics. The imbalance in the dataset caused misclassifications more often for the "Elite" players, which resulted in poor recall and F1-scores for the Elite class.

Challenges in FIFA Context

The very sensitive performance of KNN to class imbalance and outliers will greatly influence its capacity to correctly categorize the "Elite" players. Particularly in cases with limited dataset representation, KNN may misclassify uncommon players with unique characteristics as it depends on closeness to other data points. Consequently, for the less frequent "Elite" category the model could have a greater error rate.

AdaBoost

An ensemble learning method called AdaBoost (Adaptive Boosting) builds a powerful classifier by combining several weak learners, usually decision stumps (shallow decision trees). Weak classifiers are applied to the input in a sequential manner by the algorithm, with each subsequent classifier concentrating on the errors of the one before it. The model's performance is enhanced by this iterative approach, particularly in cases that are challenging to categorize.

Data Preparation

To guarantee impartial and equitable boosting, the dataset attributes are standardized, much like in previous models. The model is able to concentrate more on the more challenging-to-classify cases by assigning a larger weight to each instance that was mistakenly identified in the previous iteration. By encouraging the model to fix its prior errors during the boosting step, this weighting technique aids in improving classification performance.

Model Implementation

Based on the performance of the prior models, AdaBoost iteratively improves the classifier by modifying the decision boundary with each iteration. In order to reach a final conclusion, it aggregates the predictions of several weak classifiers, giving examples that were mistakenly categorized additional weight. The concept works especially well with edge instances that are difficult to categorize with a single decision stump, such borderline "Elite" athletes.

Performance on FIFA Dataset

With an accuracy of 83% on the FIFA dataset, AdaBoost shown promise in differentiating between "Average" and "Good" players. It did not do well in the "Elite" group, though, since it had trouble remembering these players and frequently misclassified them because of the disparity in class. AdaBoost performed worse than SVM and Logistic Regression in terms of recall for the "Elite" category,

although showing promise in handling cases that were challenging to categorize.

Challenges in FIFA Context

Class imbalance is a problem for AdaBoost, especially in datasets like FIFA where the "Elite" class is underrepresented. The model may overfit the minority class as a result of this imbalance, which would lead to poor generalization and incorrect top player categorization. Effectively categorizing unusual players is further complicated by the model's sensitivity to outliers and its dependence on repeated correction of prior errors.

3. RESULT

SVM is the best model that fits all the players because it classifies in the best possible manner giving well-balanced results across all categories: Average, Good, and Elite. Its accuracy rate stands at 90%, the same as the Logistic Regression model, higher than KNN's accuracy, which stands at 80%, and even AdaBoost's 83%. Its superior precision of 0.90, recall of 0.89, and F1-score of 0.89 all testify to its success in managing the complexities of the FIFA dataset, including high-dimensional interrelated attributes like stamina, sprint speed, and passing accuracy.

SVM does well on imbalanced datasets. For instance, in this challenging Elite category, SVM continuously shows high recall with reduced false negatives. This would ensure the best identification of players, a domain in which models such as KNN and AdaBoost significantly fail, with both models having lower recall and F1-scores due to their susceptibility to class imbalance and outliers. While Logistic Regression is similar to SVM regarding overall accuracy, it suffers from poor precision and recall of minority classes, such as Elite, giving SVM the upper hand when dealing with edge cases.

Table 1: Comparative Analysis of Models

	Accuracy	Precision (Avg)	Recall (Avg)	F1-Score (Avg)
SVM	**0.90**	**0.90**	**0.89**	**0.89**
Logistic Regression	**0.90**	**0.89**	**0.88**	**0.89**
KNN	**0.80**	**0.80**	**0.81**	**0.80**
AdaBoost	**0.83**	**0.83**	**0.69**	**0.66**

SVM improves further by applying different kinds of kernel functions that manage high-dimensional feature space in the FIFA dataset very effectively. Such a capability in SVM lets it establish good decision boundaries that capture nuanced relationships between player attributes that then make classification accurate. Compared with KNN that tends to be very noise sensitive and AdaBoost that always tends to overfit into minority classes, SVM is a great solution that is robust and dependable.

Therefore, overall performance in all evaluation metrics without impairing class imbalance or complexity of features represents a significant advantage for SVM such that it emerges as the most reliable model to classify FIFA players with accuracy into Average, Good and Elite categories.

4. CONCLUSION

By combining Principal Component Analysis (PCA) and Support Vector Machine (SVM) to manage the complexity of high-dimensional data in player performance measures, this study efficiently solves the difficulty of assessing football players. By lowering dimensionality and spotting important player qualities including endurance, sprint speed, and passing accuracy—all of which are vital for evaluating player capabilities—PCA is absolutely essential in simplifying these datasets. PCA helps scouts and analysts to concentrate on the most pertinent information by keeping just the most important components, therefore removing data noise and redundancy. By grouping players into well-defined categories—average, good, and elite—with an amazing accuracy of 90%, SVM enhances this by beating other models such logistic regression, k-nearest neighbors (KNN), and AdaBoost.

This strong mix guarantees exact classification even in difficult situations, including unbalanced datasets and edge cases like the "Elite" category, where other models typically fail. Moreover, the technology automates the scouting process, therefore saving a lot of time and effort and guaranteeing consistent, data-based conclusions. Unlike conventional techniques, which are typically subjective and prone to inconsistencies, our methodology brings scalability and adaptability, which qualifies for huge datasets spanning several leagues and national teams. This study offers a transforming solution for player recruiting by filling important gaps in past research and using sophisticated analytics, therefore opening the path for more objective and successful talent identification at both club and national levels.

5. DECLARATION

I/We, Dr. Neetu Srivastava, hereby confirm that the manuscript titled “Performance Analysis of Football Players Using PCA and SVM” authored by, Hem Srimanvith Pedda, Rohit Praveen Nair, Tanay Ashish, Avinash Pala and Neetu Srivastava has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to International Management Perspective Conference 2025 (IMPeC-25)

I/we declare that all necessary permissions have been obtained for any third-party materials included in the

manuscript, and appropriate citations and acknowledgments have been made where required.

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Entrepreneurial Mindsets in Tourism: Driving Innovation and Resilience

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ABSTRACT

Business tourism for instance, one of the three largest sources of gross domestic product globally is sensitive to shocks from environmental, economic and health wise transformations. Such challenges happen mostly and often at a rather unpredictable manner, which makes it very important that institutions and practitioners employ strategies of resilience and innovation as a way of making sure that business goes on as usual and the industry remains stable. This paper examines the centrality of entrepreneurial orientation in innovation and, particularly, environmental entrepreneurship amid the global tourism sector. This orientation working proactively and driven by innovation in response to the business environment volatility as well as pursuing new opportunities like digitalisation, sustainability and recreational touring. Consistent with the growing sentiment among the consumer for green solutions and customized solutions, firms exhibiting entrepreneurial and environmental characteristics possess greater opportunities to create customer value both in the time of increased competitiveness among players in the market environment. Sustainability entrepreneurship that combines environmental sensitivity with business management is now viewed as a critical enabler of sustainable innovation in tourism. In this paper, I have shown that it is possible to achieve both business objectives and environmental objectives within the tourism businesses sector. Sustainability culture encourages the implementation of solutions that adoption into business operations would sufficiently serve the requirements, standards and legal requirements, and boost brand image, customer satisfaction, and loyalty. Experimentation and willingness to use novel technologies and ideas make it possible for several firms to adapt more suitably to changing nature of consumers and the environment in relation to tourism experiences. For instance, incorporating digital media for unique traveler experiences or funding green and efficient assets allow for business implementation for the change needed for tourism to be sustainable. This paper employ a quantitative technique to measure the extent of business resilience innovation influenced by the presence of entrepreneurial traits, using data from 80 participants within the tourism sector. The research proves a clear link between such key strategic orientations of entrepreneurs as focus on the resilience and innovation and the performance of tourism enterprises.

Keywords: Innovation, Mindset, Resilience, Entrepreneurship, Tourism, Economic etc.

1. INTRODUCTION BACKGROUND OF THE STUDY

Tourism is a dynamic, important and major industry that majorly in contributes to global and national economies. Not only does it encourage economic growth, it helps facilitate cultural exchange as well as environmental stewardship. Yet the sector is prone to a number of challenges which are driven by everything from economic volatility and geopolitical tensions to environmental crises and pandemics. These challenges encourage more changes to more innovative and more resilient practices that maintain and increase their viability.

By way of example, global tourism affects global economic dynamics at a staggering 9.1 percent of global GDP and is one in ten jobs around the world (wttc.org, 2024). In that case, the industry is economically important; however, it is impacted by fluctuations in the economy, the impact of the environment and other challenges, such as the effects of global health crises like the COVID-19 pandemic, which caused a huge decline in international tourist arrivals by more than 70 percent in 2020.

2. RATIONALE AND PROBLEM STATEMENT

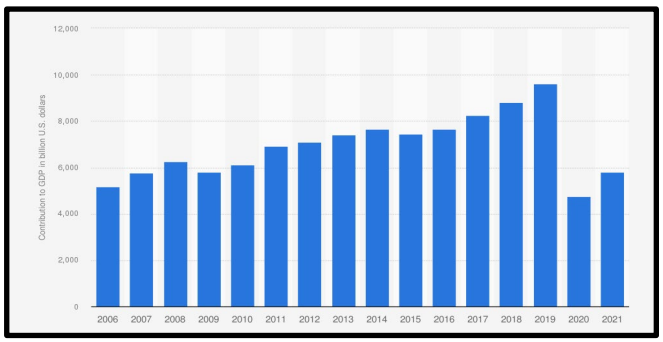

Figure 1: Total Contribution of the Travel & Tourism industry to Global GDP from 2006 to 2021

(Source: oem.news, 2022)

Tourism is a sector of vital importance to the world, particularly on the economic front, and the recovery and growth of the sector over the long term are closely related to the sector's resilience and innovation. Entrepreneurial mindsets are central to navigating these challenges in leading the adoption of innovative solutions and tourism practices which are sustainable (Pongtanalert & Assarut, 2022).

However, a big gap remains in understanding which entrepreneurial traits actually tackle these pervasive industry challenges.

In 2020, travel and tourism produced 4.5 trillion USD in direct contribution to GDP, down 49.1 percent from the previous year. On the other hand, this stark downturn underlines the need to be more agile and creative in the sector, which is currently spiralling downwards.

Aim and Research Objectives Aim

This study aims to delineate the impact of entrepreneurial mindsets on fostering innovation and resilience in the tourism industry.

Objectives

- To identify and describe the core components of an entrepreneurial mindset in tourism.
- To evaluate how these components influence the capacity for innovation and resilience among tourism businesses.
- To provide recommendations for fostering these traits within the industry to enhance overall sustainability and growth.

3. LITERATURE REVIEW

Theories of Entrepreneurship

Theories of entrepreneurship give an opportunity to learn how individuals and organisations recognise opportunities, reallocate resources, and create value. These theories share with Schumpeter that the entrepreneur is an innovator and driver of economic as well as evolutionary change by means of 'creative destruction.' Especially in tourism, where the development of new products, services and markets is based on continuous innovation. Related to the Resource View (RBV), a theory is one which acknowledges the importance of unique organisation resources and capabilities as key contributors to competitive advantage (Barney et al. 2021). These resources, in tourism, for instance, could be local culture or natural landscapes or even specialised knowledge of the hospitality industry.

Entrepreneurial Mindset

Essential qualities such as risk taking, proactivity and innovativeness make an entrepreneurial mindset in the tourism sector. The ability to identify these attributes allows individuals and businesses to capitalise on rapid change occurring within their overall environment (Haddoud et al. 2022). They are a mindset that involves a tremendous tolerance for ambiguity and a willingness to experiment with strategies. Those same strategies are always changing efforts with the market or consumer perspective shifting. It proposes that a tourism enterprise can improve performance metrics that are profitability, market share and overall business growth by embracing an entrepreneurial orientation.

Innovation in Tourism

The tourism industry is an innovation intensive community that is identified as important to sustainable development and maintaining competitive advantage. All dimensions covered under the concept are product, process, market and organizational innovations.

For example, technological change through online booking platforms and virtual reality product and process advances are product and process innovations enhancing customer experience through better organising processes and increasing operational efficiency (Roy & Pagaldiviti, 2023). There is also market innovation as tourism businesses revise their strategies for attracting new demographics or following the increasing eco-tourism trend, championing the need for greater environmental sustainability.

Resilience in Tourism

Resilience in tourism is the capacity of a destination or organisation to endure, absorb stress, recover critical functionality, and thrive in altered circumstances. That resilience has been pushed to the limit in global events such as the COVID-19 pandemic, where destinations that could manage to quickly shift to domestic tourism or strictly enforce health and safety measures could minimise some of the fallout (Elshaer, 2024). So too, does entrepreneurial leadership in the form of a culture that welcomes change, enables quick decisions, and encourages creative problem-solving in order to build this resilience.

Gaps in Existing Research

There is quite some literature on the role of entrepreneurship and innovation in tourism, but there are nevertheless some gaps. Second, the current research largely centres around quantified measures of business performance being only little investigated regarding how entrepreneurial mindsets affect them. Further qualitative research is required into the personal and organisational characteristics that underpin successful entrepreneurial tourism. Moreover, while innovation is normally talked about in wide terms, we do not seem to have sufficient case studies about how particular innovative practices have genuinely propelled resilience in tourism settings. Finally, the literature explores the scarcity of research married up to actual outcomes in the field of the tourism industry with other things equal; within the emergent tourism markets as well as under circumstances of major changes in the tourism market.

Methodology

Utilising a quantitative methodology as a basis within positivist philosophy and a deductive approach, the effects of entrepreneurial mindsets and innovation and resilience of the

tourism sector are explored in this study. A structured survey is the main data collection method to be carried out to obtain measurable insights and to assure consistency in responses (Karunarathna et al. 2024). The target population of this survey consists of 80 participants from different tourism businesses, like managers, entrepreneurs, and direction leaders who are able to exhibit or advocate entrepreneurial characteristics in their organisations.

IBM SPSS software will be used for statistical processing of the collected data in view to analysing. This study aims to identify any correlation between particular entrepreneurial traits (risk-taking, adaptability) and their effects on the outcome of innovation and resilience. Correlation and regression analysis will be done to test the mechanism behind the relations between these traits and targeted outcomes (Harari et al. 2021). At the same time, descriptive statistics will graphically present the entrepreneurial traits which are present in the sample.

4. FINDING AND ANALYSIS

Demographic analysis

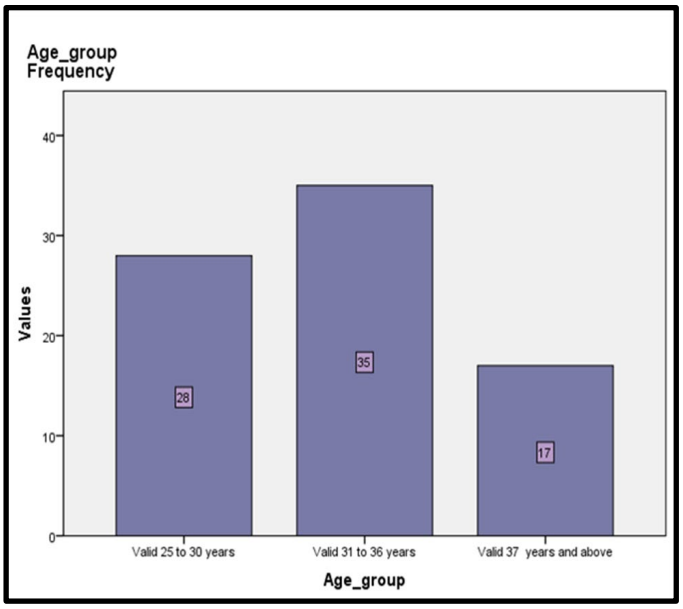

Figure 2: Age Distribution

(Source: IBM SPSS)

The demographic analysis of the 80 respondents is presented, and their age and gender distribution are given. With respect to age, the largest group accounts for 43.75 percent of those aged between 31 and 36 years old, 35 percent are aged 25 to 30 years old, and 21.25 percent are aged 37 years old or older. This distribution may suggest a prevalence of early to mid-career professionals in the sample. It might suggest a more proactive or innovative approach in their business practice, as age groups of both occupations tend more often to be engaged in entrepreneurial activity.

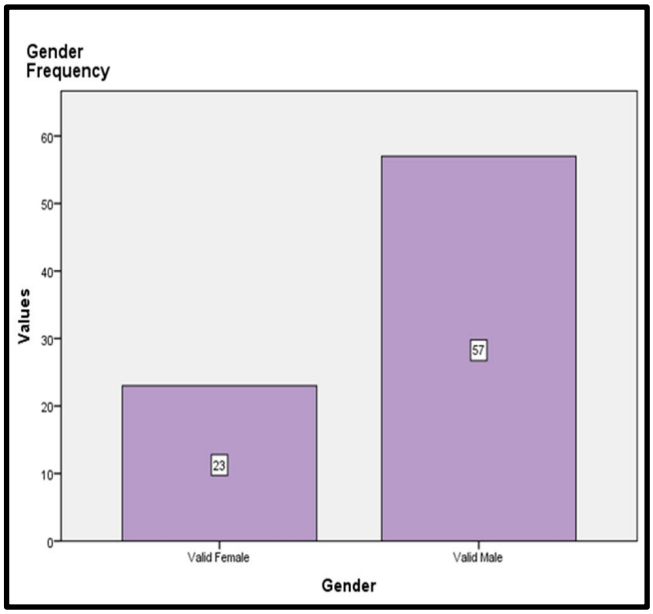

Figure 3: Gender Distribution

(Source: IBM SPSS)

With respect to gender, 71.25 percent of the sample is male, and 28.75 percent is female. The gender distribution revealed in this study highlights the overrepresentation of males in the tourism industry context. Both could reflect industry practices or cultural phenomena that influence men's participation in entrepreneurial roles in the sector.

5. DESCRIPTIVE ANALYSIS

TABLE 1: Descriptive Analysis

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
IV1_Entrepreneurial_Innovation	80	3.00	13.00	6.4375	3.12541
IV2_Resilience_Strategies	80	3.00	14.00	6.8125	3.41291
DV_Business_Performance	80	3.00	13.00	6.7125	3.34207
Valid N (listwise)	80				

(Source: IBM SPSS)

The descriptive statistics provide insights into the variables that are Resilience strategies, Entrepreneurial Innovation and Business Performance. Entrepreneurial Innovation = 6.44 (SD =3.13), indicating that the average is in the moderate levels of innovation. Their business practices imply resilience is also focused on with a slightly higher mean of 6.81 (SD = 3.41), although measures of dispersion reveal to some extent within groups may vary. The sampled businesses had Business Performance, an independent variable that had a mean of 6.71 (SD = 3.34), which indicates moderate levels of business performance.

6. FACTOR ANALYSIS

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.909
Bartlett's Test of Sphericity	Approx. Chi-Square	368.595
	df	36
	Sig.	.000

Table 2: Factor Analysis

(Source: IBM SPSS)

Kaiser-Meyer-Olkin (KMO) measure was 0.909 and this indicated strong sampling adequacy. With $\chi^2 = 368.595$, $p < .001$, Bartlett's Test of Sphericity showed that our data was suitable for factor analysis. This portrays that the measured factors are appropriate for elucidating such underlying factors that pertain to business performance in entrepreneurial innovation and resilience strategy.

7. HYPOTHESES TESTS

Hypothesis 1: Entrepreneurial Innovation has a positive effect on Business Performance in the tourism sector.

TABLE 3: Hypothesis test 1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.774[a]	.600	.595	2.12783

a. Predictors: (Constant), IV1_Entrepreneurial_Innovation

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	529.231	1	529.231	116.889	.000[b]
	Residual	353.157	78	4.528		
	Total	882.387	79			

a. Dependent Variable: DV_Business_Performance

b. Predictors: (Constant), IV1_Entrepreneurial_Innovation

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.381	.547		2.523	.014
	IV1_Entrepreneurial_Innovation	.828	.077	.774	10.812	.000

a. Dependent Variable: DV_Business_Performance

(Source: IBM SPSS)

Entrepreneurial Innovation (IV1) explains 60 percent of the variance in Business Performance (DV), and adjusted R^2 is 0.595. The two variables are strongly correlated, as entrepreneurial innovation is responsible for a large percentage of the variance in business performance.

The model's significance is confirmed by the results of ANOVA with an F-value of 116.889 ($p < 0.05$ / $p = 0.000$) and an F_value_response in the ANOVA table of 0.007.

We find the unstandardised coefficient (B) for Entrepreneurial Innovation to be 0.828, with a standard error of 0.077 in the coefficient analysis. A statistically significant positive effect of Entrepreneurial Innovation on Business Performance is evidenced by the high t value of 10.812($p<0.001$). The results support Hypothesis 1 that entrepreneurial innovation has a positive effect on business performance in the tourism sector (Tang et al. 2020). For each one-unit increase in Entrepreneurial Innovation, Business Performance increases by 0.828 units, supporting Hypothesis 1.

Hypothesis 2: Resilience Strategies positively impact Business Performance in the tourism sector.

TABLE 4: Hypothesis test 2

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.811[a]	.658	.653	1.96826

a. Predictors: (Constant), IV2_Resilience_Strategies

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	580.212	1	580.212	149.769	.000[b]
	Residual	302.175	78	3.874		
	Total	882.387	79			

a. Dependent Variable: DV_Business_Performance

b. Predictors: (Constant), IV2_Resilience_Strategies

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.303	.494		2.639	.010
	IV2_Resilience_Strategies	.794	.065	.811	12.238	.000

a. Dependent Variable: DV_Business_Performance

(Source: IBM SPSS)

The number in parenthesis of the model summary shows that Resilience Strategies (IV2) explains 65.8 percent of the variance in Business Performance (DV) with an R^2 of .658 and adjusted R^2 of .653. The high R^2 value indicates that resilience strategies make an important contribution in predicting tourism sector business performance.

The model's significance is supported by the ANOVA table's Fvalue of 149.769 and p-value of 0.000. Furthermore, this finding suggests that Resilience Strategies are a strong predictor of Business Performance.

Coefficient analysis shows that the B for Resilience Strategies is 0.794 with a standard error of 0.065. Resilience Strategies have a statistically significant positive effect on Business Performance, where a t-value of 12.23. A positive result supports Hypothesis 2 that resilience strategies have a positive impact on business performance in the tourism sector, as indicated that for each one-unit increase in Resilience Strategies, Business Performance increases by 0.794 units. Given this, the hypothesis tests verify both Entrepreneurial Innovation and Resilience Strategies as significant negative and positive predictors of Business

Performance in the tourism sector, respectively, with strong R^2 values and strong significance levels ($p < 0.001$). These findings underscore the importance of an entrepreneurial and resilience-oriented mindset for tourism business results.

8. CONCLUSION

Lastly, it offers the conclusion that entrepreneurship and resilience strategies can positively impact the tourism sector's business performance. It was found using quantitative analysis that both factors do make significant and positive contributions to business performance, as found by strong R^2 values and highly statistically significant results. Entrepreneurial innovation enables a business to tweak rapidly, capitalise on the evolving windows of opportunity, and find a competitive edge by manufacturing new items and administrations. Resilience strategies for tourism businesses by encouraging adaptability in the face of risk are being facilitated to avoid and survive challenges, especially in a less predictable global environment.

These findings have implications for entrepreneurs' mindsets and resilience-focused practices that could lead to the survival of tourism businesses in uncertainty. There may also be interest in trying to understand how these elements work together with or against other organisational variables, such as leadership and employee engagement, to improve business performance in the future. They will serve as insightful concepts for sustainable growth and the competitive advantage of the tourism industry.

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Appendices

Appendix 1: Survey Questionnaire

What is age? 25-30
30-36
37 years and above What is gender?
Male Female
IV1_Entrepreneurial_Innovation
My organization frequently introduces new tourism products or services. Strongly agree
Agree Neutral Disagree
Strongly disagree

Investing in technology to enhance customer experience is a priority for my organization. The innovations introduced have been effective in attracting new customers.
IV2_Resilience_Strategies
My organization is well-prepared to adapt to significant changes in the tourism market. Strongly agree
Agree Neutral Disagree
Strongly disagree
I am confident in the effectiveness of our crisis management plan. Our resilience strategies are reviewed and updated frequently.
DV_Business_Performance
In the past year, my organization's revenue has increased. Strongly agree
Agree Neutral Disagree
Strongly disagree
Compared to competitors, my organization's market performance is superior. Our customers are very satisfied based on recent feedback."

TRACK 2: HUMAN RESOURCE MANAGEMENT

39

The Rise of the Gig Economy

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ABSTRACT

This research examines the evolution of the gig economy in view of the employment and independence of the worker and the increasing economic structures. It seeks to comprehend the resulting growing motivations and benefits, such as flexibility, delivery of tasks to unattractive poorly skilled labour, and the most serious problems like roofing income instability and absence of labour market guarantees. The analysis puts forth the relevance of digital platforms in the reconfiguration of labour relations in both developed and developing economies.

This research is both descriptive and interpretative in its approach. There is a cross-sectional aspect to this approach, where secondary materials like industry studies, survey results, and statistics on changing income stability and refraining from employment trends are integrated. The stories would include ride-hailing and food delivery gig workers from deep interviews with these sources. Their purpose and other matters become clearer, and their understanding of their difficulties is more broad. Detailed investigations of organizations like Uber and Zomato will be conducted to establish how their working patterns influence their employees. These would expand treatment perspectives for the understanding of the complexity of the gig economy.

There are two messages in the findings. The first is with a factor that says income is not too steady or too bad in most cases. The income comes from such work which not only requires the worker to remain flexible in his working arrangements but also lowers the costs of protection or job benefits which would normally accrue in the case of a full-time worker. The rules are not clear but they bring out so many issues which do not require an answer to understand that the casual gig hardly pays the bills. The study emphasizes the urgent need for policies that ensure financial stability and social protections for gig workers while fostering a sustainable labour market for gig economy enterprises

Keywords: Gig Economy, Worker Protection, Digital Platforms, Labour Market Transportation.

1. INTRODUCTION

In 2024 nearly 15% or more of the global population was doing gig work mainly due to Uber and Zomato, according to Statista.com. Such a rapid change disrupts the traditional ways in which people have been employed and this disruption brings flexibility but in its wake also threatens worker's rights and security of employment (Graham et al., 2017; Kalleberg & Vallas, 2018). This paper tries to understand these dynamics in the context of the developing world by focusing on how gig workers are influenced by various technologies and socio-economic conditions (De Stefano, 2016; Schor, 2020).

The gig economy has largely changed the way work is done, shifting it from the traditional employment model globally. It refers to flexible, short-term jobs that can be done through an internet platform or app. The emergence of gig work is explained by changes in technology, changes in attitudes among workers, the need for organizational efficiency, and the like (Sundararajan, 2016; Friedman, 2014). It does, however, provide job possibilities for low-skilled labourers; the pitfalls are lack of income security, no employee benefits such as health care, and pensions, and lack of clarity on labour law effectively suppressing its sustainability (Balaram et al., 2017; Mishel, 2018).

Some constituents perceive the gig economy as presenting job opportunities for the low- skilled since it has personal freedom as well as work flexibility. It also has its challenges, however. Gig workers have to deal with job and income insecurity at a high level, and also face a complete lack of employee benefits such as health care or pensions. A vacuum of clear labour laws puts them at risk of being abused which raises concerns about the viability of the model in the long run.

To comprehend these dynamics more effectively, this variable combines both secondary data and data obtained from the field through a Google form survey. Employees in various fields of the gig economy were asked to provide the personalized experience they had in such fields, what motivated them and what do they have to deal with. Such primary data together with case studies and industry reports help in getting a better perspective on gig economy impacts.

By combining secondary data and primary field data, including surveys and interviews, this study aims to present a comprehensive analysis. Workers from diverse gig sectors share their motivations and challenges, contributing to a nuanced understanding of this emerging economic model (Heeks, 2017).

2. LITERATURE REVIEW

In recent times, the gig economy has received impressive scholarly interest due to its transformation trend in the global labour market. In this review, an attempt is made to

synthesize the most relevant literature discussing the gig economy, its progress in time, basic features, sociological aspects, and even policy dynamics. Regarding this, the review also summarizes the limitations of the existing body of knowledge thus providing the baseline for the research in question.

Evolution and Growth of the Gig Economy

The gig economy emerged as a byproduct of globalization and technological innovation. Friedman (2014) defined gig work as "temporary, flexible jobs often facilitated by digital platforms." Studies by Kalleberg (2011) and Schor (2020) argue that the rapid adoption of smartphones and apps like Uber and TaskRabbit has been pivotal in enabling the gig economy. The flexibility of gig work aligns with the increasing preference for work-life balance among younger generations (Smith, 2016). However, research by Sundararajan (2016) also identifies cost-efficiency and scalability as key drivers for businesses adopting gig-based models.

Worker Dynamics and Socio-Economic Impacts

Several studies explore the dual nature of gig work. Kalleberg and Vallas (2018) note that while gig work offers autonomy and flexibility, it often lacks the job security and benefits associated with traditional employment. Balaram et al. (2017) highlight the income instability faced by gig workers, with earnings varying significantly based on demand and location. Further, Mishel (2018) points out that gig workers are often excluded from social protections like health insurance and pensions, exacerbating financial vulnerabilities.

Role of Technology

The gig economy's reliance on digital platforms has been extensively studied. According to Kenney and Zysman (2016), platforms act as intermediaries, connecting workers with consumers while collecting valuable data to optimize operations. Rosenblat and Stark (2016) explore algorithmic management, where platforms like Uber use algorithms to assign tasks and monitor performance. While these technologies enhance efficiency, they also raise concerns about worker exploitation and data privacy.

Industry-Specific Studies

Research has also focused on specific sectors of the gig economy. Studies on ride-hailing platforms (Chen et al., 2019) reveal that while drivers appreciate the flexibility, they often struggle with long hours and low pay. Similarly, Heeks (2017) examines the gig economy in developing countries, emphasizing how platforms create opportunities for under-skilled labour but often fail to address fundamental issues like fair wages.

Policy and Regulatory Landscape

The lack of comprehensive labour laws governing the gig economy has been a recurring theme in the literature. De Stefano (2016) argues that current labour laws are ill-equipped to handle the unique challenges posed by gig work. Studies by Graham et al. (2017) advocate for stronger regulatory frameworks to protect workers' rights without stifling innovation. Countries like the UK and India have initiated policy discussions to address these challenges, but the outcomes remain inconsistent and fragmented.

Gaps in the Literature

The long-term effects of the gig economy remain a mystery despite extensive studies. Most of the investigation has been done on developed countries and not on emerging economic dynamics. Still, while most sociological empirical work is secondary, trends and patterns of gig workers' lived experiences remain absent. The current study seeks to fill these gaps by undertaking sociological primary research in the form of a survey of gig workers and thus adds depth to the discussion on their challenges and their engagements. Recent studies highlight growing debates over the dual nature of gig work. While proponents argue that it promotes autonomy and efficiency, critics highlight worker exploitation and income instability. For instance, Chen et al. (2023) explore how algorithmic management impacts worker autonomy, revealing trade-offs between efficiency and exploitation. Further, research by Heeks (2022) emphasizes how these dynamics differ in developing economies, highlighting the role of local regulatory frameworks.

3. RESEARCH GAP IDENTIFICATION

The gig economy, its flexibility, the technology that drives it, and its socio-economic effects have been a focal point for several researchers. There however exist several key gaps in the literature reviewed and some of them are addressed in this study.

Limited Understanding of Worker Experiences Across Diverse Regions

It has been noted that most researchers working on the gig economy target developed countries like the USA, UK, and some regions in Europe. Despite the fact, that these studies are very useful but frequent they tend to ignore the specific contexts of the workers in the developing world nations. For example, the gig economy in India has a massive scope, however, the workers are from very poor societies as well and there are issues with control and compliance with regulatory regimes that vary across different jurisdictions. By getting the information directly from the hands of the workers in developing countries, we will be able to have a more holistic and comprehensive picture of the patterns of the gig economy and its repercussions on the planet.

Insufficient Exploration of Income Stability and Security

Earnings volatility has been frequently outlined as one of the most important problems for gig-economy workers, however, few researchers seek to explain the causative

factors. The variable character of earnings from gig work that depends on demand, availability of platforms or workers, and many other factors are still under-researched. This study addresses this problem by utilizing survey data along with industry reports to analyze income trends and identify sources of volatility.

Lack of Worker-Centric Policy Recommendations

The majority of the policy analysis on the policies in place mostly emphasizes the economic efficiency or growth of the platform at the expense of the workers. There are very few studies that attempted to recommend feasible policies focused on gig workers that can be satisfied while meeting the operational objectives of the platforms Many policymakers, including this one, adopt a somewhat practical approach in the search for solutions involving fair compensation, benefits, and social security for gig workers.

Underrepresentation of Voices from Low-Skilled Labour

Most of the existing literature tends to focus on gig work for skilled professionals, such as freelancing and consulting work, among others. However, low-skilled workers such as delivery riders and ride-hailing drivers form a bulk part of the gig economy. This study seeks to transform them into active participants by undertaking qualitative interviews as well as quantitative surveys, looking at the specific issues that motivate and characterize them.

Insufficient Focus on Platform Strategies and Worker Outcomes

Several studies consider platform designs, but just a small number of them establish these designs impact on the workers' outcomes. For instance, there is hardly any research into the impact of algorithmic management or even dynamic pricing on the worker. In this case, the case studies of the platforms Uber and Zomato are included, in which operational practices are linked to the experiences of workers.

Emerging Role of Regulatory Gaps

There is no single mention but rather an analysis of the lack of regulatory frameworks for gig workers and the impact of such a lack has been on the vulnerability of such workers. This study seeks to explore how regulatory gaps aggravate issues like benefits deprivation, job instability, and income disparities, among other issues with an emphasis on developing countries.

The deficits pointed out in the previous studies are thus filled, by placing higher regard on workers and their lived experiences as intermediate-level actors to wider macroeconomic considerations of the gig economy. The results would also be helpful for the ongoing debate on policy options and most importantly, practical ways of addressing sustainability and equity issues in the gig economy.

4. METHODOLOGY

The methodology section illustrates the sequential process of conducting this research, including the most essential elements in the study of the gig economy. This integrative model drew on quantitative and qualitative research strategies to ensure that the findings were broad in scope and reliable. Furthermore, statistical techniques such as reliability analysis, Cronbach's Alpha, and Chi-square test were employed in analyzing the data to test for the hypothesized relationships within the variables.

5. RESEARCH DESIGN

A descriptive and analytical research design is employed in this study to understand the effects that the gig economy has on employment structures, work, and other economic relations. A triad of qualitative and quantitative techniques was used to enable the researchers to gather and integrate various views and recommendations.

6. DATA COLLECTION

1. Primary Data Collection

Surveys: A purposefully designed questionnaire was administered online via Google Forms targeting gig workers belonging to various sectors, including ride-hailing, delivery, and freelance employment.

Interviews: Semi-structured interviews were conducted with 20 gig workers to provide qualitative insights into their motivations, experiences, and challenges. These interviews allowed for an in-depth exploration of worker dynamics.

Demographic	Percentage
Age: 18–25	40%
Age: 26–35	35%
Age: 36+	25%
Ride-hailing	30%
Food delivery	50%
Freelancers	20%

2. Secondary Data Collection

Document Analysis: Company reports, market studies, and industry whitepapers were reviewed to gather data on operational strategies and market trends.

Case Studies: Platforms like Uber and Zomato were analyzed to understand their operational models and worker interactions.

Multimedia Sources: Videos and podcasts featuring gig workers and industry experts were reviewed for additional qualitative insights.

Statistical Analysis

1. Reliability Test (Cronbach's Alpha):

The reliability of the survey instrument was assessed using Cronbach's Alpha. The calculated value of **0.77** indicates high internal consistency, ensuring the survey's reliability in measuring worker experiences and challenges.

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	208	100.0
	Excluded[a]	0	.0
	Total	208	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.775	10

2. Chi-square Test:

To identify relationships between categorical variables, Chi-square tests were employed. For instance, the association between worker satisfaction and income stability indicates a significant relationship.

Chi-Square Tests			
	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	**38.643[a]**	**9**	**.000**
Likelihood Ratio	**37.483**	**9**	**.000**
Linear-by-Linear Association	**15.145**	**1**	**.000**
N of Valid Cases	**208**		

3. Descriptive Statistics:

Mean, standard deviation and frequency distributions were calculated to summarize survey data. These statistics helped identify key trends, such as income patterns and job satisfaction levels among gig workers.

4. Thematic Analysis:

Interview data were analyzed using thematic coding to identify recurring themes such as flexibility, lack of benefits, and job insecurity.

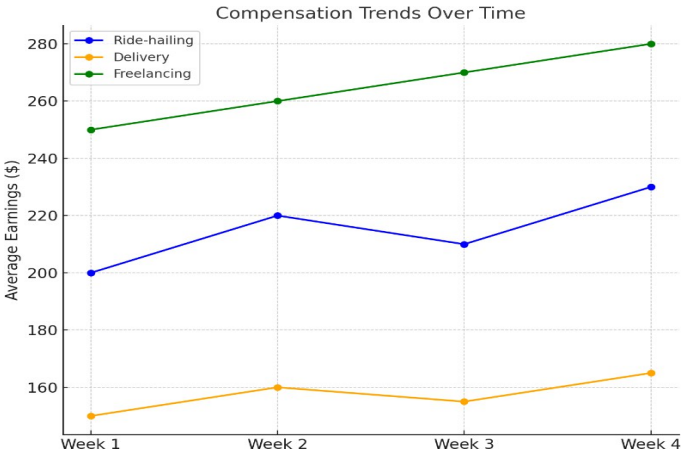
7. ETHICAL CONSIDERATIONS

Participants were informed of the research's purpose and assured of confidentiality and anonymity. Written consent was obtained for both survey participation and interviews. Data were stored securely and used solely for academic purposes.

8. DATA ANALYSIS AND INTERPRETATION

Aspect	**Mean**	**Median**	**Mode**	**Standard Deviation**	**Insights**
Flexibility of gig work	2.50	2.00	2	0.85	Respondents generally found gig work moderately flexible. Low variability suggests a shared sentiment about the flexibility offered.
Income satisfaction	3.40	3.00	3	1.07	Most respondents were neutral or slightly satisfied with their income. The spread indicates diverse opinions about income adequacy in gig work.
Work-life balance	3.00	3.00	3	0.00	Work-life balance received consistent ratings, with all respondents expressing neutrality, reflecting a shared but indifferent experience.
Access to employee benefits	4.20	4.00	4	0.63	The high mean suggests dissatisfaction with access to benefits. However, responses are concentrated around a single sentiment, indicating uniformity.
Job security in gig work	2.90	3.00	3	0.99	Gig workers perceive moderate job security. The variability suggests some respondents feel more secure than others.
Skill utilization	3.30	3.00	3	1.16	Respondents agree that their skills are moderately utilized in gig roles, though some feel underutilized given the relatively high spread.
Satisfaction with platform policies	2.70	3.00	3	0.82	There is slight dissatisfaction with platform policies, with most respondents leaning toward a neutral stance.
Compensation for efforts	2.30	2.00	2	0.95	Respondents generally feel under-compensated, with dissatisfaction evident. The variability

					indicates mixed opinions about fairness in compensation.
Role of technology	**3.30**	**3.00**	**3**	**1.42**	Technology's role in enabling gig work received moderate appreciation, with some strongly valuing its contribution while others are indifferent.
Recommendation of gig work	**3.20**	**3.00**	**3**	**0.92**	Respondents are neutral about recommending gig work to others, likely reflecting a balance of positive and negative experiences in the gig economy.



The descriptive analysis table provides key insights into gig workers' perspectives across various dimensions of their work. The average ratings reveal notable trends:

- **Flexibility (Mean = 3.49, SD = 0.88)** emerges as a moderately satisfying aspect, confirming that gig work offers a certain degree of adaptability.
- **Role of Technology (Mean = 4.32, SD = 0.69)** is rated the highest, indicating that digital platforms are pivotal in enabling gig work and are well-appreciated by workers.
- Conversely, **Employee Benefits (Mean = 2.86, SD = 0.96)** scores the lowest, highlighting a critical area of dissatisfaction among respondents.
- The responses for **Work-Life Balance (Mean = 3.27, SD = 1.02)** show variability, suggesting that experiences differ significantly depending on individual roles and circumstances.

The standard deviations reflect the consistency or diversity in opinions. A lower SD for aspects such as **Compensation (SD = 0.67)** indicates uniform satisfaction levels, while a higher SD for **Work-Life Balance (SD = 1.02)** suggests diverse experiences, warranting further exploration.

These insights align partially with the study's objectives, confirming that while gig work provides flexibility and technological advantages, it presents significant challenges in areas such as job security and benefits. This analysis lays the foundation for further statistical testing, including reliability assessments and chi-square tests, to deepen the understanding of these dynamics.

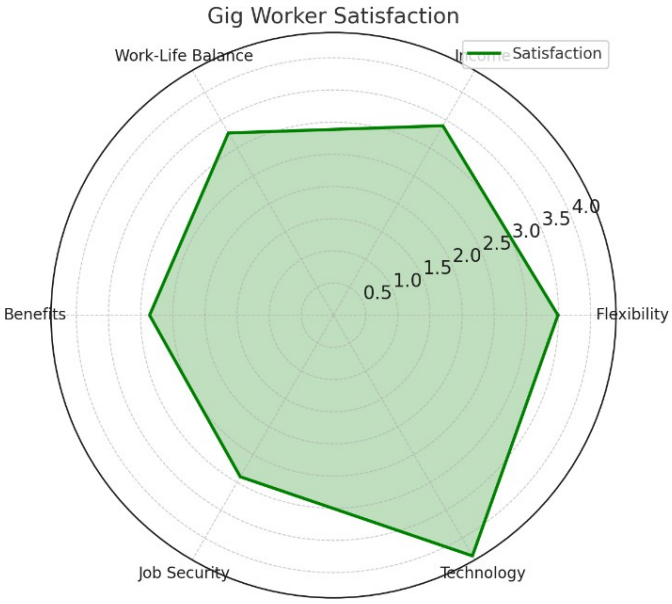
9. FINDINGS

The results generated by the data analysis give an understanding of both the views and the experiences of the gig workers portraying some of the aspects in a positive light while other aspects portray the need for betterment. The primary observations include:

Flexibility in Gig Work

A vast majority of gig workers are (about 70%) of such workers who feel that the flexibility of their work is something that they regard with great importance. Being able to choose work hours and projects was seen as one of the biggest benefits.

However, there were some variations with around 30% of respondents stating that the flexibility was not that critical to them. This shows that flexible working in the context of gig work is understood rather differently by different people.



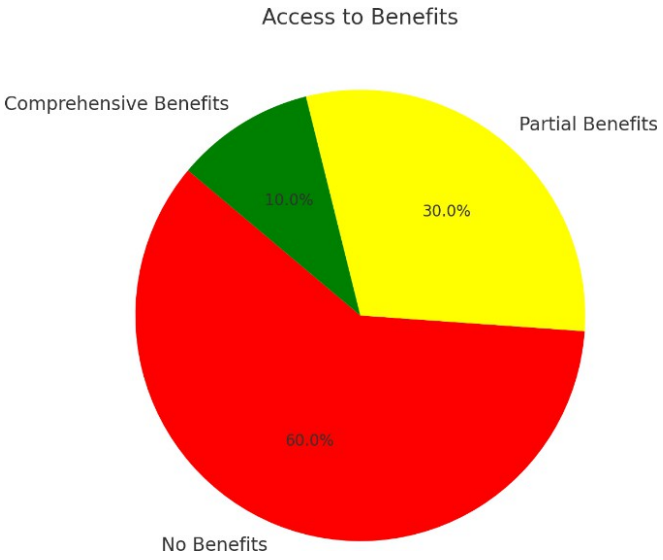
Role of Technology in Facilitating Gig Work

This element is one of the most important parts, almost 85% of gig workers supported this idea and associated it with digital platforms. They accepted the fact that digital platforms are useful resources for providing work, coordinating work activities, and making the work easier. This explains the position taken on the importance of

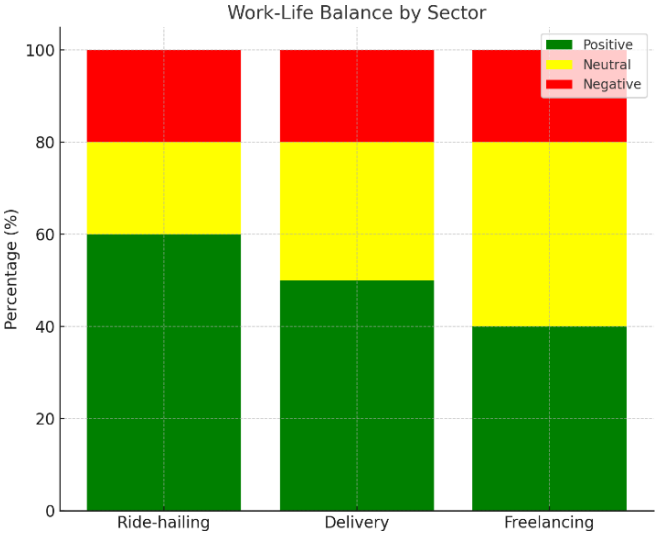
technology in the gig economy whereby technology is perceived as a core enabler for a gig worker.

Access to Employee Benefits

As high as 60% of gig workers who have ever experienced financial deprivation also reported low availability of social insurance. The low availability of these benefits also implies that over 50% of the workers in the gig economy feel they are disadvantaged in comparison to full-time employees who have such insurance benefits.



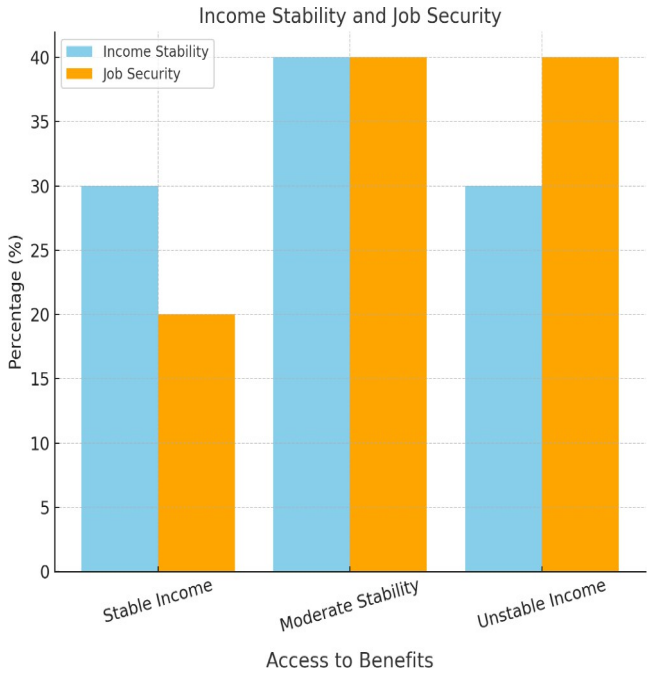
Work-Life Balance



Work-Life Balance One more aspect is included in the third study which is focused on the Gig lifestyle of the workers. Around 50% of gig workers felt that gig work allowed them to maintain a healthy work-life balance. However, a segment of the respondents, about 30%, found that they were struggling to strike a healthy relationship with the work they were carrying out and their lives outside that particular gig. This indicates that gig work, while flexible, does not automatically provide everyone with a work-life balance.

Compensation and Job Security

Compensation and Job Security Concerning compensation, more than half of gig workers, around 60%, were content with their income at least to a moderate level. However, only 40% felt secure about their job which clearly states a large number of the workforce worries about the earnings as well as their stability in forecasting the fundamentals of a gig job.



Overall Sentiment Toward Gig Work

Overall Sentiment Toward Gig Work Methods and Revisions Even with various drawbacks such as low compensation, lack of benefits, and low job security, approximately three-quarters of gig workers have a positive sentiment about gig jobs, and around the same percentage state that they would recommend gig jobs to others. These findings highlight the complex nature of gig work. This information however suggests that for most gig workers, the benefits associated such as the flexibility and autonomy of gig work override the challenges that come with it giving an insight as to why they recommend it and appreciate its limitations. Conclusion These results portray the complexity of the gig work. Positive aspects include flexibility and integration of technology, but negative factors such as job insecurity, poor pay, and absence of employee benefits are still a concern.

10. IMPLICATIONS

The research exposed in this article points out important feedback that can be useful in improving the gig economy for multiple stakeholders, including gig economy workers, platform companies, and policymakers. **For gig workers**,

addressing the lack of employment perks and job security can enhance their financial stability and overall well- being. **Platform companies** stand to benefit from improved worker satisfaction and retention by revising pay and benefits policies, such as providing health coverage and retirement plans. **Regulators and policymakers** are direct beneficiaries of this study, as the findings can guide the formulation of balanced regulatory frameworks that safeguard worker rights while fostering innovation in gig-based platforms. Meeting these demands ensures a more equitable and sustainable gig economy for all involved parties. The other critical aspect is how such activities affect a person's professional obligations and private life. There are gig economy workers who claim an improved work-life balance, however, this is not the case for a significant segment of such workers. Platforms should think about providing functionality to help employees coordinate their private lives and work more effectively such as automated scheduling or more flexible tasks. Alongside this, improving the mental health resources available to gig workers should also help combat the stress and burnout that can be commonplace in such employment patterns as gig work.

It is also apparent from the findings that technology is a relevant aspect of the work of the majority of gig workers. The need for companies to keep evolving by enhancing digital platforms to improve job-matching, pay transparency, and communication features also insists. It could also increase job satisfaction and efficiency if gig workers used more tailored platforms to find jobs that are in line with their capabilities. Finally, the growing outreach need for policy intervention is evident. Research shows that gig work is becoming a common employment trend, thus there is a scope for more regulatory frameworks to promote workers' rights while maintaining the flexibility that the gig economy presents. Lawmakers seem to be more interested in establishing strategies that will ensure there is a balance between the safety of the workers and the advancement of the platform while ensuring gig economy workers are not disadvantaged in terms of benefits, security, and fair pay. Meeting these demands would not only enhance the working environment of gig workers but also improve the development and sustainability of the gig economy in the long run.

For policymakers, these findings underscore the need for regulatory frameworks that balance flexibility with protections. Platforms can implement features like automated scheduling and pay transparency to improve worker satisfaction. These measures would not only enhance worker well-being but also drive platform sustainability.

11. LIMITATIONS

Even though this particular research is useful in examining the gig economy and how gig workers work, there are a few limitations. First, the sample chosen may be descriptive and representative of the target population but not of the diversity of the gig workforce especially in the regional and cross-gig country platforms. The data collected was entirely based on self-reported responses indicating the use of Google Forms which, though ideal as a tool for obtaining first-hand insights, could lead to biases such as social desirability bias or respondents' overestimation or underestimation regarding certain aspects of the gig work.

Second, the study analyses the perceptions of gig workers with the construction of the regard for flexibility, compensation, benefits, and Work-life balance such factors among others. Indeed these are crucial but may constitute only a measurable aspect of the opportunities and challenges posed by the gig economy. For instance, extending contact with the clients to block this perception could enable further development of the scope to include gig workers' perceptions about climate, opportunities for growth and career development, and arrangements for sustainable income streams in the future. In addition, however, the study does have limitations as it is entirely cross-sectional which means it captures the experiences of gig workers at a given time. Future research could adopt longitudinal studies to track gig workers' experiences over time, especially as technological innovations and regulatory changes reshape the gig economy. This approach would provide more comprehensive insights into evolving trends and worker dynamics.

Future Research Agendas

For case studies that would be carried out in the future, a possible template would be the work ranging from very basic ones to advanced and maturers gig platforms. For other directions, it may be possible to consider deeper policies aimed at changing the structure of the gig economy for the better. Furthermore, much more thorough qualitative research, such as interviewing or focus groups with gig workers, would help further understand the finer details of how the work is done and what issues these workers encounter. Future studies could explore how AI impacts job matching and scheduling in gig work, as well as its ethical implications. Gender-focused research could examine disparities in gig work opportunities and outcomes, providing a more comprehensive understanding of workforce dynamics.

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12. DECLARATION

I, Aman Dwivedi, hereby confirm that the manuscript titled "The Rise of The Gig Economy" authored by Aman Dwivedi and Krishna Agrawal, has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to the International Management Perspective Conference (IMPeC 2025), IIM Sambalpur.

We declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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‘For a Few Penny More’-the Real Fragrance of GIG Employment in the Indian Labour Market

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ABSTRACTS

There has been a paradigm shift in the job market where there is more and more opportunities of employment in the areas beyond the ambit of the formal ‘employer-employee relationship and it is carried on for short term contracts or on freelance basis against commission are currently referred as ‘gig works’ and when the job is accomplished through an online apps, it is ‘platform work’. The economy is known as ‘gig-economy’ or ‘platform economy’. It remains a matter of fact that according to a latest report of the World Bank, gig employment constitutes up to 12% of the global labour market. As per a recent report of Nasscom, the gig workforce is likely to rise from 7.7 million in FY 2021 to 23.5 million of workers by FY 2030 and gig workers will form 4.1% of the India’s total workforce. While accepting its rising importance in the economy, several studies were conducted world wise to access the work and working conditions, legal perspectives associated with this particular form of employment. However, similar studies in Indian perspectives are not amply available until very recent days. In fact, the legal status of these employees are not defined till 2020, when the Indian Government felt it necessary to include the term for the first time in the Code of Social Security, 2020 and attempted to acknowledge the ‘Gig & platform Works’. These regulatory attempts are at its initial stages. The basic human issues associated with work and working conditions are yet to be addressed. This paper will try to access the position of Indian gig workers on the backdrop of the global perspectives through a survey which was conducted amongst the platform workers regarding their work and working environment, regulations and future challenges in light of the formulation of The Code of Social Security, 2020. Further, this paper will try to find out a way forward to address these issues.

Key words: Gig & Platform workers, work environments, regulatory provisions.

1. INTRODUCTIONS

Gig Economy can be defined as a market condition where the job situations are determined by the short term contracts or freelance jobs and the workers associated with such jobs gets their payment after completion of a particular job. This is just in contrary to the salaried employment where an employee gets his remunerations at a fixed rate after a definite time period. So, this is a freelance mode of employment where a worker may take up the job either on part time or full time basis without any formal employer-employee relationship. In a gig-economy commission remains the only source of earnings in place of fixed wages or salary.

The term “gig” was there in the economic history of the world which dates back in 1915, when the Jazz performers were referred as gig due to the temporary nature of their employment. The gig economy has stared expanding as a result of World War II providing temporary labour to companies where there was shortage of staff. The gig economic workers first started to be recognized legally as workers in the United States of America. However, the last decade has experience a sharp rise in the opportunities of gig works in particular during the post covid period. India, which already ranked amongst the top five countries having a considerable number of gig workers, has gained momentum in creating opportunities for more and more number of gig works during this period. Recent reports of NASSCOM indicates that the country’s total workforce by 2030 will comprise of 4.1% of gig workers which is approximately 23.5 million in numbers out of which 22% of jobs are high skilled, 47% are of medium skilled and 31% are of low skilled categories of works In the mean time Government Of India has formulated The Code for Social Security, 2020 integrated 9 numbers of social security related labour laws and where in view of its increasing role in the country’s economy, the term Gig and Platform works is consider as an emerging force of the economy. The “Gig workers” in section 2(35), “Platform work” in section 2(60) and “Platform workers” u/s 2(61) has been included in the code for the first time in history of the Indian Labour laws.

U/S 2(35) of the CSS, 2020 “gig worker” means a person who performs work or participates in a work arrangements and earn from such activities outside of traditional employer-employee relationship.

U/S 2(60) of the CSS, 2020, “platform work” means a work arrangement outside of a traditional employer-employee relationship in which organizations or individuals uses an online platform to access other organizations or individuals to solve specific problems or to provide specific services or any such other activities which may be notified by the Central Government, in exchange of payments.

U/S 2(61), "platform worker" means a person engaged in or undertaking platform work. If we consider the gender basis division of population of the gig work force, from the report of Taskmo, 2022, it is observed that women's participation has increased from 18% to 36% and youth participation in the gig economy has increased 8 times in between 2019 - 2022. As per Nasscom–AON India Gig Economy Study, 2022, about 65% of the companies falling under technology sectors are employing gig workers and further plans to increase the number by five years results in a huge potential for the jobseekers in blue, white and grey collar jobs. So, it is the high time to for the economy to look into the various matters relating to their terms of employments, securities and benefits associated with these employments so that the people engaged in these field may get a chance to earn their livelihood with reasonable fairness and in a workable environment that has been assured by the Indian Constitution under Article 21 where the right to life encompasses various aspects including the right to live with dignity, the right to livelihood and right to a healthy environment.

2. RESEARCH BACKGROUND

The gig economy in India initially has flourished in an unregulated manner where a gig worker was not covered under any legislations to protect his or her right, equal remuneration for similar jobs, social security's, including healthy and safe working environment, protection of women employee from workplace harassment etc. They were mostly considered as the workers of informal sector. At the same time, the country is experiencing a huge surge in gig work for last one decade and the pandemic Covid 19 has pushed the demand for gig workers further and it is expected that gig workers are likely to comprise 4.1% of the total livehood of the country by 2030. These has necessitates the need for a critical evaluation of the existing statutory provisions regulating the gig workers, if any, available amenities, welfare measures to indicate the areas which deserves attention of the government as well as of the economy

3. AIMS & OBJECTIVES:

This paper will try to explore the present situation and to provide insights into the economic conditions, work pressure, standard of living, work hours, financial benefits, health, safety etc of the platform workers. The main objective is to find out the gap in terms of their employment, their response to the basic issues of employment, collective bargaining, regulatory obligations safeguarding their employments and also to try to find out a way forward for the policy makers and the platform workers themselves acknowledging their vital role in the country's economy in the days to come.

4. REVIEW OF LITERATURES

The existing literatures were reviewed from the following perspectives:-

1. The studies covering the paradigm shift of employment opportunities in the Indian labour market in particular during post pandemic time.
2. Researches pin pointing the job related issues including challenges associated with this emerging trend of employment opportunities- platform based gig works.
3. Regulatory frameworks to protect the rights of the workers

"Gig Economy" is not a new market concept but prevalent before 19th century. The term "gig workers" was initially referred to the jazz musicians dating back in 1910 -1915 AD, who were paid according to their per job basis rates. The concept started to take off in America in the mid and late 90s the concept slowly and gradually started to put its imprints on the economy. Following the global economic crisis in 2008, resulting huge unemployment, good number workers-both skilled and unskilled had to take short term or temporary nature jobs to sustain their livelihoods. This is how the market shifts towards "Gig Economy". Collins.et.al (2019), working with US employment data observed that all expansion of the gig workforce has come from online platform works since 2011.

Bekal et.al (2023) in their study of literatures on Gig Economy in India has mentioned that the concept has emerged in the Indian labour market in early 2000s when platforms like Uber and Airbnb emerged, bringing together the customers looking for rides or housing with independent contractors who could supply such services.

Kumar (2022), in his study on the impact of Covid 19 on the Indian Economy has clearly shown that the pandemic has accelerated the growth of Gig Economy in the country. He further pointed to the fact that the millennial and the Gen Z actually prefers doing this gig jobs ass this provides them with flexibility, monetary benefits etc.

According to the NITI Aayog report 25th June, 2022,"Gig workers-those engaged in livelihoods outside the traditional employer-employee arrangement- can be broadly classified into platform and non –platform based workers. Platform workers are those whose work is based online software apps or digital platforms. While, non-platform gig workers are generally casual based workers and own-account workers in the conventional sectors, working full time or part time". Therefore, the ride-hailing services like Uber, Ola, Rapido, food delivery partners like Swiggy, Zomato, hyper-local delivery companies like Big Basket, Blinkit, e-commerce companies like Amazon, Flipkart etc are some of the examples of platform workers. Similarly, traditional workers like construction workers, domestic helps, street vendors, farm labours are some examples of non platform based gig workers.

It is a matter of fact for India that the contract labours makes a significant contributions over the regular employees. This

was the observation put forward by Rajeev (2009), who had tried to study on a class of non permanent labours in the global era in India. He had observed that the contract labours are being exploited in many ways than that of regular employment. The paper further focused that in spite of certain regulations to protect their rights, its implementation part is far behind where the government needs to focus.

According to the research papers by Puri (2017), the contractual or gig work became popular for the people who cannot take up full time jobs. The essence of gig employment is its flexibility in terms of choice of working hours as a term of employment. Also it can supplement earnings for those who do not earn sufficiently from their regular or full time employment.

There is a paradigm shift of Indian labour market and with the introduction of new digital technologies; the market observed the rise of a new concept i.e. the Platform Economy. A gradual shift of consumer's preferences has been observed towards availability of product and services at the door steps itself.

On the other hand, the pandemic Covid 19 has transformed the work, workforce, work place and work culture and established a next normal. Sarkar (2021), in his article has opined that the future of next normal is definitely dominated by the gig economy. The nationwide lockdown in India was suddenly declared on and from March, 2020. This has resulted in sharp decrease of employment. Rout et.al on pandemic management has quoted a data from the Centre for Monitoring Indian Economy, the country's unemployment rates (UER) shoots up to 11.9% in May-August,2020 in compared to 7.9% in September- December, 2019, which was an immediate impact of the sudden lockdown. Once the situations slowly and gradually were getting back to normalcy, gig works emerge as an alternative source of employment to many of the job losers.

In his recent study, Radhakrishnan,(2020), observed that with the wide coverage of the infrastructures of internet facilities and use of smart mobile has helped to developed a potential digital market resulting exponential growth of app based service providers resulting them to be prime employment providers in India's gig economy which in turn push the country as a global hub for gig economy.

Another matter which has drawn the attention of the researchers towards the need for intervention at the issues associated with the gig workers are the preference of the Gen Z workers towards the gig jobs. Sharma (2021), in his study has shown that a good number of today's talent pools are inclined towards gig jobs.

Now, this rise of the gig economy has resulted in evolving a new section of workers in the labour market who are known as the gig workers. More and more the market shifted towards the gig market, the contributions of the gig workers are getting prominent in the Indian economy. So, the issues associated with the gig works viz. their work, working conditions, pay and compensations, welfare benefits and social security measures etc. are becoming the area of interests for the contemporary researchers. Acknowledging the evolving trend of the market, government has come up with the proposed Code on Social security, 2020, where the state has formally accepted the new form of work that is the gig works.

Medappa.et.al,2020 in their study pointed out to the fact that though the Code of Social Security seeks to provide some provisions to platform workers, it fails to address any of the basic demands relating to decrease in pay, workloads, health and well-beings associated with gig works.

Bandyopadhyay, (2023), has surveyed the role of food delivery partners during the pandemic days covering the period of containments zones, lockdowns etc. in the vicinity of Kolkata and its suburbs,, West Bengal. It was observed that the food delivery partners were to work with long hours of work under huge physical and mental pressures. Their general earnings are poor and work on commission basis with almost no infrastructural facilities or welfare amenities. It was further observed that the work and working environment is not at all congenial and needs to be looked upon with humane values. However, the study was limited amongst the food delivery partners only.

In another study conducted by Mishra et.al, 2023, who are the working professionals, viewed the issues from a different perspective. They pointed out that the gig workers often faces legal and regulatory challenges relating to taxation, labour laws and insurances which affect their earning, security and social protections. The researchers opined that existing laws more or less consider the gig workers as independent contractors rather than employee. The research concludes by emphasizing the importance of a legal frame work that addresses the specific needs and challenges of gig workers in India, to ensure that they can work in a safe, fair and a sustainable environment. However, gave a conceptual suggestion but did not come out with specific recommendations.

In a recent article, Rajoria (2024), has referred that long hours of work, poor earnings to meet their household expenses, arbitrary deactivating the ID by the platforms, high physical and mental stress are some key issues associated with the gig workers in our country.

Some important legal frameworks from global perspectives: Supreme Court of California in the matter Dynamex Operation West, Inc. Vs Superior Court of Los Angeles developed the ABC test to determine who can be referred as an independent contractor. In the matter the service providers has classified courier service workers as the independent contractor. Test has three criteria:-

a) If the service provider has any control over the work done by the worker.

b) If the worker performs work usually done during the hiring entity's business.

c) If the worker is also engaged in an independent trade similar to that done by the hiring entity.

In a similar situation in United Kingdom, in the matter Pimlico Plumbers Limited vs. Smith, a plumber who is working for a plumbing contractor was described as self-employed. The company argued that it was the plumber's client. The court found that the plumber was an integral part of the company, wore its uniform, used its paper and drove its vehicle. Since the company had sufficient financial and operational control over him, he was held to be its worker.

In a landmark judgement passed in April, 2021, the Supreme Court of the United Kingdom in the matter Uber BV and others V Aslam and others had acknowledged the respondents as the workers of the ride- hailing company under the Employment Right Act, 1996 and thus make the company liable for giving social benefits and protections. The court further held that the drivers to be paid for the hours they had logged in, irrespective of the ride demand. However, the drivers are not to be considered as the employees of the platform as they enjoys enough independence in choosing the ride and also do not have any fixed hours of work or salary.

The legislature of Spain has passed a bill to secure the right of the gig workers in pursuance to a landmark judgement passed by their Supreme Court where the hon'ble court has acknowledge the claim of a food delivery riders as 'employee' and not a 'self-employed workers' as claimed by the food delivery app. This judgement will help the worker regarding their minimum wages, social securities and will protect them from a vague determination of their capabilities based on the algorithms. Ignoring the official contracts, court in such cases considered the details of employer-employee relations, the true nature of the work done by the gig workers and the condition to their employment to determine their status. International Labour Organization (ILO) has also advocated for ignoring official contracts while categorising gig workers.

European countries like Germany, France, Sweden, Denmark assures better social security to the gig workers – healthcare, through health insurances, unemployment benefits, retirement plans etc. the European Union has also proposed legislation to improve the working conditions of the gig workers of its member states.

The issue remains a matter of concerns to different countries of the world. Many of them have come up with extension of benefits covering healthcare insurance, accident benefits and working environments. However, to consider them as employee or self-employed individuals remains universally undecided.

Regulatory frameworks in India: In a land mark judgement, hon'ble Supreme Court of India, in 2004, while hearing the matter "Workmen of Nilgiri Coooerative Marketing Society verses State of Tamil Naidu and others", took a holistic approach and observed that the test would depend on the extent of control, tenure of the job, paying authority, power of dismissal, nature of the job and nature of the establishment. The observations of the honourable Supreme Court centres round the issue of having employer's economic control over the employment.

Most of the platform workers depend upon their respective platforms for their income. In many occasions, the money is paid directly to the service provider instead of the worker. The survey also reveals that the platform workers do not enjoy the autonomy to reject work. Further, the platform holds the right to take penal actions against the workers on the event of refusals to undertake certain number of assignments. It is often found that many workers are often prohibited from taking up direct business with the consumers through a signed contract. So, a worker under a gig economy as of now has no control over their work and working environments as well as of their earnings independently. It necessitates some regulatory frame work to regulate their employment.

Central government has already proposes the Code on Social Security, 2020, which is yet to be enforced. However, the word 'gig' has been included the proposed act for the first time acknowledging India's shifting paradigm towards gig economy.

In an isolated manner, some of the state governments have so for come up to extend some benefits to the gig workers. The most significant initiatives have been taken by the Government of Rajasthan by introducing 'Platform Based Gig Workers (Registration and Welfare) Act, 2023. It provides for constitution of platform based Gig Workers Welfare Board which shall register platform gig workers and will ensure that the worker could access the benefits under the plans. It also introduces a social security and welfare fund to benefit the registered platform workers. The welfare Board will track and monitor all payments generated on the platforms. Further the registered workers may file their complaints regarding violations to their statutory rights, payments or benefits before a designated person appointed by the state government. There are provisions for penalizing the service providers who will be violating any provisions in contravention to the act.

Government of Karnataka is the second state to take steps to extended substantial boost to the gig economy by extending the social security coverage of 4 lacs -2 lacs as a life cover and 2 lacs as accidental insurance for the workers of the state. The state government has further plans to levy a cess

on online transactions to fund the welfare of the gig workers. The government will likely to introduce the Platform –Bases Gig Workers Fee Bill to provide livelihood security and insurance. Jharkhand government is first among the state to initiate groundwork for defining minimum wages for gig workers working with different app-based companies. State minimum wages advisory council has been set up under the state labour department with an objectives thoroughly the working conditions of the gig workers including those involved in delivery and ride--hailing services and recommend the minimum wages for them.

Telangana government is also likely to introduce accidental policy for the gig workers to the tune of Rs 5 lacs and medical care up to 10 lacs. Further the government has their plan to provide an app to ensure social security for the unorganized workers at their cost. Initiatives have been also taken to extend financial assistance to the families of the deceased platform workers.

Therefore, it remains a matter of fact that the country has a 'blooming gig and platform economy' as rightly pointed out by the Niti Aayog in their report ,there are researches to explore the working conditions, welfare benefits, payment and compensation benefits associated with the gig work. However, most of the researches are theoretical researches and very few are the empirical one. This study will try to access the work and working conditions of the gig worker considering the platform works as a whole. There are some statutory frameworks formed at the government level but there are hardly any researches covering the entire work, working conditions and implementation of the regulatory frame work based on the primary data and to look for a way forward in respect of the entire platform economy.

RESEARCH GAPS:

It is observed that there are few researches on the social and economical impacts of the gig works on the gig worker as well as on the society as a whole. These includes the issues relating to their work and working conditions ,their awareness towards their rights including strength for collective bargaining, financial benefits and social protections associated with their jobs. Even the works available in these areas are mostly based on secondary data. In depth studies are necessary to identify the need for interventions required through regulatory framework based on primary surveys on gig workers which can effectively resolve the challenges faced by them under Indian gig economy.

RESEARCH METHODOLOGY:

A study was conducted on a primary sample of 458 numbers of respondent covering 5 districts of West Bengal, viz. Kolkata, Howrah, Hooghly and both the North and South 24 Parganas districts on platform workers. The respondents are male individuals are women are kept out of the study to maintain the homogeneity of the survey. Initially it was decided consider the platform worker as a whole but after a pilot survey, it appears that the requirements of the female worker varies to some extent with their male counter parts and hence kept out of the study at this stage. Both part time and full time workers are selected for the purpose of the study. Further surveys were conducted on the samples who had worked for at least more than six months but less than five years so that they may have a minimum working experience but at the same time may not be that much experience which may influence their thought process with an institutional fatigue and boredom. Based on the above assumptions, total 56 numbers of respondents comprising females, newly joined, respondents working for more than 3 years or more has been kept outside the per view of the study and analyzed on the responses of 402 numbers.

While collecting the requisite information from the samples, both the questionnaire method as well as the interview methods was adopted. Out of total 402 numbers of accepted responses, 315 numbers of responses were administered through questionnaire method and rest 87 numbers were collected through interview method. Data were collected regarding their socio economic, demographic and environmental information covering their income ,hours of work, educations , leave benefits, incentives, compensations, medical benefits, welfare amenities, collective bargaining and statutory protections etc. Initially, a pilot survey was conducted with a sample seize of 30 respondents of Kolkata through field survey. The very purpose of conducting this survey was to find out the major issues affecting the respondents and there by developing the questionnaires for a wider number of respondents. The target domains of this survey were the platform workers operating in three districts of West Bengal. The data were based on the responses coming from different socio-economic and educational level of respondents. Initially, the survey was to be conducting using the technique of simple random sample. This is a process of selection of a group of unit in such a manner that every unit has an equal chance of being included in the sample. However this is a not feasible technique to conduct the survey due to time constrains, low response rate and lack of proper data available. As a result, the survey has to restore ton purposive sampling. In purposive sampling, some restaurants were selected with fair volume of business and the survey was conducted by approaching the delivery partners visiting those restaurants to collect orders. The purposive sample is basically non-probability sample that is selected based on the characteristics of a population and the objectives of the study.

SIGNIFICANCE OF THE STUDY:

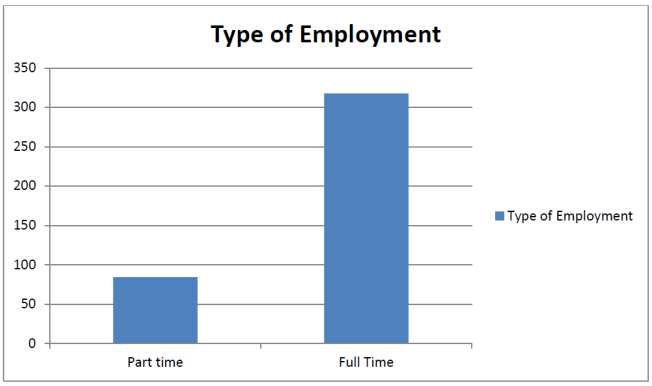
The findings of the study will throw light on the work, working conditions and statutes governing platform workers who are an integral part of the gig economy with special focus on the areas which requires interventions of the state for protecting their rights and terms of employment. The

study will be a thought provoking and pin pointer for any researchers of human resources management, social and juridical sciences.

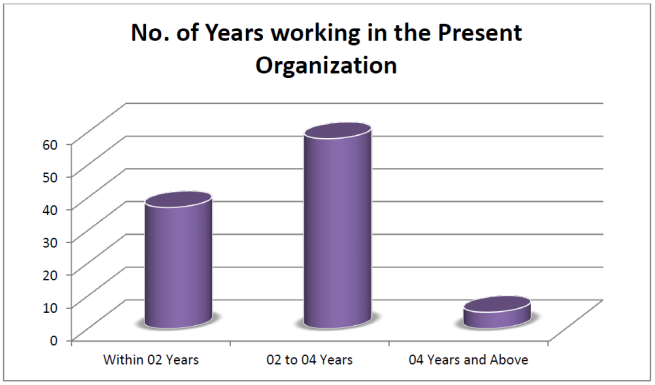
5. RESULTS & ANALYSIS:

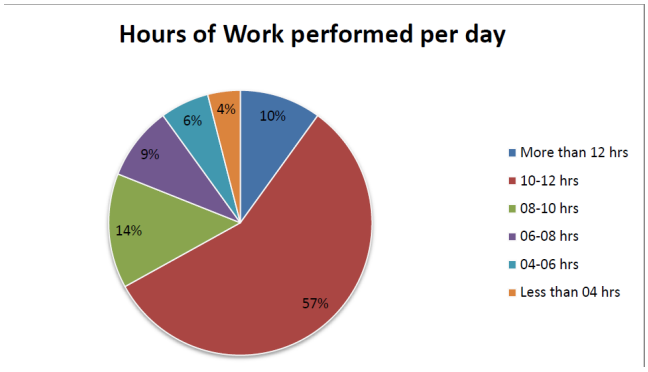
Based on the responses of 402 number of platform workers the discussions are divided into two sections viz:-Work and working conditions, Economic and Social.

A Work and Working Conditions:

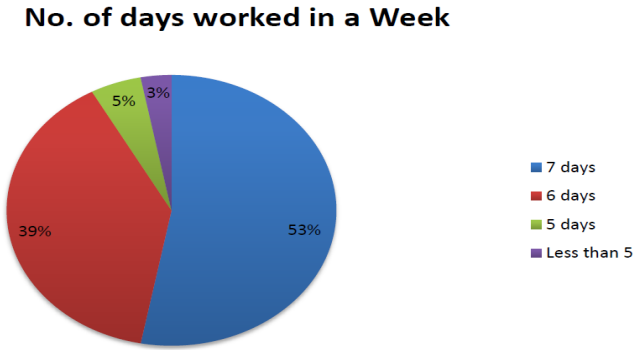


The platform workers were asked about their nature of their employment. 29% of the respondents stated that they are performing the job on per time basis where as for the rest it is taken up on full time basis. Therefore, the work remains as the main source of live hoods for majority of the workers.

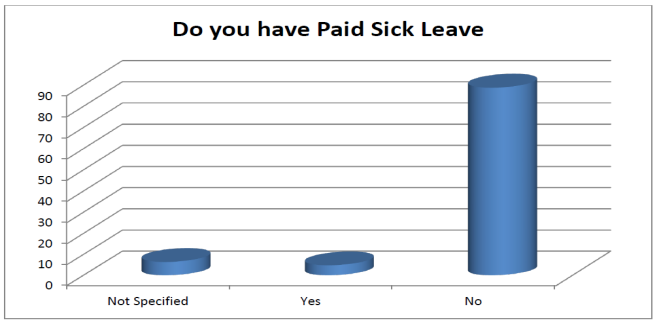




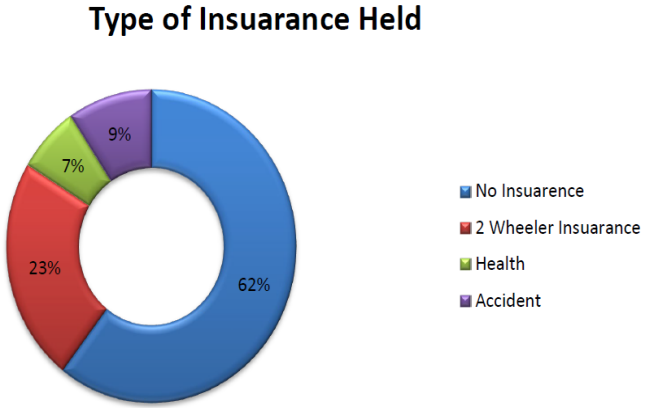
Survey was conducted across platform workers to find out the number of hours they need to sweat every day on road. It reveals that 57% of workers have to work for 10 hours to 12 hours per day while 10% sweat more than 12 hours per day and another 14% works for 8 hours to 10 hours per day. So, on an average 67% of the platform workers have to work more than 10 hours per day. So there working hours is long and the entire time they have to spend mostly on the road.



Another striking feature of the survey is regarding the number of days a platform worker has to work per week. It appears that 53% of worker has to work for all the seven days in a week where another 39% is working for 6 days every week.

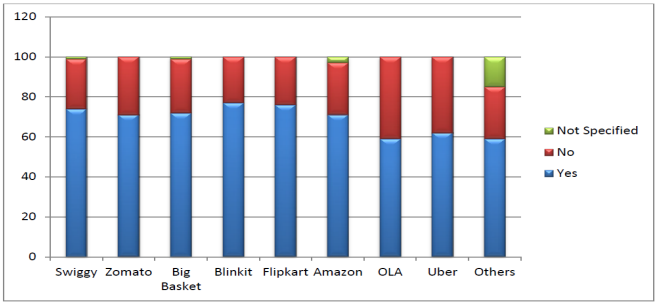


More than 88% of the respondent stated that they are not having any facilities of paid leaves. For 6.4%, respondents, they are not specific. This is another darker side of the gig economy which is coming out from the survey.

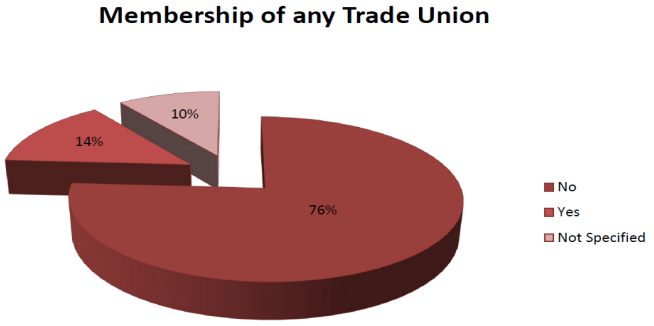


Platform workers in India are by and large not covered with any insurance. The percentage is 62% who do not have any kind of insurance at all. However, the most common form insurance is the motor-bike insurances. Very few number of workers are covered with health or accident insurances.

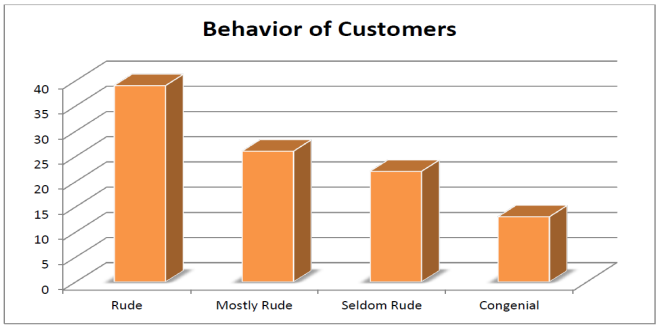
Is Your Qualification in accordance to the work performed?



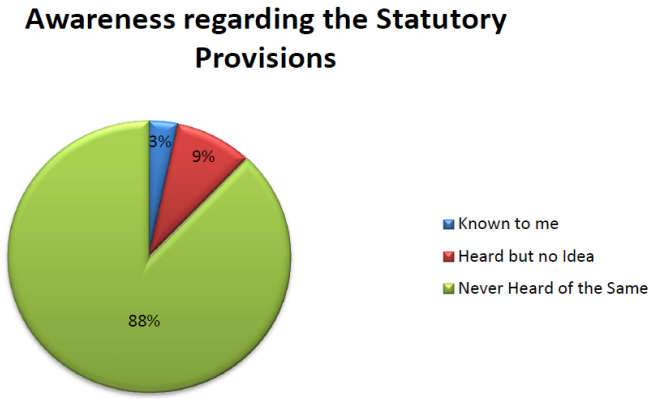
There are different type's qualifications of the platform workers and its range is wide i.e from literate to degree passed respondents. Therefore, the question whether the job remains in accordance to their qualifications remains an important one. In general, majority of the respondents replied that their jobs are in accordance to their qualifications' However, the ride drivers, particularly for OLA & Uber, almost 40% of the respondents felt that their current job is not in accordance with their qualifications.



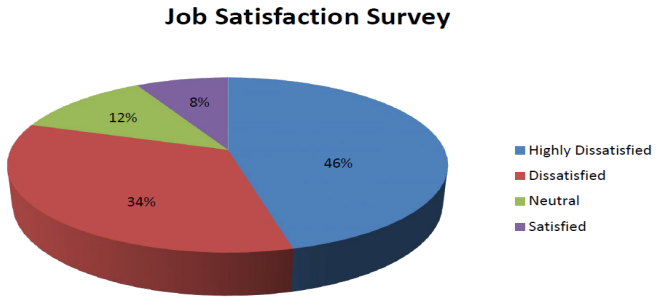
When asked about their affiliations to the Trade Unions formed with the objectives of protecting their rights and interest, 76% of the respondents have denied of having any such membership while 14 % responded of having such affiliations. However, the matter remains non specific to rest 10% of the respondents.



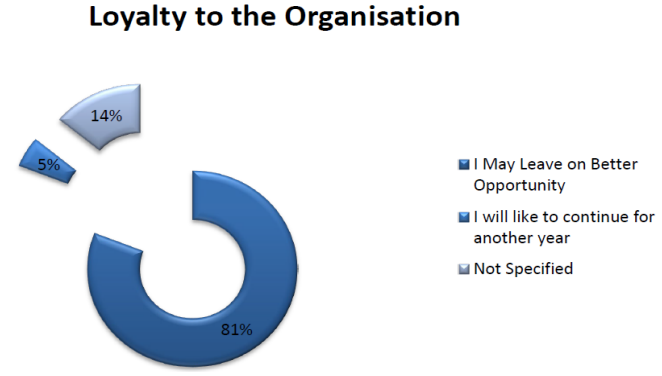
From the above figure it is observed that 65% of the workers encounter rude customer behaviour which further acts as a stress stimulators for them.



Central government has prepared draft Code of Social Security, 2020 with an attempt to include for the first time the definitions of the 'gig' and 'platform' worker. Now, the question remains whether such attempts to reach the platform worker, 88% of the responded have never heard of any such codes. This shows that formulation of act will alone not serve the purpose unless beneficial are made aware of the same.

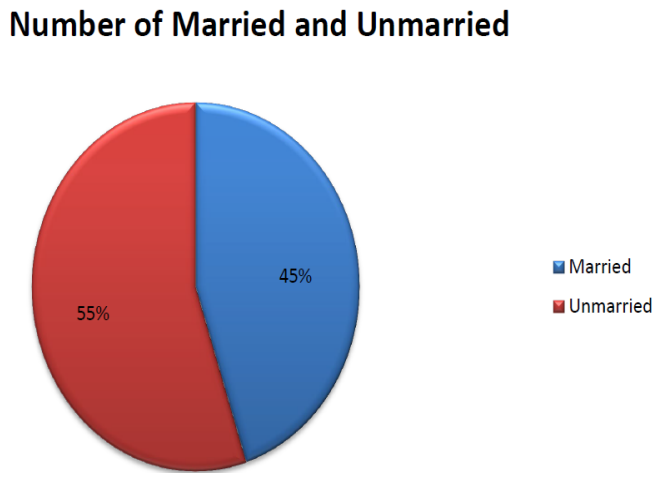


The irony of the fact remains that this blooming section of India's economy appears to be either highly dissatisfied or dissatisfied at their present job. Together the percentage is 80% which is very alarming. Another serious issue is coming up from the study is that a sizeable number of platform workers are belonging to Gen Z section. This high percentage of unsatisfied workforce is a matter great concern to any nation or the society.

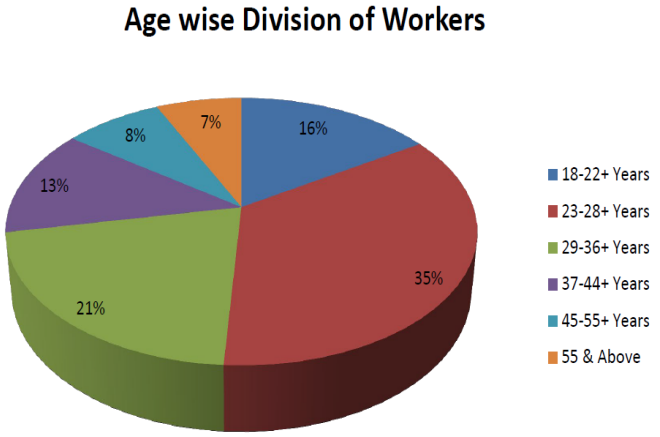


Low earnings, long hours of work, absence of paid leaves from work etc are some of the major reasons for high numbers of dissatisfied workforce. All these have adversely affected the choice of the worker choosing their respective companies as a preferred place to work. It appears that 81% of respondents are ready to leave their existing companies for better opportunities. Another 14% of the respondents are not specific about their choice. So, only 5% of the respondents are appearing to be loyal towards their companies. Further studies revealed that the part time employment who takes up their existing job along with another source of employment is the major constituents among these 5% of loyal respondents.

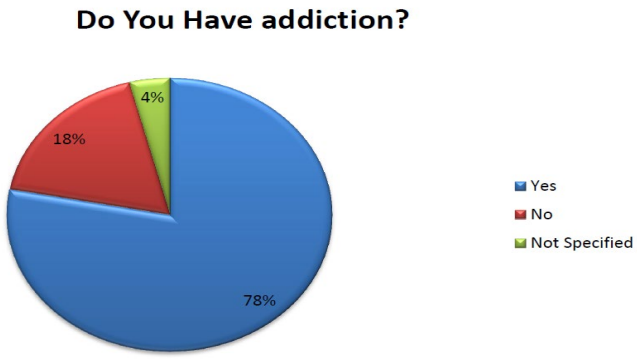
B Social



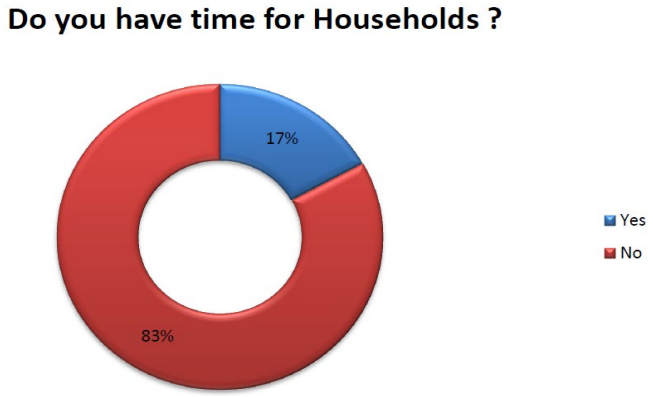
It has been observed that 55% of the workers are un married while rest 45% are married individuals. Further it is observed that since a sizeable number of platform workers are relatively younger in age and are unmarried workers are more than the married individuals.



From the above survey it reveals that 51% of the populations of platform workers are belonging to Gen Z category the percentages are even higher if we consider the millennial or Gen Y populations. So, they are relatively younger in age and their wellbeing have a far reaching consequences in the society.



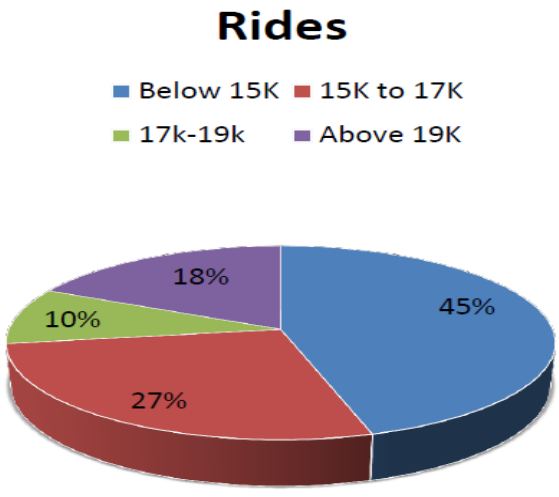
It is revealed from the study that 78% of the respondents are addicted some kind of unhealthy habits which may be cigarette, alcohol, dry addictions etc. Again a worker may be addicted to a single, both or more that two of the unhealthy habits.

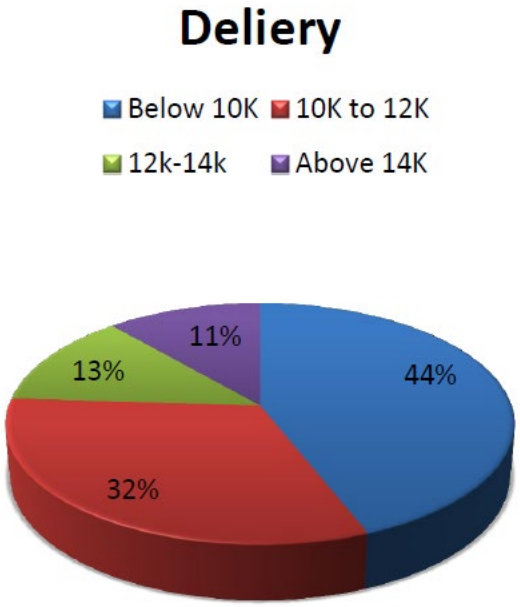


Most of the respondents (83%) have stated that there are hardly any time for them for their families. This is due to the long hours of work and almost for 6 to 7 days of work, there are hard any time for them to their families.

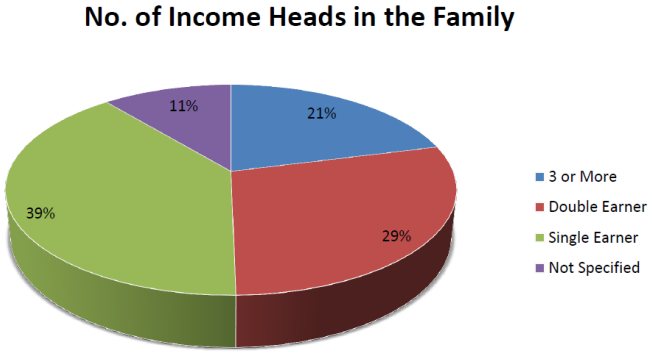
C Economic:

Monthly Income





45% of drivers/riders reported a net monthly earning below Rs 15000 after meeting all the expenses like fuel, EMI, insurance and service charges. Further, survey reveals that unfair fares, commission rates and arbitrary deductions by the aggregator companies are contributing for such low earnings. Similarly it is observed that 44% of the delivery partners are earning below Rs 10,000/- per month. Another striking feature came up during the survey which causes income loss is due to the sudden deactivation of the ID by the platforms on various reasons even without having them properly heard or it may often due to deduction of



When asked about the number of earners in their family, 39.3% of the respondents stated that they are the sole earner where as another 28.7% informed that there are dual earning member in their families. Family wise income structure largely depends on the number of earners of the family. Majority of the respondents are the single earners in their families. Their percentages are 39% while another 29% are double earners and 21% are having three or more earning members in their families. Further, analysis shows that a good number of Gen Z workers belong from double or more earning members. This is because they are younger in age and either their father or spouses are working members.

Platform workers are gets their payments on commission basis depending upon the number of jobs they perform which is mere in amount. So, in order to earn they has to work for long hours. When they were enquired about the overtime payments, majority of them (54.3%) replied that they are being paid as normal and 26% has responded that they are not being compensated.

Tipping could remain another source of income for the platform workers which may supplement their commission earnings to some extent. However, this remains at the discretion of the service clients. It is observed that most of them are being tipped occasionally while for others it is seldom or never. Only for a few instances the workers are being tipped. Further, amongst the respondents who had responded positively about the tipping art working in the field of food delivery partner. For rest it remains as insignificant.

6. FINDINGS

The survey was carried out with the purpose of finding out the socio-economic issues and the issues associated with the working condition of the platform workers working throughout the 5 selected districts of West Bengal.

The summary of the findings may be as follows:

I. Basically younger in age (Gen Z)

II. Low & irregular income

III. Limited bargaining power.

IV. Unclear legal status

V. Lack of health insurance & other insurance

VI. Many of them have developed different addictions.

VII. Absence of paid leaves

VIII. Are subject to penal measures for factors beyond their controls.

IX. Unpredictable &long working hours.

X. No job security

XI. Huge work loads

XII. Lack of time for social lives

XIII. Often subject to the rude behaviours of the customers

XIV. Some time are exposed to violence.

The Code on Social Security, 2020, has proposed social security schemes for gig and platform workers assuring their life and disability coverage, health and maternity benefits, accident insurance, old age protections etc. However, the act is yet to be enforced till date. The government has partially tried to address their problems by putting non binding obligations on the Centre and the States to roll out schemes favouring them. Putting some binding obligations still remains a fade cry.

Reviewing of the policy on Gig Platform workers: There are arguments put forward by the Unions to consider the gig workers as 'Unorganized Workers'. However, the demand for recognizing the gig workers as 'unorganized workers' under the 'Unorganized Workers Social Security Act, 2008' has been filed as PIL by The Indian Federation of App Based Transport Workers (IFAT), bearing case number WP(c) 1068/2021 before the Hon'ble Supreme Court of India for violation of Articles 14, 21 and 23 of the Constitution of India, 1950. The main contention remains that the platform workers attached to the transport and delivery sectors are subject to exploitations in contravention to the provisions of the constitution by their aggregator companies. The matter remains pending before the learned court. Some researchers argued to include the term after amendments in Industrial Dispute Act, 1947. Banerjee, 2023, pointed that India should follow the global standards to create a robust working environment in which the right of the gig workers are protected. India should treat them as employees.

Under a gig economy, workers are both permanent and temporary. Further, many of the platform workers associated with the ride hailing services are the owner of their own vehicles. The basic question remains that in the modern economy, when hire and fire though may not be ethical but still remains a common phenomenon. Start ups companies are now days are significant contributors in the country's economical progress. They prefer gig workers. So, any formal employer- employee's relationship, which is already there in the statutes, may not be an suitable alternatives of the freelance mode.

Therefore, accepting the existence of freelance mode of employment, the issue which need to be redressed at first is ensuring security and welfare of the workers-whatever is their form. And for the successful implementation of the welfare schemes is the arrangement of funds is to be made with a apex monitoring body at the government level. It is basically left with the coordination between the Central government, State governments and to some extent on the aggregators. It is apprehended that there may be chances of shouldering of responsibilities between the government and aggregators may not be willing to shoulder additional financial burden. Therefore the basic purpose of welfare schemes may get vitiated in absence of a clear cut policy.

Another important issue is the mandatory repository of the gig workers at an apex level who are taking part in the country's economic activities. The code provides for setting up facilitators or help line centres to assist gig workers, it has not been mandatory rather left at the discretion of the government. There is no system of any felicitators where gig/platform workers could register themselves or may get any Social Security cards. Then the question of their identity as workers may be even as an unorganized one remains un settled.

The Code of Social security, 2020, propose different Social Security Schemes for the gig/platform and other unorganized workers, did not clearly mentions the respective schemes associated with each of these workers. This may lead to create confusions for the implementing bodies particularly during the initial phase.

Finally, the proposed code is yet to cover the basis human as well as the ethical issues concerning the work and working environments viz. leave with pay, hours of work etc. and to be more specific the issues governing the employment of women workforces, all of which every citizen may expects from a Socialistic State.

7. CONCLUSIONS

The Code on Social Security is the only legal frame where the term 'gig-work' has its reference. It has not ensure the right of forming recognized legal bodies or unions and ensure a minimum wages at the central or state level covering all sorts of employment under the respective jurisdictions. There are no formal grievance escalating mechanisms against the service providers under which they are working. Moreover, they are excluded from the category of 'unorganized workers' or 'wage workers'. Further, the gig workers are debarred from the right of 'collective bargaining'. The above denials are in contravention to the provisions of the principle of fundamental rights under article 14 and 21 and come within the preview of 'forced labour' under article 23 of our constitution.

What might have been the way forward? On light of the survey undertaken, evaluation of the proposed code, major ruling of the courts, in conclusion, the issue may be put up in the following manner as thought provoking for the policy manners:

- A separate law for the gig workers acknowledging their emerging impact in the country's economy.
- A repository to be mandatorily set up at the respective states where aggregators proposed to operate and if operates crossing the boundaries of the state, then at the central level. Union Labour Department to monitor through a dedicated directorate.
- A Welfare Fund to be set up with imposing contributions @fixed ratio from the aggregators. Government to give equal budgetary allocations.
- States to initiate groundwork for defining minimum remunerations for gig workers working with different app-based companies. State labour departments may be monitoring the same.
- Need for adoption of policy so that the aggregators are bound to extend insurance benefits including health and accident coverage.
- Regulating the platform companies.
- The workers may be brought under the preview of any Pension Policy like National Pension Policy taking contribution from the Welfare Fund.
- Training of the worker at a definite span of time covering issues like expenditure habits, social habits, road safety, rights and duties etc.

8. LIMITATIONS

The study was conducted on selected 5 districts of West Bengal, adjacent of Kolkata. The existing study has been kept limited within the male workers. There are a good number of female workers who has got some gender specific issues that has been kept out of the preview of the study at this stage. Moreover, the responses were collected on the app based platform workers. Future studies may be conducted taking both platform and non platform based workers as a whole.

9. RECOMMENDATIONS

Further studies may be conducted covering wider geographical areas which may be through the State or even crossing the boundaries of different States. Another major factor which may draw the attention of their future researches is the study of the female gig workers. There are some gender specific issues associated with them like maternity benefit, safety at work, wash rooms etc. In depth study is required to understand the further issues associated with the female workforce.

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TRACK 3: FINANCE & ACCOUNTING MANAGEMENT

41

PMJDY is a Key Factor to Financial Inclusion

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ABSTRACT

Purpose – The current study aims to examine the effect of awareness and usage benefit, as well as their impact on the well-being of respondents and financial inclusion using the Pradhan Mantri Jan Dhan Yojana (PMJDY) scheme in the Sonepur and Boudh districts.

Design/methodology/approach – The descriptive design is used to explain the demographic profile of the respondents, while the empirical design is used to test the hypothesis at a secondary level. A structured questionnaire is used to acquire primary data from respondents. The survey was carried out between January 2024 to April of 2024. A total of 384 replies were obtained from respondents holding PMJDY accounts in all nine blocks of the Sonepur and Boudh districts. The researcher incorporated statistical tools such Percentage Analysis, Structural Equation Modelling, One way Analysis of Variance, Simple Linear Regression, chi-square test, correlation test and coefficient of variation.

Research limitations/implications – The results of this study open up various possibilities for further investigation. Future researchers would need to explain anomalies in the statistical results of different academicians in the financial inclusion field, as one of the research implications.

Social implications – The current study is an attempt to determine whether the Pradhan Mantri Jan Dhan Yojana scheme has an influence on rural residents in the Sonepur and Boudh districts. The results revealed that the awareness of the benefits provided under the scheme, usage of the scheme's benefits positively influenced the well-being of the beneficiaries. Hence, the current study provides great potential for the government and policymakers to take required measures in promoting financial inclusion in rural parts of Sonepur and Boudh districts, ensuring that these benefits reach the needy people and reduce the income inequality, then uplift them economically and socially.

Originality/value - The study is conducted to investigate empirically whether awareness of the benefits influences beneficiary well-being and whether usage influences beneficiary well-being and reduce the income inequality. The current study helps policymakers and banks improve their service delivery, so that PMJDY account holders can take use of the scheme's benefits, improve their well-being and reduce the income inequality, especially in Sonepur and Boudh districts.

Keywords: **Financial Inclusion, Pradhan Mantri Jan Dhan Yojana, Awareness, Well-being, Income Inequality, Structural Equation Modelling.**

1. INTRODUCTION

Financial inclusion is defined as the process of providing banking and financial solutions and services to all members of society without prejudice. Its primary goal is to integrate everyone in society by providing basic financial services without regard for a person's income or savings. "Financial inclusion primarily focuses on offering dependable financial solutions to economically weak segments of society without discrimination. It strives to offer financial solutions that are free of inequity. It is also committed to being open and honest when providing financial aid with no hidden fees or charges.

Financial inclusion is to involve and involve everyone in society in prudent financial management. There are many poor households in India that do not have access to banking services. They are unaware of the functioning of banks. Even if they are aware of banks, many poor people lack access to their services. They could fail to meet the minimum eligibility criteria established by banks, and hence will be unable to obtain the services of a bank. Banks have minimum income, credit score, age criteria, and years of work experience requirements. A bank is willing to provide a deposit or lend to an applicant if he or she meets these requirements. Many poor people may be unemployed with no prior employment history due to a lack of education, resources, money, and so on. These economically disadvantaged members of society may also lack adequate documents to present to banks for verification of identification or income. Every bank has a set of mandatory documents that must be provided throughout the loan application or account opening process. Many of these folks are unaware of the significance of these texts. They also do not have the ability to apply for government-issued documents.

Financial inclusion attempts to remove these obstacles and give competitively priced financial services to the less fortunate segments of society, so that they can be financially independent without relying on charity or other non-sustainable sources of funds. Financial inclusion also aims to raise public understanding about financial services and

financial management. Furthermore, it intends to create formal and systematic credit outlets for the poor.

Over the last few decades, India has made significant economic progress thanks to a strong banking industry, which is critical to the country's economic well-being. It has taken the lead by engaging in a global effort to reduce extreme poverty, and has transformed itself into one of the world's fastest-growing economies, ranking ninth in terms of progress. Despite all of the efforts made to reap the benefits of progress, unemployment and poverty remain persistent issues. Furthermore, economic and social inequalities have been increasing, resulting in severe regional imbalances and the exclusion of a large portion of the population from basic health and educational facilities (Sagar Patil 2015).

2. STATEMENT OF THE PROBLEM

Roughly 65 percent of Indians reside in rural areas, and the majority are poor members of semi-skilled or unskilled groups working in unorganised sectors. The government and banks have taken various steps via financial inclusion to eliminate poverty and empower the rural poor. Among the various schemes launched, the PMJDY scheme gained traction by opening 310 million accounts and entering the Guinness Book of World Records in a short period of time; however, the same growth rate is not seen in terms of effective utilisation of the benefits offered to PMJDY account holders in rural areas. In most cases, the accounts are dormant; beneficiaries' lack of knowledge of the schemes has kept them dependent on money lenders and excluded them from the formal banking system. This suggests that the scheme's aim did not reach the intended population due to a lack of knowledge and utilisation of the benefits provided by the scheme. As a result, the current study has been recommended to understand the impact of the PMJDY scheme on the well-being of rural people through awareness and utilisation of the scheme's benefits, thus also providing adequate benefits to the beneficiaries and assisting the government and banks in achieving the goal of Financial Inclusion in India.

In light of the aforementioned issues, the researcher has suggested the following questions:

3. RESEARCH QUESTIONS

1. Are the rural people aware of Pradhan Mantri Jan Dhan Yojana Scheme and its benefits?
2. Are all rural people who are aware of the Pradhan Mantri Jan Dhan Yojana scheme taking advantage of its benefits?
3. Does the Pradhan Mantri Jan Dhan Yojana scheme have an impact on well-being of rural people?
4. Does the Pradhan Mantri Jan Dhan Yojana scheme have an impact on reduce income inequality of rural people?

4. OBJECTIVES OF THE STUDY

Major Objective

To investigate the effect of the Pradhan Mantri Jan Dhan Yojana scheme on the well-being of rural people and reduce income inequality in the Sonepur and Boudh districts

Minor Objectives

1. To identify the progress of the financial inclusion through Pradhan Mantri Jan Dhan Yojana scheme.
2. To evaluate the demographic profile and socio-economic status of the respondents using PMJDY scheme in the Sonepur and Boudh districts.
3. To analyse the awareness, usage and impact of the PMJDY scheme based on the demographics of the respondents using the PMJDY scheme.
4. To examine the effect of awareness and usage of the benefits and their effect on the well-being of the respondents using the PMJDY scheme.

To analyse the effect of financial inclusion through Pradhan Mantri Jan Dhan Yojana scheme for minimising the gap of income inequality of the respondents.

5. REVIEW OF LITERATURE

The context and justification for the study done are presented in a chapter called a literature review (Bruce, 1994). The literature review chapter reveals gaps and aids in the development of theoretical and conceptual frameworks as well as the refining, focusing, and structuring of research topics (Coughlan et al., 2007).

(Dhaneesh, Iswarya, Pallavi, Ramachandran, & Vimala, 2022) examined the women's participation in SHG. Low-income women in self-help groups have had the greatest influence on their fashion sense, as well as their families and themselves. They are them as a family, as well as individuals who have grown as members. a sense of belonging. They are linked by mutual aid and self-help. They get together to talk about problems and come up with solutions. In Tamil Nadu, self-help groups are being studied separately from the study of women's emancipation. The project's main focus is on the effects of self-help groups on women's empowerment in Kaveripattinam, Krishnagiri District, Tamil Nadu, and India. The findings show that self-help groups have a positive impact on women's empowerment**.**

(Karthikeyan & Senthilkumar, 2022) analysed Entrepreneurs are regarded as one of the primary forces driving a civilization's economic progress. Entrepreneurs have long been credited with initiating and sustaining social growth. Female entrepreneurship is still a relatively new concept in India. Women are becoming more active in the labour force in India as the country's literacy rate rises. Self-

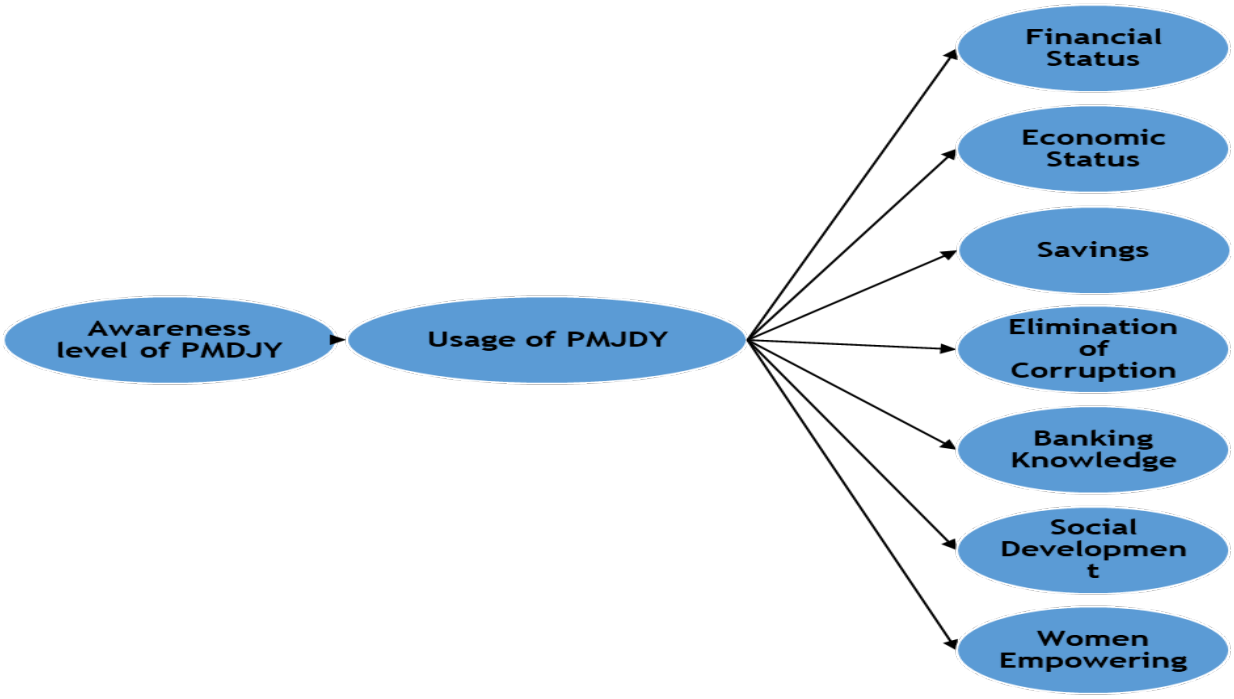
Help Groups (SHGs) have been shown to benefit rural women in several Indian states. In addition to their financial situation, their social standing has improved. This study also includes an overview of self-help groups' (SHGs') efforts to assist scheduled tribes in Tamil Nadu. This article focuses on several issues concerning women entrepreneurs in India, including their problems, challenges, and potential.

(Fathima Thabassum & Afsar Ahmed, 2020) examined micro-finance institutions (MIFs) support the growth of women members of Self Help Groups (SHGs) by providing micro-credit facilities on varied terms and conditions, with or without collateral. This study included members of SHGs from tribal communities in the Yelagiri Hills in the Vellore District of Tamil Nadu, India. Exploratory factor analysis revealed five factors: an improvement in life quality, personality development, social conditions improvement, investment opportunities, and debt repayment. Multiple regression analysis reveals that improvements in life quality, personality development, and social enhancement influence tribal women's social upliftment in SHGs through microfinance.

(Goel & Madan, 2019) investigated how "financial inclusion, as well as other factors such as familial circumstances, benchmarking, entrepreneurial motivation, and entrepreneurial intention, influence women's decision to pursue entrepreneurship as a career. Financial inclusion has a statistically significant effect on women's entrepreneurship, according to the study's findings. It provides a platform for women to start new businesses. In the future, data from various Indian regions can be collected to help generalise the study's findings. The government has implemented a number of initiatives to encourage women to start their own businesses. societal ramifications After conducting the research, the author concluded that society will accept the fact that women entrepreneurs are becoming an urgent national necessity.

6. RESEARCH GAP

According to previous studies, the numerous variables employed to analyse the influence of financial inclusion and the socioeconomic level of the beneficiaries have been assessed using the same relevant statistical procedures. However, no attempt has been made to investigate the impact of awareness and utilisation of the PMJDY scheme's benefits on the well-being of Jan Dhan account holders in Soneur and Boudh Districts. As a result, a conceptual framework is being developed.



Showing Conceptual framework of the Research gap identified

In the absence of comprehensive studies assessing the impact of the PMJDY scheme among Jan Dhan account holders in Sonepur and Boudh Districts, the researcher used a conceptual framework to determine whether awareness of the benefits affects well-being (Financial Status, Economic Status, Savings, Elimination of Corruption, Banking Knowledge, Social Development and Women Empowerment) or use of those benefits affects well-being in rural areas of Sonepur and Boudh districts and also how this PMJDY scheme helps to reduce the income inequality between the rural people in Sonepur and Boudh districts. As a result, the current study provides great potential for the

government and policymakers to take required measures in promoting financial inclusion in rural parts of Sonepur and Boudh districts, ensuring that these benefits reach the needy people and uplift them economically and socially.

7. NATURE AND SCOPE OF THE STUDY

The current study aims to examine the effect of awareness and usage benefit, as well as their impact on the well-being of respondents using the PMJDY scheme in the Sonepur and Boudh districts. The research is confined to the Sonepur and Boudh Districts of Odisha and focused on Pradhan Mantri Jan Dhan Yojana initiated by the Government of India. Therefore, the other schemes launched by the State Government of Odisha are not considered. The target population for study is rural people having PMJDY bank accounts in different branches of banks situated in the six blocks of Sonepur and three blocks of Boudh Districts.

8. RESEARCH DESIGN & METHODOLOGY

The present study includes two research designs. The descriptive design is used to explain the demographic profile of the respondents, while the empirical design is used to test the hypothesis at a secondary level.

9. SOURCES OF DATA COLLECTION

Primary and secondary data are used in the study.

10. PRIMARY DATA

A structured questionnaire is used to acquire primary data from respondents. The survey was carried out between January 2024 to April of 2024. A total of 384 replies were obtained from respondents holding PMJDY accounts in all nine blocks of the Sonepur and Boudh districts. Respondents were extremely cooperative in providing data.

11. SECONDARY DATA

Secondary data was gathered in order to develop a theoretical framework and identify research needs by examining previous publications. Secondary data was acquired from RBI websites, the PMJDY scheme's official website, and research websites like as Google Scholar, SSRN, Research Gate, and others.

Sampling Method Adopted

The researcher used the Simple Random Sampling approach in the current study because it gives each participant an equal chance of being chosen and provides an accurate representation of a huge population. The researcher identified the potential PMJDY account holders, which a sample comprising of 384 was drawn from a total population of 10,51,345 (Sonepur-6,10,183 + Boudh-4,41,162) PMJDY account holders from all nine blocks of Sonepur and Boudh Districts (6 blocks from Sonepur + 3 blocks from Bouth) as per 2011 census.

12. SAMPLING FRAME

The statistical data provided by https://www.censusindia2011.com/ was considered as a frame for selection of sample in the study.

Sonepur is a district in the Indian state of Odisha. Sonepur is well-known for its diverse cultural heritage, arts, and crafts. Sonepur's textiles, Tarva and Binka's brass metal works and philigri crafts, Ulunda's stone carving, and Dunguripali's paddy crafts have all gained international acclaim. The district is divided into two subdivisions, Subarnapur and Birmaharajpur, and six tahasils, Sonepur, Binka, Rampur, Ulunda, Tarava, and Birmaharajpur. Sonepur district consists of 6 Blocks, 962 villages, and 4 cities. According to Census India 2011, Sonepur district has 1,51,136 houses and a population of 6,10,183 people, with 3,11,312 males and 2,98,871 females.

The number of children aged 0 to 6 is 74,821, accounting for 12.26% of the total population. Sonepur district has a sex ratio of roughly 960, compared to the state average of 979. Sonepur district has a literacy rate of 65.3%, with 74.01% of men and 56.22% of females being literate. Sonepur has a total area of 2337 square kilometres and a population density of 261 per square kilometres. 91.82% of the entire population resides in cities, while 8.18% lives in rural areas. Sonepur district has a population of 25.6% Scheduled Caste (SC) and 9.37% Scheduled Tribe (ST).

Boudh is a district in the Indian state of Odisha. The Boudh district's economy is predominantly agriculture. Fishing and livestock husbandry also provide significant contributions to the economy. Small-scale industries, particularly textiles and mining, are also thriving in the Boudh district's economic scenario. Paddy is the main crop, accounting for around 75% of total cultivated land area. Boudh district is made up of three Blocks, 1182 villages, and one town. According to Census India 2011, the Boudh district has 1,06,961 houses and a population of 4,41,162 people, with 2,21,625 males and 2,19,537 females.

The number of children aged 0 to 6 is 61,847, accounting for 14.02% of the total population. Boudh district has a sex ratio of roughly 991, compared to the state average of 979. Boudh district has a literacy rate of 61.57%, with 71.58% of males and 51.46% of females being literate. Boudh has a total size of 3,098 square kilometres and a population density of 142 people per square kilometres. 95.37% of the total population resides in cities, while 4.63% lives in rural areas.

Boudh district has a total population of 23.79% Scheduled Caste (SC) and 12.55% Scheduled Tribe (ST). The researcher limited the sample to rural and semi-urban areas to generalise the study's targeted population. All nine blocks of Sonepur and Boudh Districts covered by financial inclusion were chosen, and a sample was drawn from each block.

13. SAMPLING UNIT

People living in all nine blocks of Sonepur and Boudh Districts who are PMJDY scheme participants were chosen as a sample unit for the current study.

14. SAMPLE SIZE

With the known population, the sample size is determined for the study using the formula of Smith, Scott (2013). From the known total population of 10,51,345 (Sonepur-6,10,183 + Boudh-4,41,162) with ±5 percent margin of error and confidence level 95 per cent with population of 50 per cent, 384 sample size is selected for the present study. Therefore, using the above formula and considering the sample size of 384, 230 PMJDY account holders from Sonepur District and 154 PMJDY account holders from Boudh District are chosen for the present study.

15. DATA COLLECTION INSTRUMENTS

A structured questionnaire is designed in such a way that it aids in the attainment of the study's goal while also making it easy and convenient for respondents to respond. A structured questionnaire facilitates analysis and interpretation and aids in reaching appropriate conclusions. Before constructing the questionnaire, the researcher directly interviewed 25 people to determine their level of awareness of the programme and its benefits, and a series of meetings with retired bank managers was also undertaken to gain a better understanding of the scheme.

Showing generation of variables to study the Awareness level and usage benefit of the PMDJY Scheme

Sl. No.	Variables	No. of items	Sources
1	Awareness level of the Benefits of PMDJY scheme PMDJY scheme	9	Yashika Guleria & O.P. Verma (2018) Prachi (2018
2	Usage of the PMDJY scheme	9	
3	Reduction in Income Inequality after implementing PMDJY scheme	9	Amiel, Y., & Cowell, F. A. (1992)

Showing generation of variables to study the Well-being of the respondents who are using PMJDY Scheme

Sl. No.	Variables	No. of items	Sources
1	Financial Status	7	Yashika Guleria & O.P. Verma (2018) Prachi (2018)
2	Economic Status	7	
3	Savings	5	
4	Elimination of Corruption	5	
5	Banking Knowledge	7	
6	Social Development	7	
7	Women Empowerment	5	

16. RELIABILITY AND VALIDITY

Cronbach's "Alpha was used to evaluate the consistency and legitimacy of each variable in the questionnaire. The test achieved an Alpha Value, suggesting that the data collected for the pilot project is sufficiently reliable to collect a large sample for the study. In PLS-SEM, composite reliability is preferred rather than Cronbach's alpha to evaluate the measurement model's internal consistency reliability. The composite reliability of the Constructs Awareness PMJDY, Usage PMDJY, FS, ES, S, EC, BK, SD, WE and RII are found to be 0.915, 0.879, 0.927, 0.903, 0.904, 0.910, 0.916, 0.909, 0.895 and 0.873 respectively replicating their higher levels of internal consistency reliability. Prior research suggests that a threshold level of 0.60 or higher is required to demonstrate a satisfactory composite reliability in research, but that should not exceed the 0.95 level (Hair et al., 2013).

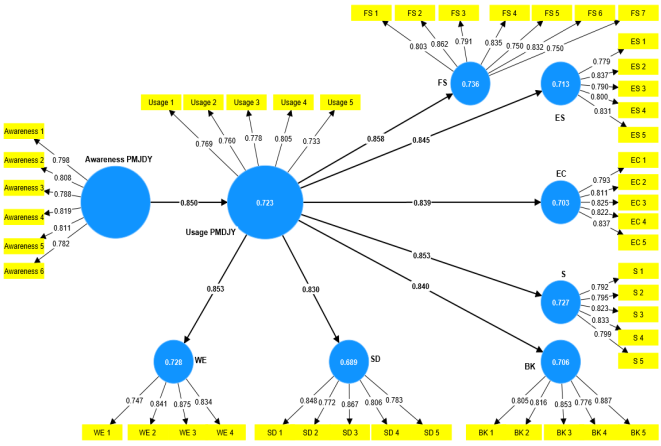
Cronbach's Alpha for Likert Scale Items

Dimension	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average Variance Extracted (AVE)
Awareness PMJDY	0.888	0.889	0.915	0.642
Usage PMDJY	0.827	0.828	0.879	0.592
RII	0.901	0.809	0.837	0.636
FS	0.908	0.909	0.927	0.647
ES	0.866	0.866	0.903	0.652
S	0.868	0.868	0.904	0.654
EC	0.876	0.878	0.910	0.669
BK	0.885	0.886	0.916	0.686
SD	0.874	0.875	0.909	0.666
WE	0.843	0.848	0.895	0.681
RII	0.817	0.856	0.873	0.672

Statistical tools used in the study

Percentage Analysis, Partial Least Square - Path Modelling (PLS-PM), One way Analysis of Variance, Chi-Square Test and Coefficient of variation.

Findings - Path Coefficient and R^2 using PLS-SEM



17. DISCUSSION AND FINDING OF THE STUDY

The structural model Collinearity is tested with the evaluation based on the inner model VIF values. Here all the VIF values falls below the threshold values. This indicates there is no indication of Collinearity between latent constructs.

The path coefficients values of Awareness PMJDY -> Usage PMDJY, Awareness PMJDY -> FS, Awareness PMJDY -> ES, Awareness PMJDY -> S, Awareness PMJDY -> EC, Awareness PMJDY -> BK, Awareness PMJDY -> SD, Awareness PMJDY -> WE, Usage PMDJY -> BK, Usage PMDJY -> EC, Usage PMDJY -> ES, Usage PMDJY -> FS, Usage PMDJY -> S, Usage PMDJY -> SD and Usage PMDJY -> WE, which falls closer to +1 are considered as a strong positive relationship.

Awareness PMJDY -> Usage PMDJY, Awareness PMJDY -> FS, Awareness PMJDY -> ES, Awareness PMJDY -> S, Awareness PMJDY -> EC, Awareness PMJDY -> BK, Awareness PMJDY -> SD, Awareness PMJDY -> WE, Usage PMDJY -> BK, Usage PMDJY -> EC, Usage PMDJY -> ES, Usage PMDJY -> FS, Usage PMDJY -> S, Usage PMDJY -> SD and Usage PMDJY -> WE, of the structural models relationships are significant and confirming our various hypotheses about the construct relationships.

Usage PMDJY -> FS, Usage PMDJY -> S, Usage PMDJY -> WE, Awareness PMJDY -> Usage PMDJY, Usage PMDJY -> ES, Usage PMDJY -> BK, Usage PMDJY -> EC, Usage PMDJY -> SD, Awareness PMJDY -> FS, Awareness PMJDY -> WE, Awareness PMJDY -> S, Awareness PMJDY -> ES, Awareness PMJDY -> BK, Awareness PMJDY -> EC, Awareness PMJDY -> SD, paths are found to be significant with 95% level of significance with a P value of 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, and 0.000 respectively. Hence the research hypotheses are supported.

The path linking Usage PMDJY -> FS exhibits the highest t value of 18.809, followed by Usage PMDJY -> WE with the second highest value of 18.468 were significant. This is followed by the other paths such as Usage PMDJY -> ES with 18.369, Usage PMDJY -> S with 18.215, Usage PMDJY -> EC with 18.123, Usage PMDJY -> BK with 18.036, Usage PMDJY -> SD with 17.932, Awareness PMJDY -> Usage PMDJY with 17.280, Awareness PMDJY -> FS with 9.299, Awareness PMDJY -> ES with 9.257, Awareness PMDJY -> WE with 9.193, Awareness PMDJY -> S with 9.173, Awareness PMDJY -> EC with 9.172, Awareness PMDJY -> SD with 9.149 and Awareness PMDJY -> BK with 9.104 were also found to be significant.

Awareness of PMJDY significantly influences Usage of PMDJY, Awareness PMJDY significantly influences FS, Awareness PMJDY significantly influences ES, Awareness PMJDY significantly influences S, Awareness PMJDY significantly influences EC, Awareness PMJDY significantly influences BK, Awareness PMJDY significantly influences SD, Awareness PMJDY significantly influences WE, Usage PMDJY significantly influences FS, Usage PMDJY significantly influences ES, Usage PMDJY significantly influences S, Usage PMDJY significantly influences EC, Usage PMDJY significantly influences BK, Usage PMDJY significantly influences SD and Usage PMDJY significantly influences WE.

The FS predicts higher accuracy of 0.736, followed by WE with 0.728, S with 0.727, Usage PMDJY with 0.723, ES with 0.713, BK with 0.706, EC with 0.703 and SD with 0.689.

In Case 1, For Usage PMDJY as an Exogenous Variable with BK, EC, ES, FS, S, SD and WE as Endogenous variables, BK has a F2 value of 2.405, EC with a F2 value of 2.370, FS has a F2 value of 2.488, S has a F2 value of 2.786, S has a F2 value of 2.665, SD has a F2 value of 2.218 and WE has a F2 value of 2.679. Which implies that usage PMDJY has a medium impact on BK, EC, ES, FS, S, SD and WE. In Case 2, For Usage PMDJY as an Endogenous Variable with Awareness PMJDY as Exogenous variables, Awareness PMJDY has a F2 value of 2.612. Which implies that Awareness PMJDY has medium impact on Usage PMDJY.

Running the blindfolding procedure with omission Distance (D) value =7, the Q2 values of 0.000, 0.423, 0.470, 0.461, 0.472, 0.464, 0.479, 0.455 and 0.493 for Awareness PMJDY, Usage PMDJY, FS, ES, S, EC, BK, SD and WE respectively, Which is found to be greater than zero. This indicates our path model's predictive relevance is high.

The HTMT values for the path between Awareness PMJDY and Usage PMJDY is 0.866, Awareness PMJDY and BK is 0.819, Awareness PMJDY and EC is 0.620, Awareness PMJDY and ES is 0.864, Awareness PMJDY and FS is 0.829, Awareness PMJDY and S is 0.526, Awareness PMJDY and SD is 0.826, Awareness PMJDY and WE is 0.638, Usage PMJDY and BK is 0.0.658, Usage PMJDY and EC is 0.763, Usage PMJDY and ES is 0.811, Usage PMJDY and FS is 0.867, Usage PMJDY and S is 0.747, Usage PMJDY and SD is 0.875, Usage PMJDY and WE is 0.727.

The SRMR value was found to be 0.047 for saturated model and 0.062 for estimated model in this research. Thus it satisfies the condition and thereby reflects a Goodness of Fit for the model. The RMS_{theta} is found to be 0.114 in this research model, which is below 0.120. This infers the model is with Good Fit index. The indirect effect of Awareness PMJDY -> Usage PMDJY -> FS found to be with a β value of 0.729, t value of 9.299 and p value of 0.000, which is found to be significant. Hence, Usage PMDJY significantly mediates the relationship between Awareness PMDJY and Financial Status (FS).

Indirect effect of Awareness PMJDY -> Usage PMDJY -> FS found to be with a β value of 0.729, t value of 9.299 and p

value of 0.000, which is found to be significant. Hence, Usage PMDJY significantly mediates the relationship between Awareness PMDJY and Financial Status (FS). Indirect effect of Awareness PMJDY -> Usage PMDJY -> ES found to be with a β value of 0.718, t value of 9.257 and p value of 0.000, which is found to be significant. Hence, Usage PMDJY significantly mediates the relationship between Awareness PMDJY and Economic Status (ES). Indirect effect of Awareness PMJDY -> Usage PMDJY -> S found to be with a β value of 0.725, t value of 9.173 and p value of 0.000, which is found to be significant. Hence, Usage PMDJY significantly mediates the relationship between Awareness PMDJY and Savings (S). Indirect effect of Awareness PMJDY -> Usage PMDJY -> EC found to be with a β value of 0.713, t value of 9.172 and p value of 0.000, which is found to be significant. Hence, Usage PMDJY significantly mediates the relationship between Awareness PMDJY and Elimination of Correction (EC). Indirect effect of Awareness PMJDY -> Usage PMDJY -> BK found to be with a β value of 0.715, t value of 9.104 and p value of 0.000, which is found to be significant. Hence, Usage PMDJY significantly mediates the relationship between Awareness PMDJY and Banking Knowledge (BK). Indirect effect of Awareness PMJDY -> Usage PMDJY -> SD found to be with a β value of 0.706, t value of 9.149 and p value of 0.000, which is found to be significant. Hence, Usage PMDJY significantly mediates the relationship between Awareness PMDJY and Social Development (SD). Indirect effect of Awareness PMJDY -> Usage PMDJY -> WE found to be with a β value of 0.726, t value of 9.193 and p value of 0.000, which is found to be significant. Hence, Usage PMDJY significantly mediates the relationship between Awareness PMDJY and Women Empowerment (WE).

The results revealed that model fit is insignificant, as the probability value does not meet the appropriate statistical criteria at 5% level of significance (Sig. > 0.05). A high significance value (Sig. 0.114>0.05) of greater than 0.05 for occupation of the respondent indicated that there is an insignificant impact of occupation of the respondent on overall income inequality is reduced after implementing financial inclusion through PMJDY scheme. Therefore, the research hypothesis is rejected. The researcher concluded from the statistical analysis that overall income inequality reduced after implementing financial inclusion through PMJDY scheme is not influenced by occupation of the respondent.

The results revealed that model fit is significant, as the probability value meets the appropriate statistical criteria at 5% level of significance (Sig. < 0.05). A low significance value (Sig. 0.000<0.05) of less than 0.05 for monthly income of the respondent indicated that there is an significant impact of monthly income of the respondent on overall income inequality is reduced after implementing financial inclusion through PMJDY scheme. Therefore, the research hypothesis is accepted. The researcher concluded from the statistical analysis that overall income inequality reduced after implementing financial inclusion through PMJDY scheme is influenced by monthly income of the respondent.

The results revealed that model fit is significant, as the probability value meets the appropriate statistical criteria at 5% level of significance (Sig. < 0.05). A low significance value (Sig. 0.000<0.05) of less than 0.05 for well-being of the respondent indicated that there is an significant impact of well-being of the respondent on overall income inequality is reduced after implementing financial inclusion through PMJDY scheme. Therefore, the research hypothesis is accepted. The researcher concluded from the statistical analysis that overall income inequality reduced after implementing financial inclusion through PMJDY scheme is influenced by well-being of the respondent.

The results revealed that model fit is significant, as the probability value meets the appropriate statistical criteria at 5% level of significance (Sig. < 0.05). A low significance value (Sig. 0.000<0.05) of less than 0.05 for usage benefit of PMDJY of the respondent indicated that there is an significant impact of usage benefit of PMDJY of the respondent on overall income inequality is reduced after implementing financial inclusion through PMJDY scheme. Therefore, the research hypothesis is accepted. The researcher concluded from the statistical analysis that overall income inequality reduced after implementing financial inclusion through PMJDY scheme is influenced by usage benefit of PMDJY of the respondent.

18. CONCLUSION

The nation's economic growth rate serves as an indicator for reducing poverty. In India, 23 crores of the people live in multidimensional poverty, according to the 'Global Multidimensional Poverty Index' 2022 report. The Indian government has made real attempts to end poverty in India, and in order to carry out this aim, the government has been launching different financial inclusion schemes. Only once the underprivileged group in society is formally admitted to the financial system will the nation's overall growth be seen. The goal of the current study is to evaluate whether the Pradhan Mantri Jan Dhan Yojana has achieved its stated goal by highlighting how it has affected rural residents in the Sonepur and Boudh rural districts.

According to the demographic profile of the respondents, the majority of respondents have not completed their education and agree that there are no financial facilities in their areas. They opened bank accounts because there was no minimum balance requirement and most of them received interest on their deposits. The respondent's family received life insurance benefits in a relatively tiny percentage of cases.

According to the research, female recipients were better knowledgeable about the benefits than male beneficiaries.

Compared to responders from other age groups, those between the ages of 20 and 40 were the most aware of the advantages and the most benefited. In line with this, those who have not completed schooling were more aware of the advantages of PMJDY scheme. Compared to other employees, self-employees were more aware of the benefits and utilised them more efficiently. However, those making under Rs. 5,000 a month were better informed and significantly impacted in term of usage of PMJDY scheme.

The SEM analysis proved that the awareness has contributed to more than 70% on the well-being of the respondents and the usage of the schemes has contributed more than 80%. The study also concluded that, among the various factors the awareness has contributed to 73% towards the well-being of the respondents through financial status and 86% has contributed towards the usage of the scheme among the respondents. The mediation study revealed that awareness has an effect on respondents' well-being; additionally, beneficiaries' well-being will be influenced by awareness combined with use of the PMJDY scheme's benefits.

The Simple Linear Regression test proved that there is a significant impact of monthly income, well-being and usage benefit of PMDJY of the respondent on overall income inequality is reduced after implementing financial inclusion through PMJDY scheme. The researcher concluded from the statistical analysis that overall income inequality reduced after implementing financial inclusion through PMJDY scheme is influenced by monthly income, well-being and usage benefit of PMDJY of the respondent. In emerging Odisha, increasing financial inclusion or decreasing involuntary financial inclusion reduces inequality in the economy. More efforts must be done to address the financial exclusion of low-income groups from financial services in order to further reduce inequality in income. In this environment, financial inclusion programmes that assist alleviate poverty will also address the region's growing income inequality.

As a result, the study demonstrated that both awareness and usage must go hand in hand in order to have an impact on the well-being of the beneficiaries while also achieving the goal of the PMJDY plan. Researchers learn from the study that the impact of the PMJDY programme on rural people allows policymakers to adopt additional steps based on the findings.

19. LIMITATIONS OF THE STUDY

a. Due to time, resource, and financial limitations, the current research is only focused on the Sonepur and Boudh Districts.

b. Since the study's focus was on rural areas, 384 respondents could be included in the sample; additionally, only 25 interviews could be conducted per day with the respondents.

c. Another challenge to the study is language; because the majority of the respondents are not fluent in English, the researcher was only able to conduct interviews with them in their native tongue.

d. The Pradhan Mantri Jan Dhan Yojana project, which was launched by the Government of India, is the only one the researcher has selected for the study.

e. The indirect benefits that beneficiaries obtained under the programme were left out of the study because the current research primarily focused on the direct benefits that recipients received under the system.

20. SCOPE FOR FURTHER RESEARCH

a. Attempts could be made to conduct the current study in other districts of Odisha and other Indian states to see whether the same results are obtained.

b. The long-term influence of financial inclusion and income inequality on Odisha region's economic growth.

c. The research can cover the multidimensional financial inclusion index for the state of Odisha, with a focus on employing technology as a dimension for the financial inclusion indicator and income inequality.

d. Efforts to analyse the response of a state's urban and rural populations to financial service utilisation.

e. The study can be expanded to similar rural areas in India, bringing a huge number of people into the purview of PMJDY initiatives.

f. Under financial inclusion, the research can cover other governmental programmes aimed at developing the disadvantaged portions of society.

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Integrating Sustainability into Business Models: The Role of Innovation and Social Responsibility in Entrepreneurship

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ABSTRACT

In the face of pressing global challenges such as climate change, resource depletion, and social inequality, sustainability has become a central concern for modern businesses. Entrepreneurs, as key drivers of innovation and change, play a pivotal role in integrating sustainability into their business models. This research explores how entrepreneurs are leveraging innovation and social responsibility to create businesses that contribute not only to financial success but also to the well-being of society and the environment. Through in-depth interviews with 18 entrepreneurs from diverse industries, this qualitative study examines how sustainability is embedded into business operations and how it influences entrepreneurial decision-making. The findings highlight that innovation is crucial in developing sustainable products, services, and processes that address environmental concerns while providing economic value. Additionally, social responsibility was identified as a key factor in promoting ethical practices, improving stakeholder relations, and enhancing brand loyalty. The research also underscores the challenges entrepreneurs face, including initial costs, regulatory complexities, and the need for specialized knowledge. Despite these obstacles, the study reveals that businesses that prioritize sustainability experience long-term benefits, such as enhanced customer loyalty, market differentiation, and cost savings. The paper concludes by emphasizing the importance of viewing sustainability as a long-term strategy rather than a short-term obligation. Policymakers are encouraged to support sustainable entrepreneurship by providing incentives and resources to help businesses integrate sustainability into their operations. The study offers valuable insights for entrepreneurs, business leaders, and policymakers seeking to foster a more sustainable and inclusive future.

Keywords: Sustainability, Innovation, Social Responsibility, Entrepreneurship, Business Models.

1. INTRODUCTION

In today's world, sustainability has become a crucial part of how businesses operate. The planet is facing many challenges, such as climate change, the depletion of natural resources, and growing social inequalities. As a result, businesses are being urged to rethink their traditional models and find ways to reduce their negative impact on the environment and society. Entrepreneurs are at the forefront of this change, playing a key role in making their businesses more sustainable. Entrepreneurs have the power to integrate sustainability into their companies by focusing on two main aspects: innovation and social responsibility. Innovation involves creating new products, services, and ways of doing business that not only help protect the environment but also support the well-being of people. For example, businesses can design products that are made from renewable materials or develop new technologies that reduce energy use. At the same time, social responsibility means that businesses should care about more than just making money. They need to make decisions that benefit society as a whole. This can include actions like treating workers fairly, supporting local communities, reducing waste, or using ethical sourcing practices. Social responsibility encourages businesses to focus on the long-term health of the planet and its people, rather than short-term profits. This research aims to explore how entrepreneurs are bringing sustainability into their business practices by using innovation and social responsibility. It will examine the importance of these two factors for the long-term success of businesses. Additionally, the study will look at how these practices can lead to positive outcomes for both the environment and society, creating a business model that works for everyone, not just for the company itself. Das (2024) emphasizes the importance of innovative business models and strategies in fostering sustainability, highlighting how entrepreneurs can drive change through creative solutions that balance environmental, social, and economic factors. This aligns with the focus of the current research, which explores how innovation and social responsibility are essential for building sustainable business practices.

2. REVIEW OF LITERATURE

The concept of sustainability in business has evolved significantly over time. Initially, the focus was primarily on environmental concerns, but over the years, sustainability has grown to encompass social and economic dimensions as well. Today, sustainability is recognized as a holistic approach that integrates environmental protection, social equity, and economic growth into business strategies. This section explores key themes and frameworks in sustainability, particularly focusing on innovation and social responsibility within entrepreneurship. Sustainability in business refers to practices that seek to ensure that companies operate in a way that is ecologically sound, socially responsible, and economically viable over the long

term. The notion of sustainability has been around for decades, but it has undergone significant changes. Early sustainability efforts primarily focused on reducing environmental harm. Companies were asked to minimize pollution, conserve resources, and reduce waste. In recent years, however, the scope of sustainability has expanded to include social and economic concerns, especially as awareness about global challenges like climate change, poverty, and inequality has increased. Sustainable business practices now involve balancing economic growth with the well-being of society and the environment. As companies have increasingly recognized their role in addressing social issues, the role of entrepreneurship in fostering sustainability has grown more critical. The most influential framework that emerged in this evolution is the Triple Bottom Line (TBL), developed by John Elkington in 1997. TBL introduced a comprehensive approach to sustainability, suggesting that businesses should not only focus on profits but should also consider their impact on people (social), the planet (environment), and their profits (economic). The three pillars of TBL—People, Planet, and Profit—are central to modern sustainability initiatives and have been widely adopted by businesses worldwide. TBL emphasizes the need for businesses to measure and report their performance in these three areas rather than focusing solely on financial outcomes (Elkington, 1997). TBL has had a lasting influence on business practices and has guided companies in adopting sustainable practices. It has shifted the perspective of business leaders from short-term profits to long-term value creation. Today, businesses are increasingly expected to demonstrate accountability in their environmental, social, and economic impacts, and sustainability is often integrated into corporate strategy. Innovation has long been viewed as a core driver of business success. However, in recent years, innovation has also emerged as a tool to drive sustainability. Sustainable innovation refers to the development of new products, services, or processes that not only contribute to economic performance but also address environmental and social challenges. Unlike traditional innovation, which focuses primarily on improving profitability or increasing market share, sustainable innovation integrates social and environmental considerations into the core of business strategy. Scholars and practitioners argue that sustainable innovation is necessary for creating business models that thrive in a changing world. Schaltegger, Hansen, and Ludeke-Freund (2016) emphasize that innovation can lead to environmental and social value while providing economic benefits. For instance, companies that innovate by using renewable energy, designing eco-friendly products, or developing green technologies are contributing to environmental protection while opening up new markets for their products. Sustainable innovation can take various forms, including product innovation, process innovation, and business model innovation. Product innovation involves creating products that are less harmful to the environment and society. For example, the development of electric vehicles, solar panels, and biodegradable packaging are all examples of product innovations that contribute to sustainability. Process innovation refers to improving the efficiency of production methods to reduce resource use and waste. Companies that adopt green manufacturing processes or use less water and energy in production are innovating sustainably by minimizing their environmental impact. Business model innovation refers to a more radical transformation, where companies rethink their value propositions, target markets, and revenue streams to align with sustainability goals. For example, companies adopting circular economy models, where products are reused, refurbished, or recycled, are innovating their business models to contribute to sustainability. In addition to addressing environmental challenges, sustainable innovation also enables businesses to reduce costs, differentiate themselves from competitors, and create new revenue streams. Porter and Kramer (2011) discuss the competitive advantage that companies gain by aligning their strategies with social and environmental goals. These companies not only improve their sustainability performance but also create new business opportunities in emerging markets that prioritize green products and services.

Social responsibility is another crucial aspect of integrating sustainability into business models. Social responsibility refers to the ethical obligation of businesses to consider the welfare of society, including their employees, communities, and the environment. Corporate Social Responsibility (CSR) is a broad term that encompasses a variety of initiatives where businesses go beyond their legal obligations to contribute positively to society. Carroll (1999) identified four dimensions of CSR: economic, legal, ethical, and philanthropic. Economic responsibility refers to the obligation to generate profit and create value for shareholders. Legal responsibility involves complying with laws and regulations. Ethical responsibility involves going beyond legal requirements to do what is right, fair, and just. Finally, philanthropic responsibility refers to charitable activities and efforts to improve society, such as donating to nonprofits or supporting community projects. Businesses that adopt CSR practices often benefit from enhanced public image, customer loyalty, and improved stakeholder relationships. Over time, the demand for socially responsible products and services has grown, with consumers becoming increasingly concerned about the ethical practices of the companies they support. According to Bhattacharya, Korschun, and Sen (2009), socially responsible companies are more likely to attract and retain loyal customers because they align with the values of ethically-conscious consumers. CSR initiatives also positively impact employee satisfaction and retention. Many workers prefer to work for companies that have a clear commitment to social responsibility, which leads to higher employee morale and productivity. CSR is no longer viewed as a mere marketing strategy; it has become an integral part of a company's values and culture. Importantly, CSR initiatives can address a wide range of social issues,

such as poverty alleviation, education, and public health. Entrepreneurs who engage in CSR activities can make a significant impact on local communities by creating job opportunities, supporting education programs, and reducing social inequalities.

While innovation and social responsibility are often discussed separately, they can work together to create a more sustainable and socially responsible business model. Sustainable innovation can drive social responsibility by creating products and services that meet the needs of society while minimizing environmental harm. At the same time, social responsibility encourages businesses to adopt practices that benefit their employees, communities, and other stakeholders, which can enhance the social impact of their innovations. For example, Patagonia, an outdoor clothing company, integrates innovation and social responsibility by designing environmentally friendly products and supporting workers' rights in their supply chains. The company has introduced innovations like recyclable jackets and environmentally sustainable fabrics while simultaneously supporting community initiatives and advocating for environmental protection. The Nestlé Creating Shared Value (CSV) initiative is another example where innovation and social responsibility intersect. Nestlé has developed new business models focused on nutrition, water, and rural development, areas where the company can innovate while also addressing significant social challenges. The company's efforts to ensure sustainable farming practices, improve nutrition, and provide clean water align with both innovation and social responsibility. While the literature on sustainable innovation and social responsibility has expanded significantly, there are still gaps in understanding how entrepreneurs can effectively integrate sustainability into their business strategies. One of the key gaps is the lack of research on the specific barriers and challenges that entrepreneurs face when trying to incorporate sustainability into their business models. Many studies have focused on large corporations or specific industries, but less attention has been given to how small and medium-sized enterprises (SMEs) can innovate sustainably. Additionally, there is limited research on the long-term impact of sustainable business practices. While many studies show the short-term benefits of innovation and CSR, such as cost savings and customer loyalty, more research is needed to understand the long-term effects on business performance, reputation, and market positioning. Another gap is the lack of research on the integration of innovation and social responsibility across different industries and regions. The drivers of innovation and CSR may vary depending on the specific context in which a business operates. For instance, the challenges faced by entrepreneurs in the renewable energy sector may differ from those in the fashion industry. Understanding these sector-specific dynamics can help entrepreneurs develop more targeted and effective sustainability strategies. The integration of sustainability into business models is no longer optional but a necessity for long-term success. Entrepreneurs who focus on innovation and social responsibility can create businesses that not only thrive financially but also contribute to positive environmental and social outcomes. As the literature demonstrates, sustainable innovation and social responsibility are interdependent factors that can drive change, create competitive advantages, and help businesses make a meaningful contribution to society. Despite the growing body of research, there is still much to learn about how entrepreneurs can successfully integrate sustainability into their operations. Further research is needed to explore the barriers and opportunities that entrepreneurs face in adopting sustainable business practices, as well as the impact of these practices on long-term business performance. By bridging these gaps, scholars and practitioners can help shape the future of sustainable entrepreneurship.

3. RESEARCH GAP IDENTIFICATION:

While much has been written about the individual roles of innovation and social responsibility in promoting sustainability, there is limited research exploring the intersection of these two factors within entrepreneurial businesses. Specifically, there is a gap in understanding how entrepreneurs navigate the challenges of integrating sustainability into their business models and how innovation and social responsibility can work together to achieve long-term success. Additionally, there is a need for more research on the practical strategies entrepreneurs use to balance environmental, social, and economic goals.

4. METHODOLOGY

This research was conducted using a qualitative approach to gain deeper insights into how entrepreneurs integrate sustainability into their business models through innovation and social responsibility. The aim was to explore how sustainable practices are being implemented in real-world businesses and to understand the challenges and strategies entrepreneurs use when adopting sustainability. Data was collected through in-depth interviews with entrepreneurs known for their commitment to sustainability, allowing the researcher to explore their experiences and perspectives on the integration of sustainability into business practices. A qualitative research design was chosen because it allows for an in-depth understanding of how entrepreneurs incorporate sustainability into their business models, particularly through innovation and social responsibility. Sustainability is a complex and multifaceted concept that varies widely across different business contexts. A qualitative approach was selected to explore the nuanced, personal experiences of entrepreneurs. The research was designed to examine the "how" and "why" of sustainable business practices, providing detailed insights into the factors influencing entrepreneurs' decisions, motivations, challenges, and the impact of their sustainable innovations. Given that qualitative research focuses on understanding human experiences, it was considered the most appropriate method to explore the

behaviors, thought processes, and real-world applications of sustainability in business. The research was approached as a case study, allowing for the detailed examination of individual entrepreneurs or businesses that had successfully implemented sustainable practices. This case study approach helped provide rich, context-specific insights into how innovation and social responsibility contribute to sustainable entrepreneurship.

The sample was selected using purposive sampling, which is a non-random technique often used in qualitative research when participants with specific characteristics are needed. In this case, the sample consisted of entrepreneurs who had demonstrated a clear commitment to sustainability through their business operations. These entrepreneurs were selected for their proactive approach to integrating sustainability in both innovative ways and socially responsible practices. A total of 18 entrepreneurs from various industries were selected, ensuring diversity in terms of sector and context. These industries included renewable energy, sustainable fashion, green technology, social enterprises, and eco-friendly agriculture. This diversity was intentional, as it allowed the study to explore different business environments and identify sector-specific patterns in how sustainability is integrated into business practices. Participants were identified through sustainability networks, industry reports, and recommendations from sustainability-focused organizations. The final selection of participants was based on their public reputation for engaging in sustainable practices and their openness to discussing their experiences with the research team.

Data was collected through semi-structured interviews, which provided a balance between structured questions and the flexibility to allow participants to share their experiences in their own words. Semi-structured interviews were ideal because they allowed the researcher to explore predefined themes while also giving participants the freedom to provide rich, detailed responses. The interview questions were designed to explore the following key themes: innovation in sustainability, challenges in integration, social responsibility, the impact of sustainability on business, and long-term sustainability goals. Each interview lasted approximately 45 to 60 minutes and was conducted either face-to-face or through online platforms like Zoom, depending on participant availability. The interviews were audio-recorded with participants' consent, ensuring that the full conversations were captured for later transcription. The data collected from the semi-structured interviews was analyzed using thematic analysis, a widely used method for analyzing qualitative data. Thematic analysis allows for the identification of key patterns and themes within the data, helping the researcher uncover shared experiences and perspectives among participants. The data analysis process followed several stages. First, the researcher became familiar with the data by listening to the interview recordings and reviewing the transcriptions multiple times. This step was crucial in ensuring that the researcher understood the nuances of each participant's responses. Next, initial codes were created by identifying segments of text that related to the research questions. Each meaningful response was labeled with a short code, such as "eco-innovation," "sustainable supply chain," or "customer engagement." These codes helped break the data into manageable chunks for further analysis. After coding the data, related codes were grouped into themes, identifying overarching patterns across the interviews. For instance, codes related to product innovation, waste reduction, and energy efficiency were grouped under the theme "Product and Process Innovation." Once themes were identified, the researcher reviewed and refined them to ensure they were adequately supported by the data. Finally, the researcher defined and named each theme in a way that captured its essence and relevance to the research questions. The findings were then compiled into a detailed report, providing insights into the role of innovation and social responsibility in promoting sustainable entrepreneurship.

Ethical considerations played a crucial role in this research, especially because the study involved human participants. The researcher adhered to several ethical guidelines to ensure the protection of participants. Before participating in the interviews, all entrepreneurs were provided with an informed consent form. This form clearly explained the purpose of the research, the voluntary nature of participation, and the fact that participants could withdraw at any time without consequences. It also explained how their data would be used and assured participants that their identities would remain confidential. To protect participants' privacy, all personal identifying information was kept confidential. Pseudonyms were used in the final report, and any references to specific business practices were anonymized.

The interview transcripts were stored securely, and only the research team had access to them. Participants were reminded that they had the right to withdraw from the study at any time without any negative consequences. The researcher ensured that the interviews were conducted respectfully and professionally, asking open-ended questions that allowed participants to express their views freely. This study used a qualitative methodology to explore how entrepreneurs integrate sustainability into their business models, focusing on the role of innovation and social responsibility. Through semi-structured interviews with 18 entrepreneurs from various industries, the research uncovered how sustainability is applied in businesses and identified the challenges and strategies entrepreneurs use when adopting sustainable practices. The thematic analysis of the interview data provided valuable insights into the role of innovation and social responsibility in shaping sustainable entrepreneurship. This methodology, combining purposive sampling, semi-structured interviews, and thematic analysis, allowed the research to gain in-depth insights into the lived experiences of entrepreneurs committed to sustainability.

5. FINDINGS

The findings of this study are derived from the analysis of in-depth interviews conducted with 18 entrepreneurs known for integrating sustainability into their business models. The purpose of these interviews was to explore how entrepreneurs are leveraging innovation and social responsibility in their operations and how these strategies contribute to the creation of sustainable business models. Through thematic analysis of the interview data, several key themes emerged that highlight the role of innovation, social responsibility, and the challenges faced by entrepreneurs in adopting sustainability in their businesses. This section provides a detailed account of the findings, drawing on quotes and examples from the interviews to illustrate the key themes.

Innovation in Sustainability: A Key Driver for Change

One of the most prominent themes that emerged from the interviews was the crucial role of innovation in integrating sustainability into business models. Many of the entrepreneurs emphasized that innovation is not just about creating new products but about rethinking the entire business process to reduce environmental impacts and enhance social value. A significant number of entrepreneurs noted that their innovation efforts were directly driven by the need to solve pressing environmental issues such as climate change, resource depletion, and waste management.

For instance, one entrepreneur in the renewable energy sector stated:

"Our primary focus has always been on creating energy solutions that are both environmentally and economically viable. We realized that through technological innovation, we could offer sustainable energy alternatives that also reduce carbon footprints. This innovation has not only opened up new market opportunities but also helped us align with global sustainability goals."

Many participants spoke about product and process innovations that contributed directly to reducing waste, increasing energy efficiency, and promoting circular economy principles. For example, several entrepreneurs from the fashion industry mentioned how they had developed sustainable fabrics made from recycled materials, which significantly reduced the waste generated in the production process. One such entrepreneur explained:

"We redesigned our entire supply chain and product development processes. Instead of sourcing virgin fabrics, we now use recycled textiles, which not only lowers environmental impact but also sets us apart from competitors in the market."

This approach to innovation highlights the idea that sustainability can be embedded within the core of the product development process rather than being an afterthought. It also underscores the importance of integrating sustainability into the innovation cycle, as entrepreneurs recognized that developing new products and processes that minimize harm to the environment can lead to both business growth and positive social outcomes.

Social Responsibility and Ethical Decision-Making

Social responsibility was another key theme that emerged from the interviews. Many entrepreneurs emphasized that their commitment to sustainability went beyond just environmental considerations and included a strong focus on the social impacts of their business decisions. Social responsibility, according to the entrepreneurs interviewed, meant considering the welfare of employees, local communities, and society at large. This holistic approach to business extended to issues such as fair labor practices, local sourcing, community development, and inclusivity.

One entrepreneur, who operated a social enterprise focused on providing access to clean water in underdeveloped regions, highlighted how social responsibility is embedded into the company's DNA:

"Our mission is to ensure that communities without access to clean water are not left behind. We don't just sell a product; we aim to improve lives by providing affordable and clean water solutions. Social responsibility isn't just a buzzword for us; it's a fundamental part of our strategy and a way of doing business."

Similarly, entrepreneurs in the food industry described how their social responsibility initiatives focused on fair trade practices and supporting small-scale farmers. These entrepreneurs explained that they worked closely with local farmers in developing countries, ensuring they received fair wages and access to international markets, thereby promoting both economic development and environmental sustainability.

Another important aspect of social responsibility, as noted by participants, was the consideration of diversity and inclusion within their businesses. Entrepreneurs emphasized that their companies promoted a diverse workplace where individuals from various backgrounds, genders, and ethnicities were given equal opportunities for career advancement. This was seen as not only ethically necessary but also beneficial for creativity and innovation within their businesses.

Challenges in Implementing Sustainability

While most entrepreneurs in the study acknowledged the importance of integrating sustainability into their business models, they also discussed the various challenges they faced along the way. One of the primary challenges highlighted was the initial cost of implementing sustainable practices. Entrepreneurs mentioned that adopting sustainable materials, processes, and technologies often required significant upfront

investment. For instance, one entrepreneur in the eco-fashion industry explained:

"It's expensive to switch to sustainable raw materials, and the technology required to reduce waste in production is costly. It took us a while to convince investors and stakeholders that these initial costs would pay off in the long run."

Several entrepreneurs noted that securing funding for sustainability initiatives was one of their biggest hurdles. Many of the entrepreneurs, particularly those in the early stages of their business, faced difficulties convincing investors and stakeholders of the long-term financial benefits of sustainable practices. This challenge was particularly acute in industries where sustainability was still seen as a secondary concern, rather than a core business strategy.

Another challenge that entrepreneurs often mentioned was the lack of knowledge and expertise required to implement sustainable practices effectively. In some cases, entrepreneurs had to invest significant time and resources into educating themselves and their employees about sustainability practices, which created additional pressure on already limited resources. As one entrepreneur in the green technology sector pointed out:

"Sustainability is not something that comes naturally for everyone, especially when it comes to adapting new technologies or business processes. It took a lot of trial and error, and we needed to invest in research and development to make our business more sustainable."

A further challenge was navigating the regulatory landscape. Some entrepreneurs expressed frustration with the lack of clear regulations and guidelines surrounding sustainability practices in their respective industries. They argued that inconsistent regulations made it difficult for businesses to plan and implement sustainable practices effectively. As an entrepreneur in the energy sector noted:

"There's still a lot of uncertainty about what is truly sustainable, and the regulations often don't keep up with the innovation happening in the market. This lack of clarity makes it difficult for businesses to know if they are complying with the right standards."

Impact on Business Performance

Despite the challenges faced, many entrepreneurs reported that sustainability had a positive impact on their business performance, both in terms of financial success and customer loyalty. Several entrepreneurs observed that adopting sustainable practices helped them differentiate their businesses in the market, allowing them to attract a growing segment of eco-conscious consumers. One entrepreneur in the sustainable fashion industry mentioned:

"Our commitment to sustainability has become a core part of our brand identity. Our customers appreciate the transparency and our efforts to minimize our environmental footprint. This has resulted in stronger customer loyalty and repeat purchases."

In addition to enhancing brand loyalty, some entrepreneurs also noted that their sustainability efforts helped them gain a competitive advantage. Entrepreneurs reported that businesses with a clear commitment to sustainability were often able to access new markets and partnerships that prioritized ethical and environmental considerations. One entrepreneur in the renewable energy sector shared:

"Sustainability has opened new doors for us. We've been able to partner with organizations that align with our values, and we've attracted investors who are specifically looking for businesses with a positive environmental impact."

Moreover, entrepreneurs in sectors such as renewable energy and green technology mentioned that sustainable practices contributed to cost savings over time. By adopting energy-efficient technologies, reducing waste, and streamlining operations, they were able to lower operational costs and increase profit margins. For example, one entrepreneur in the green building industry explained:

"By integrating energy-efficient systems into our buildings, we not only reduce the carbon footprint but also lower energy consumption, which translates into lower costs for our clients and higher margins for us."

Long-Term Sustainability Vision

Finally, the interviews revealed that many entrepreneurs were highly motivated by a long-term vision of sustainability. Most participants expressed a strong commitment to continuing their sustainability journey and expanding their efforts as their businesses grew. One entrepreneur in the sustainable food industry remarked:

"We're not in this for short-term gains. We want to create a legacy that will benefit future generations. Our long-term vision is to scale our business while maintaining the same level of environmental and social responsibility that we've started with."

Many entrepreneurs emphasized the importance of staying true to their sustainability values, even when faced with financial pressures or competitive challenges. They viewed their commitment to sustainability as not just a business strategy but a moral obligation. These long-term goals were often centered around contributing to the global sustainability agenda, such as the United Nations' Sustainable Development Goals (SDGs), which served as a guiding framework for their business operations. The findings from this research illustrate that innovation and social responsibility play central roles in helping entrepreneurs integrate sustainability into their business

models. While entrepreneurs face significant challenges in implementing sustainable practices, they also report that these practices lead to positive outcomes, including enhanced business performance, customer loyalty, and competitive advantage. The entrepreneurs in this study demonstrate that integrating sustainability into business operations is not only a moral imperative but also a sound business strategy with the potential to drive long-term success.

6. IMPLICATIONS

The findings of this study carry several important implications for entrepreneurs, business leaders, and policymakers. First and foremost, the research highlights the significant value of integrating sustainability into business models. Entrepreneurs who embrace sustainability through innovation and social responsibility are not only ensuring the long-term viability of their businesses but also contributing positively to society and the environment. By prioritizing sustainable practices, businesses can reduce their negative impact on the planet, improve the welfare of local communities, and promote fair labor practices. Moreover, these actions help build a positive brand image and foster stronger relationships with consumers who increasingly value ethical and environmentally conscious businesses. Entrepreneurs who incorporate sustainability into their core business values can differentiate themselves from competitors, attract a loyal customer base, and, ultimately, establish a reputation as leaders in their respective industries. The study suggests that this approach leads to a win-win situation, where businesses thrive financially while contributing to the greater good.

Another important implication of the research is the need for businesses to view sustainability as a long-term strategy rather than a short-term obligation. Many entrepreneurs in the study emphasized that adopting sustainable practices requires patience, persistence, and a long-term vision. While there may be initial costs and challenges associated with sustainability, the long-term benefits—such as cost savings from energy efficiency, improved customer loyalty, and access to new markets—can make the investment worthwhile. Entrepreneurs who make sustainability a priority early on can position themselves as forward-thinking leaders, anticipating future regulations and consumer demands for more responsible business practices. This proactive approach enables businesses to stay ahead of industry trends, potentially gaining a competitive edge in an increasingly sustainability-focused global marketplace. The research highlights that businesses adopting sustainability as a core part of their strategy are more likely to remain resilient and adaptable in the face of changing market conditions and environmental challenges. This approach also positions businesses to contribute to broader global sustainability goals, such as reducing carbon emissions, promoting circular economies, and fostering social equity.

Finally, the findings have important implications for policymakers and support organizations. Governments, industry groups, and NGOs have an important role to play in fostering sustainable entrepreneurship. The study suggests that policymakers should recognize the essential role of innovation and social responsibility in advancing sustainability within business. One critical implication is the need for targeted policies and incentives that encourage businesses to adopt sustainable practices. Financial incentives, such as tax breaks, grants, or subsidies for businesses that invest in renewable energy, waste reduction, or socially responsible supply chains, can make it easier for entrepreneurs to implement these practices. Additionally, governments should create supportive regulatory frameworks that provide clear guidelines on sustainability standards, making it easier for entrepreneurs to align their business practices with industry norms and environmental regulations. This kind of policy support can help to lower the barriers to entry for new businesses and provide a competitive advantage to existing ones that seek to innovate sustainably. Furthermore, entrepreneurship support organizations, including incubators and accelerators, should emphasize sustainability in their programs. By providing training, mentorship, and networking opportunities to entrepreneurs who focus on sustainability, these organizations can help drive innovation and social responsibility within the business community. By fostering an environment where sustainable entrepreneurship is not only encouraged but also supported through policy and resources, governments and support organizations can play a vital role in creating a more sustainable economy overall. The findings from this study underscore the importance of sustainability in modern entrepreneurship and business strategy. By incorporating innovation and social responsibility into business models, entrepreneurs can create businesses that benefit both the environment and society while ensuring long-term financial success. This research also calls for a broader recognition of sustainability as a key driver of business growth, encouraging entrepreneurs to think long-term and adopt sustainable practices from the outset. Furthermore, it highlights the critical role of policymakers and support organizations in providing the necessary resources and incentives to drive the adoption of sustainability within the business community. Ultimately, fostering an environment where sustainability is prioritized at every level of business can contribute to a more sustainable and equitable global economy.

7. LIMITATIONS AND FURTHER RESEARCH AGENDA

While this research provides valuable insights, it has some limitations. First, the sample size is relatively small, which may limit the generalizability of the findings. Future research could include a larger and more diverse sample of entrepreneurs to better understand the global trends in sustainable business practices. Additionally, this study

focuses on qualitative data from interviews, and future research could use quantitative methods to gather more statistical evidence on the relationship between sustainability, innovation, and business success. Further research could also explore the specific barriers and challenges that entrepreneurs face when trying to integrate sustainability into their business models. Understanding these obstacles can help develop more targeted strategies and policies to support sustainable entrepreneurship. Lastly, future studies could examine the impact of sustainability on different industries, as the factors driving innovation and social responsibility may vary depending on the sector. For example, the challenges faced by entrepreneurs in the renewable energy sector may differ from those in the food industry, and exploring these differences could provide more nuanced insights into sustainable entrepreneurship.

8. CONCLUSION

Integrating sustainability into business models is no longer merely a passing trend or a niche focus—it has become a crucial component for achieving long-term success in today's rapidly changing world. The findings from this research underscore that businesses which prioritize sustainability are not only future-proofing themselves against environmental and social challenges but are also contributing to a more equitable and sustainable global economy. Entrepreneurs who embrace innovation and social responsibility have a unique opportunity to not only drive their businesses forward but to make a tangible, positive impact on the world. These entrepreneurs understand that sustainability goes beyond regulatory compliance or public relations—it is about embedding sustainable practices into the core of their business operations, from the products they create to the way they treat employees and engage with their communities. The study reveals that innovation plays a critical role in driving sustainable change. Entrepreneurs who focus on developing new products, processes, and technologies that address environmental issues or social inequalities are able to differentiate their businesses in competitive markets. Furthermore, these innovations often provide new opportunities for growth, helping companies tap into emerging markets or meet the growing consumer demand for ethical and sustainable products. Social responsibility, equally important, extends beyond profit-making to include ethical decision-making that prioritizes the welfare of people, communities, and the environment. By ensuring fair labor practices, supporting local economies, and reducing negative environmental impacts, businesses can foster deeper connections with their customers and strengthen their brand loyalty.

While entrepreneurs are well-positioned to drive sustainability through innovation and social responsibility, the study also highlights that there are significant challenges in this pursuit. High upfront costs, regulatory complexity, and the need for specialized knowledge are just a few of the obstacles that entrepreneurs must navigate. However, the research emphasizes that these challenges are not insurmountable. In fact, by embracing sustainability early on and viewing it as a long-term strategy rather than a short-term obligation, businesses can reap significant rewards, including cost savings, competitive advantage, and enhanced brand reputation. Furthermore, policymakers and support organizations have a critical role in helping to remove some of these barriers by offering incentives, providing clear guidelines, and fostering a supportive ecosystem for sustainable entrepreneurship. Looking ahead, the role of entrepreneurs in driving sustainable change is more important than ever. Entrepreneurs have the creativity, flexibility, and vision to lead the way toward a future that prioritizes both environmental and social well-being alongside economic growth. The research suggests that by continuing to explore and deepen the intersection of innovation, social responsibility, and sustainability, entrepreneurs can catalyze a broader cultural shift toward sustainability within the business world. Through their efforts, they can influence industry standards, shape consumer expectations, and inspire other businesses to follow suit. Integrating sustainability into business models is not just a strategic advantage—it is an imperative for any business that hopes to succeed and thrive in the long term. Entrepreneurs who are committed to sustainable innovation and social responsibility have the potential to create businesses that do more than generate profits—they can create businesses that make a meaningful, positive impact on society and the environment. By continuing to advance this agenda, we can lay the foundation for a more sustainable, inclusive, and resilient global economy, where businesses and communities thrive together

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The Role of Entrepreneurship in Emerging Economies: A Case Study of the Tribal Entrepreneurship among the Oraon Tribe in Gumla District of Jharkhand Towards Creating Sustainable Economy

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ABSTRACT

Tribals and entrepreneurship are seen as alien to one another. They do not become entrepreneurs easily because entrepreneurship involves high risk. They prefer to involve themselves in traditional agriculture. Economically tribal community is one of the weakest societies in India which continues to suffer with poverty, malnutrition, illiteracy, unemployment, and displacement. The current socio-economic scenario has forced them to explore other means of livelihood. Entrepreneurship has emerged as one of the major components of livelihood along with their agriculture and dependency on government or private jobs. The present study tries to understand from the current scenario of the Oraon entrepreneurs in Gumla district in Jharkhand, it also tries to identify how their lives have changed after they embraced the entrepreneurship. The result shows positive impact in their livelihood. Entrepreneurship has helped them to secure suitable employment opportunities, and helped them in alleviating poverty to a greater extent. It also reveals the extent of increment in their income which impacted on their living standards, their social status and ultimately leading to sustainable economy. However, their struggles continue in establishing themselves as entrepreneurs among those who are efficient and equipped in managing their business.

Keywords: Tribal, Oraon, Entrepreneurship, Entrepreneurs, livelihood, sustainable

1. INTRODUCTION

Mahatma Gandhi, in his vision of Gram Swaraj, envisioned the inclusive empowerment of all sections of society in the country's development process by strengthening the farming sector, creating a robust network of business activities, and fostering rural leadership in India's villages. However, the aspirations set forth by Gandhi remain largely unfulfilled for

marginalized communities such as the Scheduled Castes, Scheduled Tribes, and Other Backward Classes. These communities face economic, social, and technological advancements exclusion which transforms the country. They continue to face severe challenges such as widespread poverty, malnutrition, illiteracy, unemployment, and migration. Their struggles for social, economic, and political recognition still continues. As Anderson (1997) notes, low-income levels and high levels of poverty are undermining the social, economic, and environmental fabric of these indigenous communities. The increasing migration of tribal people in search of basic necessities is a direct consequence of these challenges. Their experiences of social and economic dislocation have led them to explore more sustainable livelihoods. The development of any country is incomplete without including every section of people in the process of development specially the people in the periphery. Those communities who have been always pushed to the periphery need to be included in the circle of development.

In response, the Government of India and state governments are exploring various mechanisms to uplift these communities, including initiatives by the Ministry of Tribal Affairs, the Ministry of Rural Development, and various non-governmental organizations (NGOs). Despite reservations in educational institutions, government employment, and other measures to provide special opportunities, these communities still grapple with persistent inequalities. Despite numerous efforts, significant improvements in their conditions remain elusive, with many tribal communities still dependent on traditional agriculture.

Tribal communities in India, often referred to as Scheduled Tribes in the Constitution, are indigenous groups with distinct social, cultural, economic, linguistic, and political traditions. There are over 700 recognized tribes spread across various regions of the country. According to the 2011 Census, the Scheduled Tribe population stands at approximately 10.42 crore, making up 8.6% of India's total population. Tribal entrepreneurship involves the participation of tribal communities in business ventures, utilizing local resources, traditional knowledge, and skills. This form of entrepreneurship aims to create sustainable economic opportunities while preserving their cultural heritage. According to Meena et al. (2021), tribal entrepreneurship plays a crucial role in rebuilding communities, strengthening families, and contributing to the nation's economy.

Surrounded by rivers, hills, books and forests Gumla is located nearly 100 km southwest of Ranchi. It was created as a district in the year 1983 by carving it out from then Ranchi District. It has total area of 5327 sq. km. Gumla has three subdivisions namely, Gumla, Chainpur, and Basia and 12

Development blocks. According to census 2011 the total population of Gumla district is 10,25,213 and the total population of Scheduled Tribes and Scheduled Castes in the district is respectively 7,06,754 and 32,459. It has highest population of Scheduled Tribes 68.9% in State after Khunti 73.25%. Gumla District is a home to several tribes, including Oraon, Khaia, Munda, Chick Baraik, Lohra, Banjara, Kol, Kisan, Birjia, Korwa, Asur, and Birhor (the latter four are the Particularly Vulnerable Tribal Groups). Oraon tribe the biggest tribe in the district with the total population of 4,42,659. The local economy is primarily based on agriculture, cattle development, the collection of forest products, labor, mining activities, infrastructure and commercial activities. Gumla remains one of the most underdeveloped districts in Jharkhand, lacking essential amenities like roads, hospitals, and schools. Minerals like Bauxite and Laterite are found in Gumla district.

Oraons are the one of the Tribal communities living in Jharkhand, Chhattisgarh, West Bengal, Bihar and Odisha. Over the year they have migrated other states Assam, Delhi, Kerala etc., in a big number. They are also known as Kurukh, Dhangar, Kuda and Kisan. According to Dehon, (1906) The Uraons or Oraons or as they call themselves, Kurukh, are a Dravidian cultivating tribe of Chota Nagpur. They speak their own tribal language, dialect of the Dravidian family. Traditionally they depend on forests and farms for their livelihood, nowadays they have become settled agriculturists. The Oraon community in Gumla district, like many others, have traditionally lived in close harmony with nature, relying on agriculture, hunting, and gathering forest products for their livelihoods. However, deforestation, unpredictable rainfall, and the forces of globalization have disrupted their traditional way of life. Today, they face poverty, malnutrition, illiteracy, unemployment, and displacement.

Sustainability, derived from the Latin word sustinere meaning "to uphold" or "to endure," refers to practices that can be maintained over time without depleting resources or harming future generations. This concept spans environmental, social, cultural, political, and economic dimensions. Tribal communities' understanding of sustainability is deeply rooted in their values, culture, and religious practices, all of which emphasize the importance of nature. As Gouvea et al. (2022) suggest, indigenous entrepreneurs often draw inspiration from their culture, values, and traditions when developing sustainable businesses. One Native American proverb encapsulates this ethos: "We have not inherited this earth from our parents; we have borrowed it from our children," underscoring the need to protect nature for future generations.

Sustainable economic development, a key component of this vision, involves long-term growth that meets present needs without compromising the ability of future generations to meet their own. Pezzey (1992) argues that sustainability should ensure that the quality of life does not decline over time. According to Barrier (2017), the primary goal is to reduce absolute poverty by providing secure livelihoods that minimize resource depletion, environmental degradation, and social instability. Jena (2011) identifies three key principles of sustainable development: it should be holistic, process-oriented, and value-driven, addressing the interconnectedness of sectors, the social and cultural context, and the principles of democracy and accountability.

Tribal economies have seen significant degradation, with communities lagging behind not only in economic development but also in the efficient use of natural resources and human potential. This lack of progress can be attributed to factors such as traditional agricultural practices, limited access to modern technology, inadequate irrigation, low literacy rates, insufficient government support, and the loss of tribal land to mining and adaption of inappropriate mechanisms for development. According to Bogaert (1975), tribal communities are far behind their non-tribal counterparts in establishing businesses, primarily due to the underdeveloped areas they inhabit.

However, necessity has driven tribals to seek new avenues for economic survival. The failure of traditional agricultural methods, coupled with the uncertainties they face, has pushed many towards entrepreneurship. The belief that entrepreneurs are born, not made, is being replaced with the understanding that entrepreneurship can be cultivated through training and support. Gouvea et al. (2022) highlight how indigenous entrepreneurship helps strengthen communities and ensure cultural survival. It has become a central pillar of economic growth for indigenous groups. Entrepreneurship among tribal communities has the potential to create sustainable livelihoods, supplementing traditional agriculture and boosting their economies. Economic empowerment through entrepreneurship can offer tribal communities additional sources of income, thus contributing to their overall socio-economic development.

2. TRIBAL ENTREPRENEURSHIP IN LITERATURE

The concept of tribal entrepreneurship has emerged as a field of study primarily driven by the growing involvement of tribal communities in entrepreneurial activities. However, there remains a significant gap in research specifically focused on tribal entrepreneurship, with most studies addressing issues such as the success and failure of tribal entrepreneurs, the need for training and development, and the role of entrepreneurship in socio-economic advancement.

Despite the growing interest in this area, there are limited studies exploring the relationship between tribal entrepreneurship and sustainable development. Tribal entrepreneurship must be understood from various perspectives, particularly in the context of sustainable economic development. As Trivedi (1991) notes, the structure and functioning of tribal entrepreneurship are

influenced by several factors, including isolation, hostile geographic conditions, and feudal exploitation, all of which contribute to the challenges faced by tribal entrepreneurs.

Das (2024) highlights that skill development training, extended working hours, shifts in employment, and increased involvement in entrepreneurial activities have played a pivotal role in improving the economic conditions of tribal communities. He emphasizes the importance of addressing infrastructure gaps by providing storage facilities, establishing household plans, expanding new programs, and setting up training and development centres. Similarly, Kumar (2021) analysed the impact of government-sponsored skill development programs in Telangana, finding that these initiatives had a positive influence on the socio-economic status of tribal communities, leading to increased income and improved social status. Khanum et al. (2022) conducted a study on the livelihood status of tribal women in the Sylhet region of Bangladesh, which demonstrated significant growth in human, financial, natural, social, and physical assets after the women became entrepreneurs. Entrepreneurship not only improved their financial status but also helped these women gain recognition and a respectable identity within their communities.

Barrier (2017) examined the concept of sustainable economic development and concluded that environmental conservation and economic development are not mutually exclusive but can reinforce one another. De Bruin and Mataira (2018) emphasized that advancing indigenous economic development is closely linked to reducing dependence on government benefits and reasserting indigenous sovereignty. Gupta (2023) argued that tribals, by connecting agriculture and forest produce with markets through innovative institutional mechanisms, have been able to establish self-sustaining enterprises that contribute to their economic well-being.

Studies focusing on tribal women have also highlighted the positive impact of entrepreneurship on gender equality and empowerment. Hazarika and Goswami (2018) found that entrepreneurship among tribal women in Assam enhanced both their traditions and socio- economic conditions, helping to alleviate gender inequality. Similarly, Naveen et al. (2023) observed that entrepreneurship played a critical role in the identity formation and empowerment of tribal women in Odisha, with literacy, NGO membership, training, and

personal business revenue contributing significantly to their empowerment. However, Sahoo and Teena (2023) identified a lower degree of positive impact of tribal entrepreneurship on economic and women's empowerment, as well as a negative impact on social empowerment, though they noted that micro-enterprises had reduced the reliance on private money lenders.

Nayak and Patra (2023) conducted a comprehensive review of 40 articles on tribal entrepreneurship, summarizing that, through their own efforts and support from government and non-governmental organizations (NGOs), tribal communities are increasingly integrating into the mainstream economy. This integration has led to improvements in lifestyle, education, income, and occupational status, although they have not yet fully professionalized their entrepreneurial approaches. Vinamrta and Chakraborty (2020) pointed out several challenges faced by tribal entrepreneurs, including poor infrastructure, limited access to credit, and a lack of technical know-how. They stressed the need for entrepreneurial education in agriculture, forestry, and mining sectors to further develop tribal entrepreneurship. Hemasrikumar et al. (2018) observed that easy access to credit and training significantly enhanced the entrepreneurial skills and wealth creation of Toda women in Tamil Nadu, contributing to capacity utilization and the resolution of unemployment, poverty, and low living standards.

Guercini and Cova (2015) presented a case study of the Gruppo Speleologico della Montagna Pistoiese, which illustrated the positive role of tribal-enterprise systems in fostering innovation and creating consumer markets. Sanap and Jadhav (2018) explored the role of forest products in the sustainable livelihoods of tribal communities, emphasizing the importance of creating a conducive environment and identifying potential tribal entrepreneurs, as forest products can serve as vital sources of food, nutrition, income, and employment.

The majority of studies on tribal entrepreneurship emphasize its role in increasing income, improving economic conditions, enhancing living standards, creating markets, and generating employment opportunities. Additionally, some studies highlight its role in preserving tradition and culture, as well as its potential in addressing unemployment, poverty, and migration. However, many studies fall short of examining whether tribal entrepreneurship contributes to sustainable economic development in a broader sense. There is a clear need for further research to explore how tribal entrepreneurship can align with sustainable development goals, ensuring long-term economic viability and cultural preservation while addressing the challenges faced by tribal communities.

3. RESEARCH GAP IDENTIFICATION –

Based on the aforementioned studies the following issues emerge as topics for further discussion.

1. The role of tribal entrepreneurship in increasing the economic sustainable development. Can tribal entrepreneurship be conducive in creating sustainable economic development?
2. Exploring the parameters for measuring the sustainability of economic development. What are different parameters expressing the sustainable economic development among the tribal entrepreneurs?

4. OBJECTIVES OF THE STUDY

1. To explore the long-term impact of entrepreneurship among the Tribal Entrepreneurs in the context of globalisation
2. To suggest a development model for conducive towards sustainable developmental growth among the tribals and other farmers in Jharkhand

5. RESEARCH METHODOLOGY

This was exploratory research conducted among the tribals in Gumla district of Jharkhand. A Semi structured survey was designed for the primary data collection among the existing tribal entrepreneurs in the area. Along with the semi structured survey form personal visits and observations of the researchers were used to understand the entrepreneurial pattern among the Oraon entrepreneurs.

The data was collected through survey among the exiting Tribal entrepreneurs to capture information about their social, economic, cultural and political position in the Gumla district in Jharkhand. The entrepreneurs were from Oraon Tribe. The main focus of the research was to find out how the involvement in entrepreneurship has changed their life style and what is the sustainability of their economic development.

Analysis: The three models of tribal sustainable development in the line of United Nations sustainable Goals

The United Nations Sustainable Goals

The demand of sustainability in human life style is increasing rapidly. Understanding the need of sustainability the united nation proposed 17 Sustainable Development Goals in 2015 to be

achieved by 2030. These sustainable goals integrate different elements of balance social, economic and environment sustainability. They are designed to end poverty, hunger, AIDS, and discrimination against women and girls which would be achieved through creativity, knowhow, technology and financial resources from all of society.

The application of tribal entrepreneurship development in practice is a difficult process. It can be properly understood through the application of different models. There are various models proposed by economists. Some models can be selected and applied according to the needs and requirement of place. Three models have been taken for the study.

The First Model

This model is proposed by Fonda Walters and John Takamura (Walters & Takamura, 2015) to decolonise the Western view of economic development, innovation, and entrepreneurship is known as Decolonized Quadruple Bottom Line. The Decolonized Quadruple Bottom Line: A Framework for Developing Indigenous Innovation provides a perspective to lead to a more functioning, viable economy of different communities and nations. The model is grounded in unique Indigenous experience and American Indian knowledge and has the potentially to create sustainable tribal economies in the immediate future.

The decolonized quadruple bottom line is a framework for innovative strategies towards community development and nation building. It includes four unique factors of indigenous people namely Community, Spirituality, Sustainability and Entrepreneurship for sustainable enterprise creation. The combination of four factors of indigenous perspectives which lead to subset of Cultural, Social, Economic and Economic factors. The overlapping factors located at the epicentre of the quadruple bottom line result in the creation of Indigenous Innovation, which is vital to the development of sustainable indigenous entrepreneurial ventures. Here, community is the community of indigenous people or tribe, Spirituality encompasses indigenous social beliefs, values, and traditions, Sustainability refers to economic sustainability and resilience as well as environmental sustainability and entrepreneurship is a unique blend of indigenous social, economic, and socio-ecological factors. Indigenous innovation is the specific type of innovation that occurs within indigenous communities from the combination of Community, Spirituality, Sustainability, and Entrepreneurship. Indigenous innovation exists in the epicentre of the decolonized quadruple bottom line and can be achieved though the holistic blending of all the aspects.

The Second Model

Pathak & Deshkar (2023) have assembled different components of the SMART Village (SMART-V) model framework. The SMART- V encompasses various dimensions such as sustainable environment, manageable economy, adaptive society, responsive governance, and technological infrastructure. It will be conducive in reduction of rural poverty, human slavery and inequality besides achieving sustainability. The SMART-V focuses on the paradigm shift: transformation to a new rural development where the key principles focus shift from focus on rural areas only and agricultural and industrial development to rural areas inextricably linking to cities, regions and national contexts and answering the questions of inequalities, climate change and rapid population growth. The Key sector targets shift from agriculture and rural communities to multi sectors in the context of failure of agriculture in answering the sustainable needs of growing population and inflow of migrants to cities. Their Main approach shifts from project based, agriculture technology and green revolution to specific context, prioritised and realistic and well-sequenced to maximizing synergies. The Key actors shift from agricultural ministry, agriculture research and extension,

donors, local, government and farmers to multi- agent participation including broad set of stakeholders across public and private sectors from national to local in the new context of greater participation by non-government actors including the private sectors, rural communities, civil society organizations (CSOs) and Non- Governmental Organizations (NGOs).

In India the domain of SMART -V development is more comprehensive. It includes the approaches and objectives related to Smart Environment, Smart Energy, Smart Water Management, Smart Sanitation, Smart Connectivity, Smart Agriculture/ Horticulture, Smart Health and Smart Education.

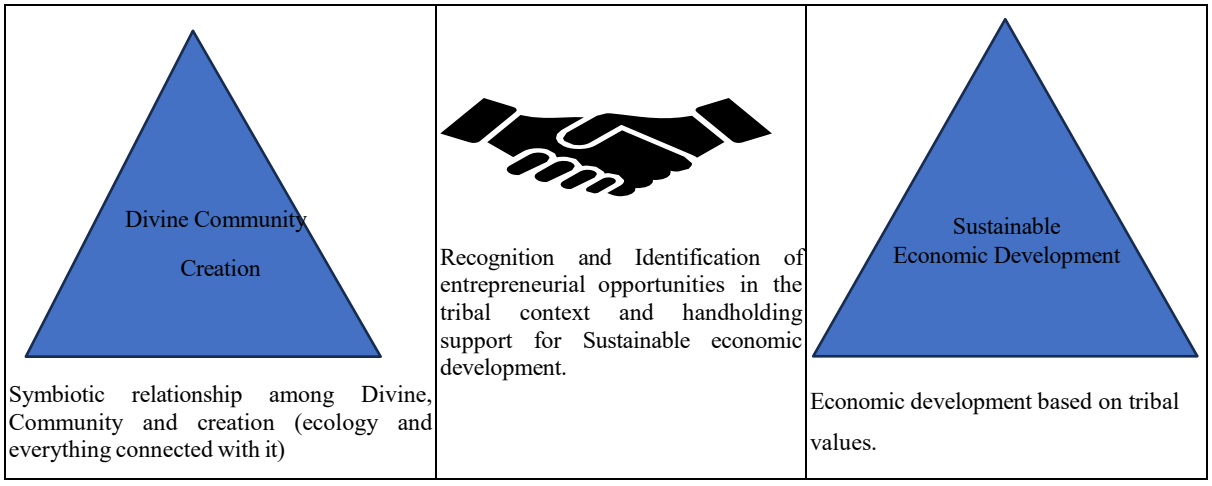
The Third Model

The Third Model is initiated by Syngenta Foundation India a not-for-profit organization for Sustainable Agriculture (SFSA) and Syngenta India Limited aiming at sustainable Agriculture. It is known as Agri Entrepreneur Growth Foundation's Agri-Entrepreneurs (AE) program. Agri Entrepreneur Growth Foundation's AE program, a joint venture with the Tata Trusts aiming at developing 1,00,000 Agri-Entrepreneurs (AEs) in the following five years to ultimately achieve the goal of serving 20 million smallholders. It empowers young people in rural areas through training under Agri Entrepreneur Growth Foundation (AEGF) to the motivated, self-employed rural youth to become Agri-Entrepreneurs (AEs) in rural areas to actively participate in agricultural development. It follows a decentralized approach, bringing together services such as credit, market linkage, access to high-quality inputs, and crop advisory for a group of 150- 200 farmers. The AE Model is designed to address the challenges faced by smallholder farmers by improving their access to essential resources and information.

The prescribed models are scientific models for assisting tribal entrepreneurs in sustainable economic models. Proper implementation of these models enhances the rapid growth and development as well as sustainable of resources, economy and human life. The limitations of these models lie in lack of proper implementation of these models among the tribal entrepreneurs due to poor educational background.

The Simplified Model

The Simplified Model of development is process of relating philosophy of symbiotic relation and triable aspiration of development. Maintenance of sustainability is innate among the tribals. They believe in the symbolic relationship between tribal community, creation and divine. Their care for earth, resources and human beings come from myths, philosophies and cultural, social and religious values. The Simplified Model recognises and identifies entrepreneurial opportunities in the tribal context and provides handholding support along with their traditional agriculture for sustainable economic development. The governments, NGOs and other organizations can provide emotional support, policy guidance and financial assistance for proper growth.



The most suitable sustainable model for tribes would include development of small entrepreneurial endeavours allowing them to grow in their own local circumstances along with their traditional livelihood. Need of encoring tribals emerges prominently in the Tribal Pancasila presented by Vidyarthi and Rai (1985) 1. People should develop along the lines of their own genius and we should try to encourage in every way their own traditional art and culture. 2. Tribal rights in land and forests should be respected.

3. We should try to train and build up a team of their own people to do the work of administration and development 4. We should work through their own social and cultural institutions. 5. We should judge results, by the quality of human character that is evolved.

6. FINDINGS

The findings of the study show a very positive impact in the life of entrepreneurs. entrepreneurship plays very significant role in their sustainable growth. The findings are presented tabular form. The first part includes the details about their gender, educational background, family background and yearly income. The second part of the study measures the sustainable growth through the parameters of growth in annual income, growth in living standard, stopping migration and economically self-sufficiency.

TABLE 1: Profile of respondents

Gender	Frequency	Percentage
Male	64	58
Female	47	42
Total	111	100

Gender in an important parameter to explore the development process among the tribals entrepreneurs. The first table gives the details of gender representation of the respondents. There are 111 respondents out of which 58% males as compared to the females 42% who came forward for the response. The involvement of male is seen more as compared to females in the entrepreneurship activities shows men are more outgoing as compared to the female counterparts.

TABLE 2: Educational Background of tribal entrepreneurs

Qualification	Frequency	Percentage
Illiterate	2	2
Primary School passed	13	12
Middle School passed	12	11
Matriculation passed	26	23
Intermediate pass	27	24
Graduation passed	15	14
Technical Studies passed	8	7
Other	8	7
Total	111	

The second table gives educational background of the tribal entrepreneurs. There is uneven distribution in their educational background. 2% are illiterate, 12% have passed matriculation, 11% have passed middle school, 23% have passed matriculation, 24% have passed, 14% have passed graduation and 7% have the technical background and 7% have other backgrounds of educational qualifications. There is lack of professional touch in the entrepreneurship because one 28% of the entrepreneurs have passed graduation or other technical studies. Others 72% of them have not been able to study beyond 12th standard. The number of entrepreneurs after Matriculation and intermediate is more because many do not afford to pursue their higher educations and look for easier option of livelihood.

TABLE 3: Family Background of tribal entrepreneurs

Family Background	Frequency	Percentage
Agriculture	99	89
Agriculture (Retired)	7	6
Service	3	3
Business	0	0
Any other	2	2
Total	111	100

The Third table presents the details of family backgrounds of the respondents. 89% of the entrepreneurship is agriculture, another 7 % come from agricultural families who are retired after their jobs only 3% come from families involved in service and only 2% come from other background. They turned to entrepreneurship because the agriculture alone could not support them. They experienced the need of some alternative source of income.

TABLE 4: Yearly income of the tribal entrepreneurs

Yearly Income	Frequency	Percentage
Below 1,00,000	32	29
1,00,001 to 5,00,000	73	66
Above 5,00,000	6	5
Total	111	100

The fourth table presents the details of yearly income of tribal entrepreneurs. 29% entrepreneurs have yearly income of less than Rs. 1,00,000, 66% have yearly income of Rs. 1,00,000 to five lakhs while one 5% have yearly income of more than Rs. 5,00,000.

TABLE 5: Increasement and consistency in annual income of tribal entrepreneurs

Response	Frequency	Percentage
Yes	107	96
No	4	4
Total	111	100

The fifth table presents the status of growth in income of the entrepreneurs. 96% acknowledge that there is increment as well as consistency in their annual income. which 4% say there is no growth in their income. Increase income gives. Consistency and regularity of income strengthens the economy of any community. With the consistency and regularity of income they are able to plan well for their future

course of action. One of the important contributions of the tribal entrepreneurship playing important role in keeping the away from the clutches of money lenders and exploiters.

TABLE 6: Growth in living standard

Response	Frequency	Percentage
Yes	89	80
No	22	20
Total	111	100

The sixth table presents the status growth in living standard. 80% say there is growth in their living standard while 20% say there is no growth in their living standard. They are able afford the basic necessities of the life, they are able to send their children to good schools and there is also some increment is saving. Some of them have been able to make good house and there is also increment in their comforts. They do not need to depend on external support.

TABLE 7: Stopping migration

Response	Frequency	Percentage
Yes	111	100
No	0	0
Total	111	100

The seventh table presents the role of entrepreneurship in stopping migration. All of them (100%) say that entrepreneurship prevented them from migrating in search of joy opportunities and means of livelihood. Many of their neighbours have to looks other source of income to complete the family needs which is completed through migration of some of the family members. But there is no need of sending someone out of their family in search of job opportunities.

TABLE 8: Increasing Self-sufficiency

Response	Frequency	Percentage
Yes	98	88
No	13	12
Total	111	100

The eight table presents the increment of self-sufficiency. 88% entrepreneurs say that they that they have become economically self-sufficient while 12% say that they have not become self- sufficient. They have become self-sufficient in terms of securing self-employment, regular source of income and completing the needs of their life without any external support. They do not need to look for government schemes. Many of them experienced the growth in their social status after embracing the entrepreneurship.

The prescribed tables represent the status of tribal entrepreneurs in Gumla district. Their status in these parameters of sustainable economic development show a very positive response from the respondents. There is growth in their annual income, growth in the living standards, growth in their self-sufficiency and it has played a vital role stopping their migration in search of other opportunities of livelihood. They have helped the entrepreneurs in becoming self-sufficient. They are able to identify the opportunities of securing self-employment opportunities for themselves and creating constant source of income which leads towards the sustainable development.

One of the short comings of the tribal entrepreneurship is limited operational capacity and management capacity. The entrepreneurs have not been able to reach to the level of proving employment opportunities for the others. They are not able to go beyond the level of self- employment.

7. IMPLICATIONS

Economic development is often viewed as a core component of the broader development process. Ecological, social, cultural, political and ethical development are centred around economic development. The desire of rapid economic development often leads to destruction of ecological sustainability. Economic sustainability must grow hand in hand with ecological growth. Tribal communities present a beautify example of sustainable economic development. They have the potential of solving unbalanced economic. There is a need of learning from their good practices instead of imposing external understanding of development among them. The development of the tribals must be the blend tribal values and positive aspects modern development. Tribal development should not alienate them from their rich social, cultural, ethical, political, religious and economical values. Encouragement must be made to their efforts of combining their values with the modern development for the sustainable development among them.

8. LIMITATIONS

The research area covers the entrepreneurs of a very small territory for the study which may not represent all the cases. The sustainability perspectives of tribals of Chhota Nagpur is often misinterpreted as over conservative therefore it will not solve the problems of those having unending desire for wealth. There are different aspects of sustainable development which are not covered in this paper. The researchers have assumed that the tribal entrepreneurs know their value system.

9. FURTHER RESEARCH AGENDA

Tribal entrepreneurship is an emerging subject of study. Its role could be explored in the field of ecological, sociological, political, technological innovation, resource conservation and energy sustainability. Though entrepreneurship makes positive contribution in the life of entrepreneurs tribal do not have inclination towards it. As of now very few entrepreneurs have come to embrace the opportunities as

compared to the non-tribal groups in the society. There is need also a need of identifying proper mechanisms to encourage them for tribal.

10. CONCLUSION

Tribal were often seen as aberrant of development and entrepreneurship due to the financial risk associated with it. The changing scenario forced to embrace entrepreneurship in the context of decreasing opportunities which not only became conducive in solving the problem of unemployment, poverty, malnutrition and poor income but also played an important role in their sustainable economic development. Tribal entrepreneurship can be instrumental in creating a balanced world essential for the sustainable growth of the people in the lower strata specially the tribals by providing them with opportunities of growth. They are not anti-development but they seek sustainable development model corresponding with the value system. The Government, NGOs and other organization should support, guide and protect their development model for the further growth. They should avoid imposing the developmental models alien to them.

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TRACK 4: STRATEGIC MANAGEMENT

Effect of Government Support on Entrepreneurial Performance: A Perceptual Analysis

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ABSTRACT

In the era of contemporary development, entrepreneurship has drawn attention from both scholars and policymakers due to its inherent contribution towards the overall development in an economy. This in turn has compelled the nations to build a conducive entrepreneurial ecosystem to promote entrepreneurial culture among its netizens. The current study aims to examine the effect of government support on entrepreneurial performance of the early-stage ventures in the developing economy of India. The study uses primary data collected from 447 early-stage entrepreneurs through questionnaires. Regression analysis was conducted through SPSS to test the possible determining role of government support on entrepreneurial performance of these ventures. Being a perceptual study in nature, the current study employed 5-point Likert scale to evaluate the perception of the entrepreneurs towards the various dimensions of government support. Similarly, the entrepreneurial performance has been measured based on the entrepreneur's perception about his/her venture on multiple aspects ranging from the revenue growth to its brand value increment. The findings of this study suggest that government support has a positive and significant effect on entrepreneurial performance of early-stage ventures measured across multiple dimensions. The current study also supports the findings and hypothesis of the previous literature implying towards the unwavering role of government support in enhancing entrepreneurial performance of early-stage ventures.

Keywords: Government Support, Entrepreneurial Performance, Early-stage Ventures, Perception Study.

1. INTRODUCTION

Entrepreneurial activities are often considered as catalyst for the economic growth, employment generation, technological innovation, and societal transformation of a nation (Ordeñana et al., 2024; P. & M., 2022; Wong et al., 2005). Particularly in developing economies like India, fostering entrepreneurial culture is crucial as it can address the embedded structural challenges such as inequality in wealth distribution, inefficiency in resources utilization, and raising unemployment level (Koster & Rai, 2008; Pathak & Mukherjee, 2021). Early-staged entrepreneurs, defined as individuals involved in initiating and managing business ventures in their initial phases, play a critical role in strengthening the overall entrepreneurial ecosystem. By enhancing entrepreneurial activities with the sheer efforts from these early-stage entrepreneurs, developing economies often tackle obstacles pertaining to the societal challenges, balanced regional development, and building economic resilience (Doran et al., 2018; Munyo & Veiga, 2024; Stoica et al., 2020). However, the entrepreneurial journey of any business venture is often fraught with significant challenges, including limited financial support, inadequate infrastructure, inefficient mentorship, and regulatory complexities (Abaddi & AL-Shboul, 2024; Kabonga et al., 2021). These issues become more pronounced in case of early-stage entrepreneurs, who often fall short of the resources and business networking in order to sustain in a competitive market. In that regard, effective government support can help the early-stage entrepreneurs to overcome these challenges. Intervention of supporting government policies through conducive entrepreneurial ecosystem act as a crucial enabler for rapid entrepreneurial growth in the economy (Sampaio et al., 2018).

The term government support refers to a multifaceted construct that comprises a wider range of assistance including financial aid, infrastructural facilities, advisory and mentorship programmes, and regulatory relaxations that promote inclusivity and innovation. These initiatives from the governmental standpoint will accredit the entrepreneurs by reducing the systemic barriers and facilitating a favourable environment for business growth (Fotopoulos & Storey, 2019; Wei, 2022). To address these prevailing issues, the Government of India has launched multiple schemes and initiatives designed to nurture entrepreneurship in the country, such as Startup India Policy 2016, Stand-up India Policy 2016, establishment of business incubators and accelerators, conducting skill development programs, and sector-specific subsidy programs along with streamlined regulatory process. Although, policies focusing on entrepreneurship development are increasing with time, the

influence of government support on entrepreneurial performance still remains a subject of considerable debate, particularly in the context of early-stage entrepreneurs (Islam et al., 2018; Lanivich et al., 2021; Svetek, 2022). Previous studies have shown a divergence in their findings related to the probable impact of government support on entrepreneurial performance (Nakku et al., 2020a; Pulka et al., 2021). While some studies provided the evidence suggesting that government interventions through suitable policies and programs improve the performance of the business ventures (Farinha et al., 2020; Nakku et al., 2020b; Prasannath et al., 2024), others argued that the impact is inconsistent over time or is limited due to inefficiencies in implementation of policies and improper resource allocations (Buffart et al., 2020; Ibyzhanova et al., 2023). Also, to provide a convergence view of the subject matter, comprehending the performance indicators such as business survival, operational growth, market share expansion, and innovation output is crucial.

In a developing economy like India, where entrepreneurship is considered as a cornerstone for accomplishing sustainable and inclusive development, it is imperative to gain insights into the relationship between government support and entrepreneurial performance of the business ventures. Early-stage entrepreneurs, often considered as the most innovative yet vulnerable segment of the entrepreneurial ecosystem, can get immensely benefitted from well-planned and executed government support programs (Baral et al., 2023; Khokhawala & Iyer, 2024; Tiwari et al., 2019). Despite the rapid proliferation of academic studies concerning entrepreneurship, empirical studies focusing on the interplay between the dimensions of government support and its resultant impact on entrepreneurial performance within the Indian context is scarce. Extant literature often explored the topic in isolation or at macroeconomic level, which tends to neglect the context-specific and nuanced issues encountered by the early-stage entrepreneurs which significantly differs from the established business organisations (Islam et al., 2018; Marion et al., 2012; Rosenbusch et al., 2013). Moreover, the intricacies between forms of government support – financial, regulatory, networking, and policy – and entrepreneurial performance indicators like revenue growth, innovation outcome, market dominance, and operational scalability remains under-researched. This gap necessitates a comprehensive examination of the possible effects of government support on entrepreneurial outcomes with a strong backing of empirical evidence.

The current study aims to address this gap by examining the influence of government support on the entrepreneurial performance of the early-stage entrepreneurs in India. By leveraging on a robust empirical approach, this study seeks to establish evidence on the significant impact of government support on the entrepreneurial outcomes of a business ventures across multiple dimensions. The findings of the study will contribute largely towards the academic discourse on entrepreneurial support system and their role in fostering sustainable economic growth, while providing key insights for policymakers seeking to optimize the policy design. Ultimately, this study aspires to elevate the understanding of how government initiatives can promote a more resilient entrepreneurial ecosystem in India.

2. REVIEW OF LITERATURE

2.1. Forms of Government Support

Government support can be considered as a critical factor of entrepreneurial ecosystem, especially in emerging economies struggling with market inefficiencies often results in stagnant entrepreneurial growth. Government interventions through multiple forms such as funding assistance, leniency in regulatory frameworks, infrastructural development, and skill-building programs can significantly enhance entrepreneurial activities in an economy (Zhang & Ayele, 2022). For instance, subsidies on inputs, tax holidays and breaks, and lower-interest loans are certain financial tools that enable the entrepreneurs to gain access to the required capital for sustenance and expansion of their venture (Yusoff et al., 2021). Moreover, networking and collaborative support, such as the establishment of incubation centres and business accelerator programs provide essential mentorship and market connectivity to entrepreneurs, especially in their startup phase (Alkahtani et al., 2020; Pulka et al., 2021). Similarly, government intervention with policy and regulatory support can often promote the entrepreneurial culture in the economy thereby inducing the next generation of early-stage entrepreneurs. Kodithuwakku & Rosa (2002) in their study have emphasized on the fact that simplified registration procedures, minimal bureaucratic involvement, and protection of intellectual property can significantly improve the ease of doing business. Furthermore, sector-specific policies focusing on high-growth industries, such as technology and renewable energy, tend to reward innovation and attract more efficiency (Opute et al., 2021). However, proper design and efficient execution are the decisive factors for the effectiveness of these of the government policies and programs. Few studies have suggested that highly complexed policies or misjudged incentive planning can result in entrepreneurial inefficiencies, ultimately depending upon subsidies(Minniti, 2008). This warrants for a targeted and context-specific support system designed considering the unique attributes of the early-stage entrepreneurs.

2.2. Dimensions of Entrepreneurial Performance

The construct of entrepreneurial performance is a multifaceted one, as evident from the extant literature, encompassing operational, financial, and innovation-oriented outcomes. Key performance indicators mostly include revenue generation, market expansion, employment generation, product or service innovation, efficient cost reduction, and maintaining liquidity positions (Fried & Tauer, 2015; Murphy et al., 1996; Rauch et al., 2009; Wach

et al., 2016). These metrices are used widely across the domain to assess the viability and success of entrepreneurial ventures across a diverse range of industries.

Also, previous studies have highlighted several intrinsic and extrinsic factors that play a role in influencing the entrepreneurial performance of their venture. Internal characteristics such as entrepreneurial orientation, resilience, and strategic decision-making are crucial for entrepreneurial success (Sturm et al., 2023; Zighan et al., 2022). Similarly, the external factors like easy access to resources, business opportunities, and conducive institutional support system improves the likelihood of favorable entrepreneurial outcomes (Ahsan et al., 2021; Deng et al., 2024) Arguably, early-stage entrepreneurs are more vulnerable towards the external constraints, such as funding shortage, market barriers, lack of efficient mentorship, which can hinder their performance over time (López Pérez et al., 2024). The empirical evidence advanced in the previous studies emphasize the positive impact of external support system on various dimensions of entrepreneurial performance. For instance, adequate funding support reduces the liquidity constraints, that allows the entrepreneurs to invest in capacity building and market penetration (Chow & Fung, 2000; Shaikh et al., 2024). Similarly, non-financial support, such as skill development and mentorship programs empower the entrepreneurs to gain knowledge and business networks required for a competitive market (Hu & Liu, 2022).

The intricacies involved in between government support and entrepreneurial performance has garnered a considerable interest among the scholars of the entrepreneurship domain. Numerous studies have contended that implementation of efficient government policies can significantly improve the entrepreneurial performance of the business ventures by addressing the systemic and structural barriers of the ecosystem. For example, (Abdesselam et al., 2018) provided evidence that favorable government policies results in higher entrepreneurial activity and enhanced venture performance when studied in the context of entrepreneurs from OECD countries. Similarly, another study conducted by Lazzarini (2015) demonstrated that firm-level productivity and competitiveness among the entrepreneurial founders can be achieved with proper government intervention with special attention towards the innovation and knowledge dissemination among the early-stage entrepreneurs.

When studies from the Indian perspective, government initiatives such as Startup India and Make in India demonstrates the possible impact of government support to enhance entrepreneurial performance. A study conducted by Mittal & Madan (2020) corroborate the above argument by showing empirical evidence that both financial and non-financial incentives under these programs has positively influenced the revenue growth and market expansion of the early-stage entrepreneurial ventures. Moreover, Sandhu & Hussain (2021)in their research emphasized the effective role of policy reforms in reducing the market entry barriers and developing conducive business environment for early-stage entrepreneurs.

However, the real challenge remains in converting the government support policies into tangible entrepreneurial outcomes. For example, poor allocation of subsidies and excessive reliance on state-driven initiatives can hinder market-driven innovation Lim & Su (2023) This highlights the importance of proper designing of support systems that cope with the entrepreneurial needs and market realities.

In summary, the extant literature has established a concrete theoretical and empirical foundation that links government support to entrepreneurial performance. While both financial and non-financial support mechanisms positively influence a wide range of performance metrics, the effectiveness of such support mechanisms relies on their contextual relevance and implementation efficacy. The current study builds on these key insights to further advance the understanding on how government support influences the performance of the early-stage entrepreneurs in India, thereby addressing a critical gap in the existing literature.

3. RESEARCH METHODOLOGY

The current study adopts a quantitative research design to evaluate the influence of government support on the entrepreneurial performance of the early-stage entrepreneurs in India. The study is exploratory in nature, aiming to establish a causal relationship between the above-mentioned variables through empirical evidence. The target population for this study comprises of the early-stage entrepreneurs, defined as individuals who have started a business venture within the last 5 years i.e. between January 2019 to December 2023. Early-stage entrepreneurial ventures are considered as a crucial part of the entrepreneurial ecosystem of any economy, as they navigate the initial challenges of establishing and sustaining their business venture. To collect the data required for the study, a purposive sampling method was select participants meeting the study's criteria of being early-stage entrepreneurs. In order to expand the sample pool and ensure the diversity of sample, the snowfall sampling technique was utilized, where the existing participants referred to other entrepreneurs deeming fit to our study. This approach helped the enumerators to reach a wide range of early-stage entrepreneurs across multiple industries and geographic locations within India. The final usable sample consists of responses from 447 early-stage entrepreneurs who participated in the study, providing a robust sample for analysis.

The study has defined 'Government support (GS)' as independent variable, measured through a structured survey evaluating the participants' perception of financial, infrastructural, and policy support by the government. Similarly, 'Entrepreneurial Performance (EP)' has been considered as the dependent variable, measured through a

various performance indicators ranging from revenue growth, market expansion, and innovation outcomes. Both the dependent and independent variables were measured on 5-point Likert scale, in which the respondents indicated their level of agreement with the statements related to the particular construct. The questionnaire administered to collect the data from the respondents was designed based on the scales validated in the previous relevant studies to ensure reliability and validity of the collected data. Respondents participated in the survey were assured of the confidentiality of their responses to encourage them to provide honest and accurate reporting free from possible bias. A simple linear regression analysis was conducted to examine the possible interrelationship between government support and entrepreneurial performance. The motive behind choosing this technique was to allow for assessing the assumed direct influence of an independent variable (GS) on a dependent variable (EP). The regression analysis was performed using the SPSS software, version 25.

The sampling method, purposive and snowfall sampling, was used to ensure the inclusion of relevant participants while facilitating access to a wider network of early-stage entrepreneurs. Also, the use of simple linear regression as an analysis technique is considered suitable for this study as it provides a clear yet robust method to test the hypothesized relationship between GS and EP. Furthermore, SPSS software provides reliable statistical tools to conduct the required analysis and interpret the results in an accurate manner. To empirically verify the interrelationship between government support and entrepreneurial performance of the early-stage entrepreneurs the following hypothesis has been formulated for verification.

H1: Government support in various forms has a positive significant influence on the performance of the early-stage entrepreneurs in India.

4. DATA ANALYSIS AND INTERPRETATION

A simple linear regression analysis was conducted using the SPSS software to examine the possible influence of government support on the entrepreneurial performance of the early-stage entrepreneurs in India. The hypothesis (H1) was tested to verify the presumptions made about the probable role of government support in enhancing entrepreneurial performance of the venture.

$$EP = \beta 0 + \beta 1 * GS + \epsilon$$

Where, EP = Entrepreneurial performance, and GS = Government support.

The regression model used the 'Enter method', that allows for the simultaneous inclusion of the selected independent variable into the equation in order to assess its impact on the given dependent variable. The analysis primarily focused on evaluating whether government support significantly predicts the changes in the entrepreneurial performance.

TABLE 1: Descriptive Statistics

Descriptive Statistics			
	Mean	Std. Deviation	N
EP	3.8978	.96236	447
GF	4.1478	.46156	447

Prior to the regression analysis, descriptive statistics were calculated to provide a summarized view of the characteristics of the data. The mean value of entrepreneurial performance (EP) stood at 3.89 with S.D. of 0.96, indicating a moderate perception of support among respondents. Government support (GS) obtained a mean of 4.14 with S.D. at 0.46, indicating a higher average performance level. Consequently, the summary of the regression analysis is shown in Table 2 below.

The dependent variable EP was regressed on predicting variable GS to test the H1. GS significantly predicted EP, $F(1, 445) = 300.520$, $p < 0.001$, which indicates that the GS can play a significant role in shaping EP ($b = 1.324$, $p < 0.001$). The obtained results clearly depict the positive significant influence of GS on EP. Moreover, the coefficient of determination (R^2) = 0.403 indicates that approximately 40.3% of the variance in EP can be explained by GS. This suggests a moderate to strong relationship between the two selected variables. Table 3 below shows the summary of the findings.

TABLE 2: Model Summary

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R2 Change	F Change	df1	df2	Sig. F Change
1	.635a	.403	.402	.74435	.403	300.520	1	445	.000
a. Predictors: (Constant), Mean_GF									
b. Dependent Variable: Mean_EP									

The unstandardised coefficient (B) = 1.324, indicated that for every one-unit increase in GS, the EP increases by 1.324 units, considering all other variables constant. The standardised coefficient (β) = 0.635 reflects that GS has a strong positive influence on EP. The result obtained in the analysis is highly significant ($p<0.001$) (Knief & Forstmeier, 2021).

TABLE 3: Summary of Findings

Hypothesis	Regression Weights	Beta Coefficient	R2	F	p-value	Hypothesis Supported
H1	GS → EP	1.324	.403	300.520	0.000	Yes

*Note: *p < 0.05, GS = Government support, EP = Entrepreneurial Performance*

The results of the regression analysis confirms that the independent variable government support (GS) is a significant predictor of the dependent variable entrepreneurial performance (EP). The positive coefficient indicates that higher levels of perceived government support are linked with enhanced entrepreneurial performance of the early-stage entrepreneurs. This aligns with the findings of the previous studies emphasizing the vital role of government support through various forms such as financial assistance, infrastructural development, and regulatory support in improving entrepreneurial outcomes of the business venture (Alkahtani et al., 2020; Hassan, 2024; Osei & Zhuang, 2024; Pergelova & Angulo-Ruiz, 2014; Shu et al., 2019).

5. FINDINGS AND IMPLICATIONS OF THE STUDY

The primary objective of this study was to examine whether government support (GS) significantly influences the entrepreneurial performance (EP) of the early-stage entrepreneurs in India. The results of the analysis highlighted some key findings for the study. Firstly, the independent variable, government support, was found to exhibit a statistically significant positive influence on the dependent variable, entrepreneurial performance, suggesting that a higher level of government support is associated with enhanced and improved performance of early-stage entrepreneurial ventures. Secondly, the regression model demonstrated that approximately 40.3% of the variance in entrepreneurial performance could be explained by government support, showing a substantial role of GS on EP. Thirdly, the value of unstandardized regression coefficient obtained at 1.324, which indicates that an unit increase in perceived government support can lead to a proportional improvement in entrepreneurial performance, highlighting the practical relevance of government support, especially in a developing economy like India.

The empirical findings obtained in this study align with the extant literature emphasizing the vital role of supportive government interventions in promoting the entrepreneurial performance of the early-stage entrepreneurs. They further highlight the role of government support as a crucial factor in developing a conducive entrepreneurial ecosystems, particularly in emerging economies like India.

The current study advances the knowledge base on the entrepreneurial ecosystem by providing empirical evidence on the interrelationship between government support and entrepreneurial performance based on the perception of the early-stage entrepreneurs of India. This fills the gap in the existing literature by considering the early-stage entrepreneurs in the Indian context, a research area that has received scarce attention from the scholars in the recent times. Furthermore, the empirical findings of this study support the existing theoretical frameworks by highlighting the importance of institutional support for fostering entrepreneurial success. Also, the study offers some practical implications as well. For instance, the forms of government support that has been advocated in the study can be considered by the policymakers while drafting policies and programs to promote entrepreneurship in the economy. This will be immensely relevant for better outcomes as the study has advanced the findings based on the perception of the early-stage entrepreneurs from varied sector and locations across India. These implications are quite significant for policymakers, emphasizing the need for continuous and optimized government interventions for better entrepreneurial performance.

6. CONCLUSION AND FURTHER RESEARCH AGENDA

The current study was conducted with an objective to examine the interlink between the provision of government support and its resultant impact on the entrepreneurial performance of the early-stage entrepreneurs in Indian context. The study adopted a quantitative research method to offer empirical evidence on the proposed hypothesis. The findings of the study affirm the significant influence of government support on the entrepreneurial outcomes of the early-stage entrepreneurs of India in a positive manner. Supportive government policies and programs can effectively enable the entrepreneurs to overcome the systemic barriers which further enhance their entrepreneurial performance. By helping the stakeholders in policy formulation, entrepreneurship development, and strategizing economic growth, the implication of this study extends beyond the academic discourse. Although the current study underscores a key aspect of entrepreneurial ecosystem by considering the impact of government support on entrepreneurial performance, the study limits itself by ignoring the other relevant factors affecting the entrepreneurial performance of the business ventures as described on the previous literature. Future studies consider additional variables along with government support, such as prevailing market conditions, accessibility towards business networks, and entrepreneurial orientation of the entrepreneur, in order to build a more comprehensive and elucidating model. Also, sector specific studies can be of another avenue for further research, which can focus on identifying the nuanced sectoral differences as a consequence of government support. Future research could further explore the various dimensions government support to identify and focus on the specific areas with the highest impact on entrepreneurial outcomes.

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Mission Shakti: A Path towards Sustainable Livelihood and Social Entrepreneurship

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ABSTRACT

Research Objective: In these days, where United Nations created Sustainable Development Goals (SDGs) which are critical call for action by all the developing as well as developed countries but in India, Odisha's government initiative, Mission Shakti, a program existing for more than 20 years aiming for Sustainable Livelihood, women empowerment and poverty alleviation of underprivileged women by Self-Help Groups through different income generating activities and ultimately social entrepreneurship. This paper has attempted to examine the Mission Shakti program in building Sustainable Livelihoods and promoting social entrepreneurship.

Methodology: A framework showing relationship between dependent and independent variables has been developed. Also, hypothesis has been constructed. Both primary and secondary data has been used for a comprehensive analysis such as Chi-Square test. The primary data has been collected through a structured questionnaire distributed to the self-Help Groups of selected districts of Odisha.

Major Findings: It has been found that the program indeed a revolutionary initiative by the state government to overcome the poverty and become a path towards Sustainable Livelihood and Social Entrepreneurship. The study has some limitations. Besides it might help the researchers, policy makers and local authorities who are involved in the concerned area to broaden the sphere in a possible way as to ensure the sustainability of any given project.

Keywords: Mission Shakti, Self-Help Group (SHG), Sustainable Livelihood, Social Entrepreneurship.

1. INTRODUCTION

The sustainable livelihood management is a method of analysing and changing the lives of people experiencing poverty and disadvantages. All people have abilities and assets that can be developed to help them improve their lives. The components of sustainable livelihood framework are people-centred, holistic, dynamic, building on strengths, macro-micro links and sustainability.

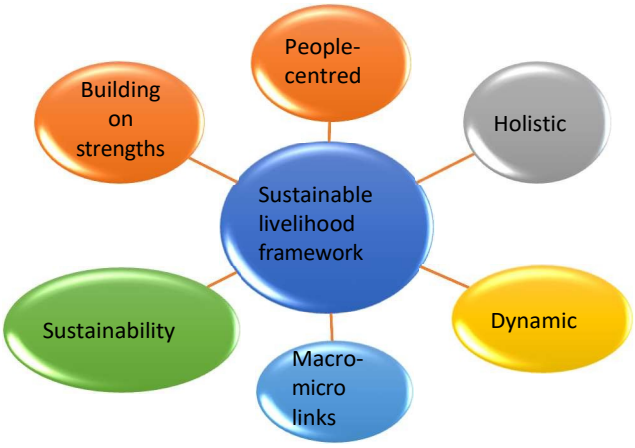


Fig. 1.1 Components of sustainable livelihood Framework

One of the schemes launched for socio-economic development of women which crossed a huge milestone is Women Self- Help Groups (WSHGs). group. The idea of SHGs gained popularity in rural development, women's empowerment, and the fight against poverty. Women's empowerment initiatives must be prioritised in order to end poverty, spur economic progress, and improve living conditions.

On 8th March 2001, "Mission Shakti Programme" was introduced in Odisha, with the goal of empowering underprivileged women by organising them into small groups and teaching them good saving practises. The main target group of the programme are SHG members. However, a very small number of SHGs have also progressed beyond money lending by taking part in income-generating activities, but these activities are still limited to the production of spices, pickles, badis, and papad, etc. No one can also dispute the fact that a select few SHGs have developed businesses worth lakhs of rupees, but these few do not speak for all SHGs.

For this reason, the government of Odisha introduced a new project that aims to broaden the peripheral operations of SHGs outside the confines of four walls and that is the convergence of "Mission Shakti" with 10 Government Departments for the provision of services and the

acquisition of commodities. No doubt Mission Shakti aims to provide sustainable livelihood to the poor and helps in transforming SHGs to SMEs (Small and Medium- sized enterprises).

Moreover, entrepreneurship is the pursuit of starting, managing, and scaling a business. It involves combining

innovation, skills, and vision to develop new products, services, or ideas that meet market demand and create value for a target audience. Entrepreneurship is categorized into four main types and social entrepreneurs is one of them and others are small businesses, scalable startups and large companies. Social entrepreneurship is the application of the ideas and advice used by entrepreneurs and start-up founders to a company that directly affects a social cause or creates social change. Reducing systemic social or cultural issues is the main driving force behind social entrepreneurs. In this case the social issue is gender inequality, patriarchy, poverty, unemployment, illiteracy, malnutrition and many more. The objective of Mission Shakti program is somehow addressing these issues and promoting social entrepreneurship with the help of SHGs.

Here, the research question is whether Mission Shakti Program in Odisha achieving its goals or not. The goal is to empower women and make Odisha a land of equal opportunities irrespective of gender, where women live with dignity and in good economic and social condition. Hence, the objective is to study the effect of Mission Shakti Program on the Sustainable Livelihoods of women in the Self-help group and whether the program promotes Social Entrepreneurship and bring social change in the society.

Sambalpur District at a Glance

The western most District of Odisha, Sambalpur District with a geographical area of 6,702.00 Sq.Km and having 50.18% under forest area. The number of blocks in the district is 9 with 1322 number of villages. The blocks are Bamra, Jamankira, Jujomora, Kuchinda, Maneswar, Naktideul, Rairakhol, Rengali, Dhankauda (Sadar Block). The district has three sub-divisions, Kuchinda, Rairakhol and Sambalpur.

The economy of Sambalpur District is basically dependent on agriculture and secondly on forests. Forests play an important role in the economy in terms of contribution to revenue, Domestic Product as well as dependence of people for livelihood. The people living adjacent to the reserved forests of Sambalpur Forest Division are heavily dependent on these forests. The total population of the district is 1,041,099 (2011 census). The male and female population is respectively 526,877 and 514,222 constituting 50.61% and 49.39% of the total population. The rural and urban population is respectively 733,006 and 308,093 constituting 70.41% and 29.59%. SC and ST population comprises of 18.43% and 34.12% of total population of the district. The overall literacy rate of female is 44.12% and illiterate female is 60.38%. The rural households comprise 73.99% of the total households in the district.

Sambalpur district of the Odisha state is famous for its hand loom textile works, popularly known as Sambalpuri Textile. It has earned international fame for its unique pattern, design and texture. Apart from textiles, Sambalpur has a rich tribal heritage and fabulous forestlands.

2. LITERATURE REVIEW

The functional structure of Mission Shakti has been analysed from top to bottom of the hierarchy along with the performance of the programme at grass root level. It has been found that WSHG is an agent of development for its members, it provides opportunity for the members to earn from new and independent sources, in post-WSHG period members are encouraged towards financial institution and they are more interested towards production- oriented loan too. Poor deliver system, lack of training, shortage of fund, lack of internal democracy etc. are common problems faced by members in WSHG. (Jnanaranjan Mohanty, 2015)

SHG model is a noteworthy endeavour for women's empowerment. The involvement of SHG women in different Govt. department activities not only makes the operation process vibrant but will also ensure transparency by reducing the possibilities of corruption in the system. A careful analysis of the new scheme makes one realize that it has the transformative potential to challenge the patriarchy by broadening the working spheres of WSHGs from four walls of the domestic sphere to a public platform. (Singh, 2020)

There has been impact of micro finance on income generation and livelihood of members of self-help groups. The study showed that there is an increase in the level of income and assets of the rural women of SHGs and reduction in the level of poverty as a result of intervention of micro finance by SHGs. The study indicates that the women who are involving themselves in economic activities and are able to earn independently are taking independent decisions in panchayat raj institutions. (K. Sivachithappa, 2013)

The determinants of empowerment of SHGs has been examined empirically as micro finance clients to microenterprise investors and problems faced by them in this transition as well as in undertaking microenterprises on a viable and sustainable basis. Micro finance can be an effective strategic instrument for poverty alleviation only if it used for income generating microenterprise development. The SHG-Bank linkage has already proved as the most appropriate and cost-effective mechanism for financing the poor. The NGOs should be encouraged more to play as facilitators rather than financiers. (Suprabha K. R, 2014). The concept of empowerment of women along with SHGs linkage microfinance growth and also explains current position of women empowerment in India has been discussed in detail where Self-help Groups emerge as an important strategy for women empowering women and poverty elimination. Self-Help Groups is pro poor people scheme and it is organization is significant step towards empowering women. The intention SHGs is not only to reduce rural poverty but also increase the gainful employment in rural economy. (Thipperudrappa.E et.al., 2018)

The effectiveness of self-help groups in their developmental influences on the livelihood security and gender

empowerment has been examined and found that there was a definite improvement on all aspects related to empowerment and livelihood security after joining the SHGs as compared to before joining the SHG as there was positive impact in all types of groups. This may be due to the fact that the group processes improve the human capability of its members to deal with life conditions with confidence in a better way. (Nishi Sharma et.al., 2014). To gain meaningful insights into a microfinance programme in two different agro- ecological settings has been conducted in India. It is found that the programme has by-passed the poorest of the poor. It is observed, however, that participation in microfinance has a positive and significant impact on women empowerment. (Simantini and Bimal, 2016)

The role of self-help groups (SHGs) in providing an environment for the empowerment of Indian rural women has been examined and argued that the SHG empowerment strategy paves the way for the process of development of bottom-up empowerment of women. SHG is a systematic strategy and is not solely based on credit, but also incorporates many other dimensions necessarily required for developing an empowerment process. (Pallavi and Parul, 2017)

3. RESEARCH GAP

- There are many studies showing the different framework of sustainable livelihood of the Self-Help Group. But in this study, it focuses on the effect of the factors of Mission Shakti on the sustainable livelihood development of the Self-Help Group members.
- The paper discussed about the indicators of sustainable livelihood and social entrepreneurship and emphasized more on the individual's experience and their quality of life.
- There are not sufficient study showing the linkage between the factors of the Mission Shakti program and social entrepreneurship.

4. METHODOLOGY

The research methodology used to study the impact of Mission Shakti Programme on the factors such as sustainable livelihood, financial inclusion, women empowerment and socio- economic development of SHG members of selected blocks in the district of Sambalpur in Odisha will be based on both primary and secondary data. A conceptual framework showing relationship between dependent and independent variables has been developed. Some hypothesis has also been constructed.

Data Collection

The research relies on both primary and secondary data. The primary data will be collected through well-structured questionnaire, interviews, key informant survey and focus group discussions (FGDs) of the self-Help Groups of Sambalpur district of Odisha. Where as the secondary data has been collected from the websites, journals, newspapers, magazines, and reports on Self-Help Groups.

Conceptual Framework of Sustainable Livelihood Indicator

After reviewing the literatures, the following framework is suggested for the sustainable livelihood of the women of the self-help group specially in rural areas. But can be applied in case of both urban and rural self-help group members. The below framework and model defines the dimensions of sustainable livelihood and their indicators.

TABLE 4.1: Indicators of Sustainable Livelihood

Dimensions	Indicators
Social	Gender equality & empowerment Improving women's access to rights and resources. Independent decision maker
Economic	Financial independence Increase in income & asset Travelling and mode of transportation
Well-being & Quality of Life	Access to better healthcare facility Education to women & their children Standard of living
Resilience	Enhanced ability to cope with and recover from shocks and stresses Maintaining or improving their livelihood over time

In this study, four dimensions has been considered namely social, economic, well-being & quality of life and resilience. The above table shows the dimensions and their specified indicators.

5. CONCEPTUAL MODEL

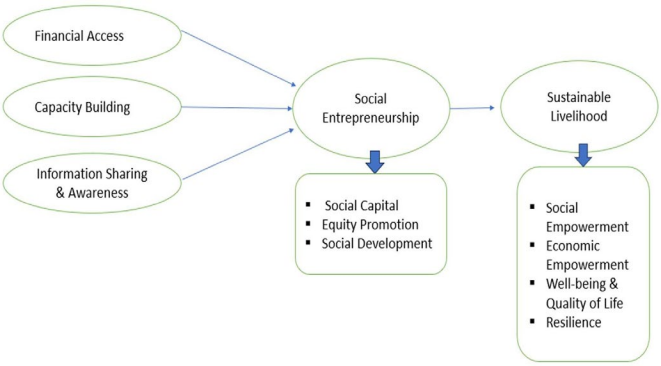
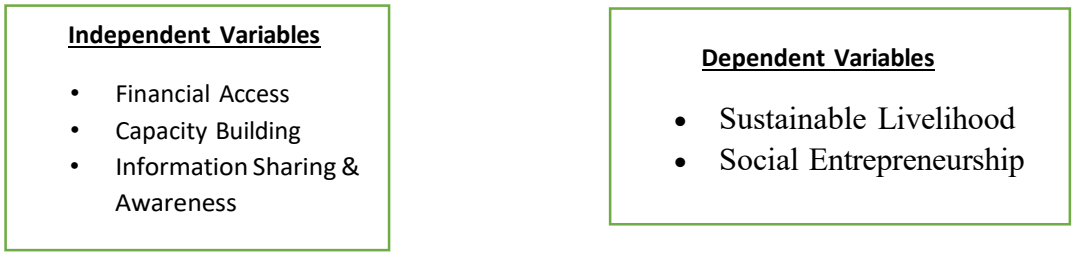


Fig 4.1: Conceptual Model showing factors involving social entrepreneurship and Sustainable Livelihood



Based on the framework a conceptual model is prepared having factors of Self-help group of the Mission Shakti program and indicators of social entrepreneurship and the outcomes of sustainable livelihood. The specified factors of Self-help group are financial access, capacity building and information sharing and awareness are considered as independent variables in the research. The model also contains indicators of social entrepreneurship and the outcomes of sustainable livelihood which are considered as dependent variables.

Hypothesis Developed

Based on the literature review support, the following hypotheses are postulated:

- **H1**: Financial Access has a significant effect on Social Entrepreneurship.
- **H2**: Capacity Building has a significant effect on Social Entrepreneurship.
- **H3:** Information Sharing & Awareness has a significant effect on Social Entrepreneurship
- **H4**: Social Entrepreneurship has a significant effect on Sustainable Livelihood

Sampling

The sample of the research will be drawn from different selected blocks of Sambalpur district where income generating activities are going on through Mission Shakti Programmes. The data will be collected through multi-stage simple random sampling technique and convenience sampling for selecting a representative sample.

In Sambalpur district, out of nine blocks, three blocks are selected namely Dhankuada, Jujumura and Maneswar. The study is based on women members of SHG of Sambalpur district. There are **11,355** Women Self Help Groups (WSHG) and a total of **1,12,294** members in the district (https://missionshakti.odisha.gov.in/ district-pages/sambalpur), which constitute the population. And so the population consists of **1,12,294** women members associated with **11,355** WSHG spread over **9** blocks of Sambalpur district. Only **113** women from the WSHG were allowed to take part in the study, due to time restrictions. These **113** women were randomly chosen from **3** blocks to make up the sample for the pilot study.

TABLE 4.2: Sampling data

Block	Gram Panchayat	Village	Activity	Name of the SHG	Members
Dhankuada	Kilasama	Balbaspur	Fish Culture	Alibha	10
				Jay Maa Durga	6
				Subhashree SHG	11
				Manisha	10
Jujumra	Kabrapali	Kabrapali	Floriculture (Gendu)	Bhagya laxmi	10
				Maa Tulashi	9
				Jay Maa Bhawani	7
			Chattua making	Maa Saraswati SHG Kabarapali	8
Maneswar	Nuadihura	Nuamura	Floriculture (Gendu)	Bijaya laxmi SHG	10
				Jay Jagannath	12
				Laxmi Narayani SHG	10
			Mushroom farming	Maa Ramchandi	10
Total number					**113**

Demographic Characteristic of the Sample

The respondents were asked for their demographic profile in the questionnaire at the time of data collection. The demographic profile included their age, social category, education, occupation and income. These were analysed as follows:

TABLE 4.3: Age of the Respondents

Age

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Below 30 years	7	6.2	6.2	6.2
31 to 40 years	69	61.1	61.1	67.3
41 to 50 years	29	25.7	25.7	92.9
above 50 years	8	7.1	7.1	100.0
Total	113	100.0	100.0	

TABLE 4.4: Education of the Respondents

Education

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Up to high school	34	30.1	30.1	30.1
Matriculation	39	34.5	34.5	64.6
Up to 12th	30	26.5	26.5	91.2
Graduation & above	10	8.8	8.8	100.0
Total	113	100.0	100.0	

TABLE 4.5: Occupation of the Respondents

Occupation

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Housewife	67	59.3	59.3	59.3
Farmer	23	20.4	20.4	79.6
Labour	10	8.8	8.8	88.5
self-employed	13	11.5	11.5	100.0
Total	113	100.0	100.0	

TABLE 4.6: Income of the Respondents

Income

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Less than Rs. 5000	68	60.2	60.2	60.2
Rs.5000 to Rs.10,000	29	25.7	25.7	85.8
Rs.10,000 to 20,000	15	13.3	13.3	99.1
Rs. 20,000 & above	1	.9	.9	100.0
Total	113	100.0	100.0	

TABLE 4.7: Social Category of the Respondents

Social Category

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Others	1	.9	.9	.9
OBC	58	51.3	51.3	52.2
ST	50	44.2	44.2	96.5
SC	4	3.5	3.5	100.0
Total	113	100.0	100.0	

The demographic profiles shows that most of the respondent are of the age category of 31- 40 years having education qualification less than graduation. The monthly income of most of the respondents are less than Rs. 5000 as most of them are housewife. This indicates that most of them come under below poverty line. The respondents almost equally belong to the social category of OBC and ST and some of them also belong to SC and other category.

6. RELIABILITY TEST

To measure the scale reliability of questionnaire, Cronbach's alpha is used. It shows the measurement of the internal consistency, which shows the close relativeness of a set of items as a group.

TABLE 4.8: Reliability Statistics

Cronbach's Alpha	N of Items
.867	25

The above table shows the reliability statistics, in which the Cronbach's alpha value is 0.867 which means the scale of the data is reliable. It suggests that the items have relatively high internal consistency (In general, when the Cronbach's alpha, $0.8 > \alpha > 0.7$, then the internal consistency is acceptable).

TABLE 4.9: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
SL1	113	3.00	5.00	4.1858	.64847
SL2	113	3.00	5.00	4.2124	.54201
SL3	113	3.00	5.00	4.1416	.62489
SL4	113	3.00	5.00	3.9646	.76683
SL5	113	3.00	5.00	4.0442	.68647
FA1	113	3.00	5.00	3.9823	.74381
FA2	113	3.00	5.00	4.2212	.59363
FA3	113	3.00	5.00	4.0265	.74953
FA4	113	3.00	5.00	4.1593	.62058
FA5	113	3.00	5.00	3.9646	.66721

CB1	113	3.00	5.00	4.0177	.68115
CB2	113	3.00	5.00	4.0265	.74953
CB3	113	3.00	5.00	3.9735	.64725
CB4	113	3.00	5.00	4.0354	.69345
CB5	113	3.00	5.00	3.9204	.75760
IA1	113	3.00	5.00	3.9735	.70026
IA2	113	3.00	5.00	4.1062	.65958
IA3	113	3.00	5.00	3.9912	.77339
IA4	113	3.00	5.00	4.1327	.63393
IA5	113	3.00	5.00	4.1504	.58586
SE1	113	3.00	5.00	4.1150	.65127
SE2	113	3.00	5.00	3.9735	.67427
SE3	113	3.00	5.00	4.0885	.67556
SE4	113	3.00	5.00	4.0796	.69618
SE5	113	3.00	5.00	4.1327	.66150
Valid N (listwise)	113				

TABLE 4.10: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	.769
Bartlett's Test of Sphericity Approx. Chi-Square	973.612
df	300
Sig.	.000

A KMO value over 0.5 and a significance level for the Bartlett's test below 0.05 suggest there is substantial correlation in the data. Here the KMO value is 0.769 and significance level is 0.00 which is less than 0.05. this indicates that the sampling was adequate in conducting the next stage of factor analysis.

7. RESULTS OF NORMALITY ANALYSIS

TABLE 4.11: Descriptive Statistics

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
SL1	113	-.199	.227	-.655	.451
SL2	113	.111	.227	-.113	.451
SL3	113	-.108	.227	-.467	.451
SL4	113	.060	.227	-1.286	.451
SL5	113	-.057	.227	-.845	.451
FA1	113	.029	.227	-1.175	.451
FA2	113	-.105	.227	-.406	.451
FA3	113	-.043	.227	-1.203	.451
FA4	113	-.117	.227	-.458	.451
FA5	113	.040	.227	-.714	.451
CB1	113	-.022	.227	-.809	.451
CB2	113	-.043	.227	-1.203	.451
CB3	113	.025	.227	-.566	.451
CB4	113	-.047	.227	-.889	.451
CB5	113	.134	.227	-1.235	.451
IA1	113	.036	.227	-.931	.451
IA2	113	-.116	.227	-.681	.451
IA3	113	.015	.227	-1.318	.451
IA4	113	-.114	.227	-.521	.451
IA5	113	-.033	.227	-.190	.451
SE1	113	-.117	.227	-.629	.451
SE2	113	.031	.227	-.763	.451
SE3	113	-.108	.227	-.781	.451
SE4	113	-.108	.227	-.908	.451
SE5	113	-.150	.227	-.705	.451
Valid N (listwise)	113				

The above tables show the normality of the data by various descriptive statistics like standard deviation, skewness and kurtosis. When the skewness is zero the distribution is normal. The above both the tables show that the data is normally distributed.

Correlation

Relationship between Financial Access and Social Entrepreneurship

TABLE 4.12: Correlations

		Financial Access	Social Entrepreneurship
Financial Access	Pearson Correlation	1	.669**
	Sig. (2-tailed)		.000
	N	113	113
Social Entrepreneurship	Pearson Correlation	.669**	1
	Sig. (2-tailed)	.000	
	N	113	113

The above table shows the correlation statistics between two factors that are financial access and social entrepreneurship. The result shows that the Pearson correlation coefficient for financial access and social entrepreneurship is 0.669, which shows a fairly strong positive correlation, which is significant ($p < 0.01$ for two-tailed test). It indicates a positive relationship between financial access and social entrepreneurship, which define the first hypothesis (H1) in the study.

Relationship between Capacity Building and Social Entrepreneurship

TABLE 4.13: Correlations

		Social Entrepreneurship	Capacity Building
Social Entrepreneurship	Pearson Correlation	1	.439**
	Sig. (2-tailed)		.000
	N	113	113
Capacity Building	Pearson Correlation	.439**	1
	Sig. (2-tailed)	.000	
	N	113	113

The above table shows the correlation statistics between two factors that are Capacity Building and social entrepreneurship. The result shows that the Pearson correlation coefficient for Capacity Building and social entrepreneurship is 0.439, which shows a moderate positive correlation, which is significant ($p < 0.01$ for two-tailed test). It indicates a positive relationship between Capacity Building and social entrepreneurship, which define the second hypothesis (H2) in the study.

Relationship between Information Sharing & Awareness and Social Entrepreneurship

TABLE 4.14: Correlations

		Social Entrepreneurship	Information Sharing & Awareness
Social Entrepreneurship	Pearson Correlation	1	.665**
	Sig. (2-tailed)		.000
	N	113	113
Information Sharing &	Pearson Correlation	.665**	1
Awareness	Sig. (2-tailed)	.000	
	N	113	113

The above table shows the correlation statistics between two factors that are Information Sharing & Awareness and social entrepreneurship. The result shows that the Pearson correlation coefficient for Information Sharing & Awareness and social entrepreneurship is 0.665, which shows a fairly strong positive correlation, which is significant ($p < 0.01$ for two- tailed test). It indicates a positive relationship between Information Sharing & Awareness and social entrepreneurship, which define the third hypothesis (H3) in the study.

Relationship between Sustainable Livelihood and Social Entrepreneurship

TABLE 4.15: Correlations

		Social Entrepreneurship	Sustainable Livelihood
Social Entrepreneurship	Pearson Correlation	1	.457**
	Sig. (2-tailed)		.000
	N	113	113
Sustainable Livelihood	Pearson Correlation	.457**	1
	Sig. (2-tailed)	.000	
	N	113	113

The above table shows the correlation statistics between two factors that are Sustainable Livelihood and social entrepreneurship. The result shows that the Pearson correlation coefficient for Sustainable Livelihood and social entrepreneurship is 0.457, which shows a moderate positive correlation, which is significant ($p < 0.01$ for two-tailed test). It indicates a positive relationship between Sustainable Livelihood and social entrepreneurship, which define the fourth hypothesis (H4) in the study.

8. FINDINGS

The present study was undertaken to establish the nature and extent of inter-relationships that exists between the factors of Mission shakti and social entrepreneurship and sustainable livelihood. The followings are the major findings of the study:

- The factors such as financial access (FA) and information sharing and awareness (IA) have a fairly strong positive correlation with social entrepreneurship which means the first two independent variable increasing are strong indicators of the dependent variable increasing. But this correlation doesn't necessarily mean that one variable is causing the other.
- The Capacity Building and social entrepreneurship have a moderate positive correlation between them. This means the capacity building of the SHG can be used as a moderate indicator of the social entrepreneurship and vice-versa.
- At last social entrepreneurship is correlated with Sustainable Livelihood and the result shows a moderate positive correlation.

It can be concluded that the factors of mission shakti such as financial access, capacity building and information sharing & awareness has a significant effect on social entrepreneurship and sustainable livelihood. Hence, the aim of the mission shakti program has proved that it is very relevant and

effective in offering sustainable livelihood and has great potentiality to be developed social entrepreneurship**.**

9. IMPLICATIONS

The study will significantly contribute towards the socio-economic development and sustainable livelihood management of the Self-Help Group and in the field of social entrepreneurship. The study will find out the relationship between different factors of the Mission Shakti program and social entrepreneurship. The study will help to find out the region where numerous income generating activities through Mission Shakti are going on and the reason behind their success. It will help to find out the region where such activity is not popular and the reason behind their downfall.

The study will cover the significance of convergence of Mission Shakti on the socio- economic development of SHG members. It will show the contribution of Mission Shakti program in empowering women and eliminating patriarchy. It might help the researchers, policy makers and local authorities who are involved in the concerned area to broaden the sphere in a possible way as to ensure the sustainability of any given project. It will ultimately fulfil the Sustainable Development Goals (SDGs).

10. LIMITATIONS

- The result has based on the pilot study, final study needs to be conducted taking more blocks and villages of Sambalpur district.
- The study only shows the correlation between the dependent and independent variables. Analysis such as regression and chi-square test are needed to show the impact and association of the variables.
- Due to time limitation, only 113 sample size has been considered for the pilot study, more data could have given more accurate results.
- Geographical area restriction is another limitation in this study. Only one district that also three blocks of Sambalpur district has been considered, more districts and blocks could have given more outstanding results.
- The model and hypothesis are based on the SHG who are involved only in income generating activities through Mission Shakti program.

11. FURTHER RESEARCH AGENDA

- The future scope of the study is that a final study with more data will be needed for more accurate result. This paper is based only on the pilot study.
- The paper only shows correlation between variables, different analysis such as regression and chi-square test are needed to show the impact and association of the variables.
- The study needs to done in other districts of Odisha also in order to cover more geographical areas.

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The Impact of Entrepreneurial Education on Fashion Design Students' Entrepreneurial Aspirations

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ABSTRACT

Entrepreneurial education is an integral part of fashion education, as design students often aspire to own their own brands and labels. This industry primarily revolves around changing consumer preferences, production, digital developments, and sustainability concerns, with the fashion industry being the second-largest polluting industry in the world. This paper explores the impact of entrepreneurial education on fashion design students' entrepreneurial aspirations.

For this purpose, both primary and secondary data were collected. Primary data were gathered through a structured questionnaire administered to undergraduate fashion design students at the National Institute of Fashion Technology and semi-structured interviews with the faculty of this institute. The sample size consisted of 250 fashion design students and 25 faculty members. A convenience sampling technique was used to collect the data.

Secondary data were collected from published research articles, reports from the government and other design educational institutes, websites, etc. For data interpretation and analysis, statistical tools such as percentage calculations, chi-square tests, and graphs were used.

A major finding of the study is that the impact of entrepreneurial education on fashion design students' entrepreneurial aspirations is low, as the majority of students prefer to obtain paid employment with an existing brand or designer, or pursue graduate programs. Faculty members face challenges in teaching business knowledge, financial acumen, providing industry mentorship, and offering real-world entrepreneurial experiences to design students, as traditional fashion education tends to focus on design-related subjects.

Key Words: Entrepreneurial Education, Fashion Design, Entrepreneurial Aspirations, Business Acumen

1. INTRODUCTION

As per the Global Entrepreneurship Monitor (GEM) National Entrepreneurship Context Index (NECI) India is ranked 2nd out of 49 countries in terms of the quality of its entrepreneurship ecosystem in 2023.In 2021 India position was ranked 16th and 2022 it rose up to 4th position. This significant improvement in score indicates that India has emerged as a global center for startups. As of 2023 India has impressive record with over 90,000 startups and 107 unicorn firms valued at $30 billion, following only the United States and China, as published by Mint." With such favourable environment with in the country and other government policies of Make in India and Atmanirbhar Bharat it is imperative to understand and analyse the entrepreneurial aspirations of the fashion design students. The textiles and apparel industry in India is the second-largest employer in the country providing direct and allied employment to 45 million and 60 million people respectively. Fashion as an industry is dynamic, creative and has huge potential for entrepreneurial opportunities for fashion designers. Fashion Designer aspire to launch their own labels or venture ad with the evolving changes in fashion such as sustainability, digital platforms and use of Artificial intelligence entrepreneurial opportunities have increased for fashion designer. While the appeal of entrepreneurship is obvious the path from design school to successful entrepreneurship is full of risk and challenges. For these design students aspiring to be Entrepreneurs an entrepreneurial education plays a very important role in preparing them to achieve their aspirations. When they are exposed to entrepreneurship as a subject they gain knowledge in industry practices, design, business and management.

2. REVIEW OF LITERATURE

Entrepreneurial Education: Entrepreneurial education focuses on fostering individuals' ability to identify and act on commercial opportunities, emphasizing skills in opportunity recognition, resource management, and business initiation (Jones & English, 2004). This approach integrates student-centered learning methods or the development of entrepreneurial ecosystems that combine education, research, and venture development (Clark et al., 2020). Research shows that entrepreneurial education enhances attitudes, perceived behavioral control, and intentions, which subsequently influence venture creation behavior (Rauch & Hulsink, 2014).Promoting entrepreneurial education at all levels, starting from primary school, is recognized as a vital driver of employability, self-employment, innovation, and personal development (Dermol et al., 2017). To improve its effectiveness, defining learning outcomes, enhancing teacher training, and introducing entrepreneurship courses in higher education curricula are crucial. Teachers play a pivotal role by adopting innovative and creative teaching approaches to make entrepreneurial education more impactful (Dermol et al., 2017).

Entrepreneurial Aspirations: Entrepreneurial aspirations significantly influence individuals' motivation to engage in entrepreneurial activities and initiate ventures (Gregori et al., 2021; Bogatyreva & Shirokova, 2017). These aspirations are shaped by personal traits like locus of control and innovativeness (Julian & Terjesen, 2006). However, an intention-action gap persists, where not all entrepreneurial intentions result in start-ups (Bogatyreva & Shirokova, 2017).External factors such as family business backgrounds, university support, and regional entrepreneurial institutions play a critical role in bridging this gap (Bogatyreva & Shirokova, 2017). Entrepreneurial identity aspirations can also influence workplace behaviors, fostering intrapreneurial activities and improving job performance (Hamrick & Murnieks, 2022). In creative industries like the designer fashion industry (DFI), entrepreneurship necessitates blending creativity and innovation, often termed "cultural entrepreneurialism" (Ellmeier, 2003). This transition requires building social capital to support entrepreneurial ventures (Adler & Kwon, 2002; Johansson, 2004; Lounsbury & Glynn, 2001).

Challenges in Entrepreneurship: Entrepreneurs face various challenges in establishing and sustaining their businesses. Financial constraints, such as limited access to capital, remain a significant hurdle (Kanchana Bhavan, 2013; Islam, 2023; Kushwaha, 2024). Other challenges include assembling skilled teams, navigating competitive pressures, managing innovation, and dealing with rapidly changing global markets (Shahidi et al., 2008). Regulatory hurdles and labor-related issues further complicate the entrepreneurial journey (Islam, 2023).For student entrepreneurs in India, additional challenges include societal attitudes and lack of mentorship (Kushwaha, 2024). Success in these contexts demands qualities like patience, adaptability, and a deep understanding of industry trends (Kanchana Bhavan, 2013). Addressing these challenges requires targeted support systems to foster a thriving entrepreneurial ecosystem.

Gaps in Curriculum: Design education often serves as a foundational platform for students transitioning from creative thinkers to socially oriented innovators. However, it traditionally does not prioritize entrepreneurship (Nabi et al., 2006). Research in New Zealand indicates that while design programs equip graduates with creative skills, they often fail to prepare them for commercializing their work (Blomfield, 2002). Entrepreneurship education in creative industries demands a unique blend of creativity and business acumen. Yet, existing curricula lack comprehensive entrepreneurial components, leading to a disconnect between the skills taught and industry demands (Hermann et al., 2008). To address this gap, integrating experiential learning opportunities, such as real-world projects and internships, into curricula is critical. Social capital—comprising structural, relational, and cognitive dimensions—plays a pivotal role in entrepreneurial success. It facilitates trust, reciprocity, and access to resources, with personal networks being particularly valuable during the initial stages of business development (Adler & Kwon, 2002; Nahapiet & Ghoshal, 1998). As ventures grow, formal networks and relationships become more important, enhancing the quality and complexity of shared information (Hung, 2006; Lee & Jones, 2008).Enterprise orientation also shapes how aspiring entrepreneurs navigate the balance between creativity and business processes. Mills (2011a, b) identifies three orientations—Creative Enterprise Orientation (CEO), Creative Business Orientation (CBO), and Fashion Industry Orientation (FIO)—each reflecting distinct motivations and aspirations. Understanding these orientations helps align educational approaches with entrepreneurial goals.

Entrepreneurial Education Programs: A study at Universiti Putra Malaysia demonstrated the impact of entrepreneurship programs on fashion design students. Over five months, students participated in workshops, seminars, and mentoring sessions. While the program enhanced entrepreneurial intentions, its impact on competencies was limited due to time constraints. The study highlighted the need for structured, long-term initiatives to maximize learning outcomes. Similarly, studies by Fang (2017) and Zhang (2020) underscore the importance of innovative entrepreneurial education, particularly in China. Zhao's (2017, 2018) research identifies key factors influencing aspirations, such as personality traits, financial support, and access to information. These studies collectively emphasize creating supportive environments to nurture entrepreneurial intentions among fashion design students.

3. RESEARCH GAP

In spite of the spread of entrepreneurship courses and initiatives within fashion education very little information is available with regards to the impact of these on design students Entrepreneurial Aspirations and also understand their capabilities. The Research aims to analyse the gap in entrepreneurial aspirations and Entrepreneurial Education of fashion design students. The Study will explore the impact their motivations, perceptions, and readiness for entrepreneurship.

4. METHODOLOGY

Primary data: A structured questionnaire administered to undergraduate fashion design students & semi-structured interviews with the faculty of National Institute of Fashion Technology

Sample size: 250 fashion design students & 25 faculty members

Sampling technique: A convenience sampling technique was used to collect the data.

Secondary data: Published research articles, Government reports Data interpretation and analysis: Statistical tools, percentage calculations, chi-square tests,

5. TESTING THE HYPOTHESES:

TABLE 1: for Hypothesis Statement

	Null Hypothesis (H_0)	**Alternative Hypothesis (H_a)**
Alignment Between Faculty Perceptions and Student Aspirations	Faculty perceptions of curriculum adequacy are not associated with students' entrepreneurial aspirations.	Faculty perceptions of curriculum adequacy are associated with students' entrepreneurial aspirations.
Confidence vs. Curriculum Support	Confidence levels (e.g., in financial management) are not influenced by curriculum support as perceived by faculty.	Confidence levels (e.g., in financial management) are influenced by curriculum support as perceived by faculty.

6. FINDINGS & IMPLICATIONS

I. The analysis of a structured questionnaire administered to 250 undergraduate fashion design students.

The collected information encompasses both demographic insights and an in-depth understanding of key aspects related to entrepreneurship among fashion design students. Entrepreneurial Aspirations: Insights into the students' career ambitions revealed a strong inclination toward launching fashion brands, e-commerce platforms, and service-based businesses, reflecting diverse entrepreneurial goals.

Motivational Factors: The study identified key drivers of entrepreneurship, including the pursuit of financial independence, creative expression, innovation, leadership opportunities, and societal impact.

Challenges to Entrepreneurship: Common barriers faced by students include financial constraints, a lack of knowledge and practical skills, fear of failure, difficulties balancing academic and business commitments, and limited access to networking opportunities.

Strengths of Entrepreneurial Education: The analysis highlighted the existing strengths of formal entrepreneurial education, such as coverage of business planning, marketing strategies, and financial literacy, along with its perceived effectiveness by students.

Gaps in Entrepreneurial Education: Areas needing improvement include the limited focus on legal aspects of business, fundraising, and advanced entrepreneurial knowledge, underscoring a disconnect between educational content and industry requirements.

Sources of Entrepreneurial Knowledge: The primary sources of knowledge were classroom learning and online courses, with workshops, self-study, mentorship, and networking events playing supplementary roles but remaining underutilized.

Suggestions for Improvement: Practical recommendations included introducing more hands-on courses, access to experienced mentors, networking opportunities, internships, and financial assistance to better prepare students for entrepreneurial success.

TABLE 2: Analysis of responses of undergraduate fashion design students.

Gender Distribution	Female: 60%, Male: 35%, Prefer not to disclose: 5%
Year of Study	First Year: 25%, Second Year: 30%, Third Year: 25%, Fourth Year: 20%
Departmental Representation	Fashion Design: 75%, Knitwear Design: 15% Textile Design : 10%
Entrepreneurial Aspirations	55% aim to launch their own fashion brand. 30% are interested in e-commerce platforms. 10% prefer service-based businesses (e.g., styling consultancies).
Motivational Factors	65% seek financial independence.,60% are motivated by creative expression,50% value freedom to innovate,45% desire leadership opportunities,35% aim for societal impact.
Challenges to Entrepreneurship	75% face financial constraints, 60% lack knowledge and practical skills,55% fear failure,40% struggle with balancing studies and business, 30% cite limited networking opportunities.
Strengths of Entrepreneurial Education	70% attended formal entrepreneurial courses. Topics covered include business planning (80%), marketing strategies (75%), and financial literacy (70%). 45% found the education highly effective; 35% rated it moderately effective.
Gaps in Entrepreneurial Education	Limited focus on legal aspects of starting a business (40%) and fundraising (30%). Lack of emphasis on advanced entrepreneurial knowledge and strategies.
Sources of Entrepreneurial Knowledge	Classroom learning (60%) and online courses (50%) are primary sources. Workshops/seminars (45%) and self-

	study (35%) contribute significantly. Mentorship (25%) and networking events (20%) are underutilized.
Suggestions for Improvement	65% recommend more practical courses and workshops. 60% request access to experienced mentors. 50% seek networking events with industry professionals. 45% suggest hands-on internships in startups. 35% emphasize the need for financial assistance (e.g., scholarships, seed funding).

II. The Following is the analysis of semi-structured interviews with 25 faculty of National Institute of Fashion Technology.

The collected information encompasses the perception of the faculty from Design, Technology and management on the key aspects related to Adequacy of Current Curriculum, Entrepreneurial Aspirations of the Fashion Design Students , Motivational Factors of the Students , Challenges Faced by Students, Current Offerings in Curriculum, Institutional Support, Suggested Improvements

TABLE 3: Analysis of responses of Faculty from Design School

	Findings	Percentage
Adequacy of Current Curriculum	Curriculum does not adequately address entrepreneurial skills.	40%
	Curriculum partially or adequately addresses entrepreneurial skills (e.g., entrepreneurship management, etc.).	60%
Entrepreneurial Aspirations	Students with high entrepreneurial aspirations (driven by independence, creativity, and personal branding).	70%
	Students uncertain or unsure about their aspirations.	30%
Motivational Factors of the Design Students	Desire for independence and autonomy.	65%
	Passion for creativity and design.	60%
	Freedom to innovate.	50%
	Interest in building personal brands.	45%
	Economic factors and job market challenges.	35%
Challenges Faced by Students	Lack of financial resources.	75%
	Lack of business knowledge and skills.	60%
	Fear of failure.	55%
	Difficulty accessing market information and resources.	50%
	Competition from established brands.	40%
	Balancing studies and business.	35%
Current Offerings in Curriculum	Entrepreneurship management, product development, e-commerce, marketing, merchandising, and informal activities.	70%
	No formal or structured entrepreneurial education opportunities.	30%
Institutional Support	Establish an entrepreneurship center or incubator.	70%
	Offer mentorship programs.	60%
	Organize industry networking events.	50%
	Provide funding and resources for student startups.	45%
Suggested Improvements	Introduce mandatory entrepreneurship courses covering business fundamentals, market research, and financial planning.	65%
	Organize guest lectures and workshops featuring successful design entrepreneurs.	60%
	Create design incubators or co-working spaces to foster collaboration and provide resources.	50%
	Integrate entrepreneurial thinking into design projects for real-world problem-solving.	45%

The entrepreneurial intent among fashion design students is notably strong, reflecting their aspirations to innovate and lead in a competitive industry. The data highlights a predominant interest in launching fashion brands and exploring e-commerce platforms. This enthusiasm is fuelled by a blend of creative ambition, economic independence, and the desire to challenge conventional norms. However, the

path to entrepreneurship is not without challenges, underscoring the need for institutional support and strategic curriculum enhancements.

Entrepreneurial Intent: Fashion students exhibit a clear vision for their entrepreneurial future, with many aspiring to establish independent fashion brands or leverage digital tools to create e-commerce ventures. These aspirations are not merely artistic pursuits but also a reflection of the evolving market dynamics, where digital platforms and niche branding offer lucrative opportunities. The intent signifies a readiness to navigate the complexities of entrepreneurship, provided students receive adequate guidance and resources.

Institutional Support: Educational institutions play a pivotal role in shaping entrepreneurial readiness. Current programs effectively cover foundational topics such as business planning and marketing strategies. However, critical gaps remain in areas like legal compliance, fundraising, and advanced entrepreneurial methodologies. For instance, students often lack exposure to intellectual property rights, venture capital acquisition, and scaling strategies—essential knowledge for sustaining and growing a business. Addressing these gaps can significantly enhance the relevance and impact of entrepreneurial education.

Barriers to Entrepreneurship :Three primary barriers impede the entrepreneurial journey of fashion students:

1. Financial Challenges: Starting a fashion business requires substantial investment in production, marketing, and operations. Limited access to funding sources, such as seed capital or scholarships, exacerbates this issue.
2. Practical Skill Deficiency: While theoretical knowledge is imparted, students often lack hands-on experience in real-world business scenarios, leading to low confidence in executing entrepreneurial strategies.
3. Fear of Failure: Psychological barriers, including fear of competition and market rejection, deter students from taking risks necessary for entrepreneurial success.

Suggestions for Advancement:Participants in the study emphasize the importance of experiential learning, mentorship, and networking to bridge the gap between education and industry realities:

- Experiential Learning: Introducing internships, live projects, and startup collaborations can help students apply their knowledge in practical settings, building confidence and skills.
- Mentorship Programs: Access to industry experts and successful entrepreneurs can provide personalized guidance, fostering resilience and strategic thinking.
- Networking Opportunities: Creating platforms for students to connect with professionals can open doors to collaborations, funding, and market insights.
- Financial Support: Offering scholarships, grants, and seed funding can alleviate financial constraints and encourage entrepreneurial initiatives.

Untapped Potential: Mentorship and networking events remain underutilized resources within the entrepreneurial ecosystem. These platforms hold immense potential to inspire, guide, and connect students with industry stakeholders. By investing in such initiatives, institutions can create a robust support system that nurtures entrepreneurial aspirations.

Faculty Perception: Faculty perceptions provide valuable insights into the effectiveness of current entrepreneurial education frameworks, their alignment with student aspirations, and the areas requiring improvement. These perceptions reflect both the progress made in entrepreneurial training and the gaps that hinder its ability to fully equip fashion design students for entrepreneurial success.

Adequacy of the Current Curriculum: Faculty acknowledge that while the curriculum addresses entrepreneurial skills in some areas, such as entrepreneurship management, product development, e-commerce, marketing, and merchandising, it falls short in fostering comprehensive entrepreneurial readiness. There is a notable lack of emphasis on practical business skills, advanced entrepreneurial strategies, and financial literacy. These gaps are seen as significant barriers to bridging the divide between theoretical knowledge and real-world entrepreneurial application, limiting students' preparedness for the challenges of starting and managing their ventures.

Alignment with Entrepreneurial Aspirations: Faculty recognize the strong entrepreneurial intent among students, many of whom are driven by goals of independence, creativity, and personal branding. However, a portion of students remains uncertain about their entrepreneurial ambitions, which underscores the need for better mentorship and guidance. Faculty emphasize the importance of aligning the curriculum with student aspirations by fostering creativity, autonomy, and innovative thinking. These elements are central to motivating students and supporting their entrepreneurial endeavors.

Motivational Factors: From the faculty's perspective, students are primarily motivated by independence, a passion for creativity, and the freedom to innovate. Additional drivers include opportunities for personal branding and addressing economic challenges in the job market. Faculty understand the diverse nature of these motivations and advocate for a curriculum that balances creative expression with the development of practical business skills. This approach ensures that students' personal and professional goals are adequately supported.

Challenges Identified by Faculty: Faculty perceive financial challenges as a major barrier for students, who often lack access to adequate resources for starting their ventures.

Additionally, many students are seen as lacking essential business knowledge and skills, which impacts their confidence in pursuing entrepreneurial goals. Fear of failure, difficulties in accessing market information, and the competitive nature of the fashion industry further compound these challenges. Balancing academic responsibilities with entrepreneurial pursuits is another significant hurdle. Faculty highlight the importance of institutional support and innovative solutions to address these issues effectively.

Institutional Support: Faculty strongly advocate for the establishment of entrepreneurship centers or incubators to provide structured support for student ventures. They emphasize the importance of mentorship programs and industry networking events as critical components of an effective entrepreneurial ecosystem.

Financial support, including scholarships and seed grants, is also identified as a key area where institutions can alleviate constraints and encourage student entrepreneurship.

Suggestions for Curriculum Improvements: Faculty recommend introducing mandatory entrepreneurship courses that cover business fundamentals, market research, and financial planning. They stress the value of organizing guest lectures and workshops featuring successful entrepreneurs to inspire and educate students.

The creation of design incubators or co-working spaces to foster collaboration and provide resources is also seen as essential. Furthermore, integrating entrepreneurial thinking into design projects for real-world problem-solving is encouraged. These recommendations reflect a faculty-driven approach aimed at making entrepreneurial education more relevant, impactful, and aligned with industry demands.

III Integrating the Student responses and faculty perception: A Hypotheses testing done on the following

1. Alignment Between Faculty Perceptions and Student Aspirations

Null Hypothesis (H_0) Faculty perceptions of curriculum adequacy are not associated with students' entrepreneurial aspirations.

Alternative Hypothesis (H_a)Faculty perceptions of curriculum adequacy are associated with students' entrepreneurial aspirations.

2. Impact of Curriculum Gaps on Student Confidence

Null Hypothesis Confidence levels (e.g., in financial management) are not influenced by curriculum support as perceived by faculty.

Alternative Hypothesis (H_a) Confidence levels (e.g., in financial management) are influenced by curriculum support as perceived by faculty.

Hypothesis	Test	Result
Alignment Between Faculty Perceptions and Student Aspirations	Chi-Square Test of Independence	Chi-Square Statistic: 2.22; p-value: 0.329. No significant association between perceptions and aspirations (retain H0H_0H0).
Impact of Curriculum Gaps on Student Confidence	Correlation or ANOVA	Financial Literacy (Correlation: 0.35, p = 0.045); Business Acumen (ANOVA: F = 3.1, p = 0.07)

The analysis of faculty perceptions and their alignment with student aspirations and challenges offers valuable insights into entrepreneurial education. The chi-square test reveals no significant association between faculty perceptions of curriculum adequacy and student entrepreneurial aspirations (p-value = 0.329). This suggests a disconnect, where faculty views on curriculum effectiveness do not directly influence or align with the aspirations of students. This finding highlights the need for more student-centric approaches to curriculum design.

The impact of curriculum gaps on student confidence underscores the importance of specific skill sets. Correlation analysis shows a moderate positive relationship between addressing financial literacy gaps and increased student confidence (Correlation: 0.35, p = 0.045). While gaps in business acumen also indicate an influence on confidence levels, the result is less statistically robust (ANOVA: F = 3.1, p = 0.07). These findings suggest that strengthening areas like financial literacy and business acumen could significantly enhance student entrepreneurial readiness.

Suggestions:

Institutional Support: Entrepreneurial education provides students with foundational knowledge in business planning and marketing strategies. While existing courses are valued, students often find them insufficiently practical for addressing the complexities of modern entrepreneurial challenges. Critical gaps exist in areas such as legal frameworks, fundraising, and advanced entrepreneurial strategies. These gaps highlight the need for a more interdisciplinary approach that blends design creativity with entrepreneurial expertise. To address these deficiencies, institutions must incorporate underrepresented areas into their curriculum. Modules on intellectual property, global fashion markets, and investor engagement should be introduced to equip students with a comprehensive skill set.

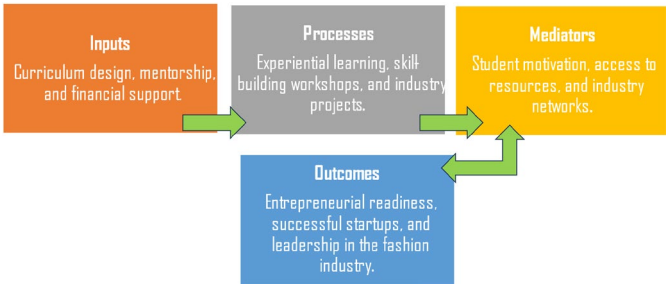
Barriers to Entrepreneurship: Financial challenges are a significant obstacle for students, particularly in securing adequate funding for production, marketing, and scaling operations. Institutions can address this issue by providing seed funding, scholarships, and financial literacy programs. Another pressing issue is the lack of practical entrepreneurial

skills. Students often lack exposure to hands-on activities, leading to reduced confidence in their abilities. Offering real-world learning opportunities, such as internships and live projects, can bridge this gap and empower students. Psychological barriers, including the fear of failure and competition, also hinder entrepreneurial pursuits. Confidence-building workshops and showcasing success stories can help students develop resilience and a stronger mindset for tackling challenges. Market saturation and competition pose additional hurdles, as students struggle to identify unique niches amidst established players in the fashion industry. Teaching differentiated strategies and niche marketing can prepare students to compete effectively in this dynamic marketplace.

Opportunities in Entrepreneurial Education: The growing prominence of e-commerce and digital platforms presents an economically viable way for students to introduce their brands and access international markets. Courses on digital marketing, social media strategy, and e-commerce are essential to prepare students for this domain. Sustainability and ethical fashion are emerging areas of opportunity, driven by increasing consumer demand for environmentally conscious products. Incorporating sustainability-focused modules will position students as leaders in conscious fashion. Additionally, advancements in fashion technology, such as artificial intelligence, 3D printing, and virtual fashion, open new entrepreneurial avenues. Collaborating with tech startups can provide students with the tools needed to innovate in these areas. Incubators and accelerators play a crucial role in providing structured support through mentorship, funding, and networking. Institutions should either partner with existing accelerators or establish their own programs. Experiential learning models, including workshops, competitions, and internships, offer students real-world exposure, bridging the gap between theoretical knowledge and practical application. Such experiences not only enhance skills but also boost confidence.

Strategies for Curriculum Enrichment: Educators must be trained to effectively deliver entrepreneurship-focused curricula, and inviting industry experts as guest speakers can further enrich the learning experience. Continuous education for faculty ensures they remain informed about current industry trends and developments. Blending technical design education with business and entrepreneurial training creates holistic professionals capable of applying their skills in market-relevant ways. A comprehensive curriculum featuring modules on business fundamentals, marketing techniques, financial planning, and innovation is essential. Capstone projects and real-life case studies should be integrated to develop students' analytical and problem-solving skills. Partnerships between academia and industry, including collaborations with fashion companies, startups, and technology firms, provide valuable internship and project opportunities. These partnerships prepare students to tackle entrepreneurial challenges with industry exposure and practical insights. Progressive assessment methods should replace traditional examinations. Evaluating practical skills and creativity through simulated business environments and startup presentations can better measure students' entrepreneurial readiness.

Proposed Institutional Support:Institutions should establish entrepreneurship centers or incubators as dedicated spaces for students to collaborate, prototype, and access critical resources. These centers can offer mentorship, funding, and training to support student ventures. Connecting students with industry experts and successful entrepreneurs through mentorship programs provides personalized guidance and enhances problem-solving skills. Financial barriers can be alleviated by offering scholarships, grants, and seed funding, as well as fostering alliances with investors and industry stakeholders. Networking events, including industry panels, alumni meet-ups, and business networking sessions, facilitate connections that can lead to collaborations and mentorship opportunities. These initiatives collectively create an ecosystem that empowers students to realize their entrepreneurial aspirations effectively.



Process of Entrepreneurial education for Entrepreneurial Aspiring Desing Students

Conclusion & Future Implications

Enhancing Entrepreneurial Education Entrepreneurial education is instrumental in shaping the aspirations and readiness of fashion design students. By addressing current gaps and leveraging opportunities, institutions can empower students to excel in their entrepreneurial journeys.

Key actions include:

- Developing practical, interdisciplinary courses tailored to industry needs.
- Offering real-world learning through internships, projects, and mentorship.
- Fostering innovation through technology, sustainability, and creative expression.
- Providing financial and institutional support to overcome barriers.

Entrepreneurial education plays a pivotal role in equipping fashion design students with the skills and confidence to

navigate the challenges of starting and managing their ventures. The findings from this study underscore both the potential and the gaps in current educational frameworks. By addressing the barriers and leveraging opportunities, institutions can foster a robust entrepreneurial ecosystem that aligns with industry trends and student aspirations.

Bridging Curriculum Gaps: The current entrepreneurial education framework provides foundational knowledge in areas like business planning, marketing strategies, and product development. However, gaps persist in critical domains such as legal frameworks, fundraising strategies, and advanced entrepreneurial concepts. These shortcomings hinder students' ability to translate their creative ideas into viable business ventures. To address these gaps, educational institutions must integrate interdisciplinary modules covering intellectual property, global fashion markets, and investor engagement. Enhancing these aspects will prepare students to manage the complexities of the modern fashion industry effectively.

Overcoming Barriers: Financial constraints remain the most significant barrier for aspiring entrepreneurs. Limited funding for production, marketing, and scaling operations discourages many students from pursuing their entrepreneurial dreams. Similarly, a lack of practical business knowledge and hands-on experience erodes confidence. Psychological barriers, including fear of failure and market rejection, further exacerbate these challenges. Institutions must address these issues through comprehensive support systems, including seed funding, scholarships, financial literacy training, and confidence-building workshops. By alleviating these barriers, students can focus on developing innovative and competitive ventures.

Leveraging Opportunities: The evolving fashion landscape offers immense opportunities for entrepreneurial growth. Digital platforms and e-commerce enable cost-effective brand launches and global market access, while sustainability and ethical fashion create niches for conscious innovation. Technological advancements, such as AI, 3D printing, and virtual fashion, open new pathways for creative entrepreneurs. To capitalize on these trends, educational institutions should incorporate courses on digital marketing, sustainability practices, and fashion-tech integration. Collaboration with tech startups and industry leaders can further enhance students' readiness to innovate.

Institutional Support and Ecosystem Development: Institutional support is crucial in fostering an entrepreneurial mindset among students. Establishing entrepreneurship centers or incubators can provide a structured environment for collaboration, mentorship, and resource access. Mentorship programs connecting students with industry experts and successful entrepreneurs are essential for personalized guidance and problem-solving. Additionally, organizing networking events and industry panels can facilitate connections that translate into funding, partnerships, and market insights.

An innovative approach to curriculum design is also necessary. Institutions should emphasize blended education, combining technical design training with entrepreneurial concepts to create well-rounded professionals. Experiential learning models, such as internships, competitions, and live projects, bridge the gap between theoretical knowledge and practical application. Moreover, innovative assessment systems that evaluate project-based outcomes and startup scenarios can better gauge entrepreneurial readiness.

7. FUTURE IMPLICATIONS

The findings highlight the importance of region-specific interventions and long-term research on the outcomes of entrepreneurial education. Policymakers, educators, and industry leaders must collaborate to shape frameworks that support student startups, foster creativity, and promote sustainable practices. A collaborative ecosystem connecting academia, industry, and students is vital for continuous innovation and growth. By addressing gaps, overcoming barriers, and harnessing opportunities, educational institutions can empower fashion design students to thrive as entrepreneurial leaders. Such an approach not only benefits students but also drives innovation and sustainability in the global fashion industry, ensuring its evolution in a competitive and dynamic landscape.

8. FUTURE RESEARCH AND POLICY

- Focus on region-specific entrepreneurial challenges and opportunities.
- Research on long-term outcomes of entrepreneurial education programs.
- Involve educators, industry leaders, and policymakers in shaping entrepreneurial education frameworks.
- Advocate for funding initiatives that support student startups.
- Establish a collaborative ecosystem connecting academia, industry, and students.
- Promote continuous research on emerging trends in fashion entrepreneurship.

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A Systematic Review on the Role of Financial Inclusion in Women Entrepreneurship Development: Future Research Agenda for Sustainable Entrepreneurial Strategies Formulation in Emerging Economies

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ABSTRACT

The purpose of this study is to furnish a systematic review on the role of financial inclusion in the women entrepreneurship development with an aim to derive a structured future research agenda with reference to sustainable entrepreneurial strategies formulation in the emerging economies. A multipronged research design is devised for this study. First a Systematic Literature Review (SLR) of 101 Scopus-indexed publications (ABDC journals published during November 1999-June 2024) is carried out using the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) tools to get an overview of the current trends of financial inclusion in women entrepreneurship research. This study has also performed ADO-TCM framework-based review to derive a structured future research agenda and the direction to carry out future research in this domain with a focus on sustainable entrepreneurial strategies formulation in the emerging economies context.The ADO (Antecedents-Decisions-Outcome) framework finds that cognitive, normative and regulative antecedents have played a crucial role in the decision-making process of women belonging to the bottom of pyramid segment for a favorable entrepreneurial outcome. The TCM (Theory-Context-Method) framework used in this study provides a structured insight on the theoretical, contextual and methodological drivers underlying the relationship between financial inclusion and women entrepreneurship. This research study has also found the role of favourable public policy in shaping the financial inclusion focused women entrepreneurship growth of any country. This systematic review had identified the government driven innovative inclusive finance schemes as the key strategy for the women entrepreneurial growth in Indian context whereas it also revealed the cases of institutional void in many parts of Africa affecting the women entrepreneurial growth. This study can also be considered as one of the frontier research works in the framework based systematic review pertaining to financial inclusion and women entrepreneurship policy arena by applying the ADO-TCM framework.

Keywords: Financial Inclusion, Women Entrepreneurship, SLR, PRISMA, ADO-TCM Framework

1. INTRODUCTION

"Financial inclusion" is the key enabler for the holistic inclusive development and sustainable entrepreneurship growth of any developing economy (De, U., & Pal, M.,2019; Goel & Madan,2019; Ajide,2020). Financial inclusion provides bouquet of "financial" and "non-financial" products like micro savings, micro credit, micro insurance & digital banking which had enabled women in engaging entrepreneurial activities (Swain & Wallentin,2009).Various cross country research studies have highlighted the catalytic role of financial inclusion in self-employment and sustainable women entrepreneurial growth across the Bottom of the Pyramid (BoP) segment (For Details on BoP: Refer Annexure 1) (Goel & Madan,2019; Pal & Gupta,2023).

Different financial inclusion programmes and pro-poor financial schemes of governments across the globe have provided the necessary financial resources and competency building activities to the women for running any entrepreneurial activities (Sahu et al.,2024). For instance, India's focused livelihood and women entrepreneurship scheme, "Deendayal Antyodaya Yojana-National Rural Livelihood Mission (DAY-NRLM)" (Sinha,2024) initially promoted the formation of community institution like SHGs comprising women from the BoP segment and enabled them financially stable through its universal financial inclusion approach like SHG Bank linkage. The financial sustainability led these women based SHGs to leverage the benefits of different livelihood and entrepreneurial sub schemes under DAY-NRLM for venturing any entrepreneurial activities (Chatterjee et al., 2018a; Aggarwal et al.,2020).

However, existing literature fails to address the role of financial inclusion in harnessing entrepreneurial orientation skills in women (Kivalya & Caballero-Montes,2023).Rather majority of the earlier systematic reviews in this field have explained the catalytic role of "financial inclusion on women empowerment" without addressing the multidimensional aspect of women entrepreneurship such as role of affordable finance in early stage of the enterprises, mezzanine finance and its relevance in the growth stage of enterprises, financial literacy and basic knowledge of business skills among women entrepreneurs (Parwez & Patel,2022).

Second, existing reviews lack theoretical framework highlighting different dimensions and antecedents of women entrepreneurs (Kivalya & Caballero-Montes,2023).

Third, existing reviews do not provide any theoretical linkage to financial inclusion-based women entrepreneurship research barring the work of Kivalya & Caballero-Montes (2023) which has focused on institution theory and feminist economics theory.

Fourth, there is dearth of framework based systematic review capturing the key financial inclusion-based antecedents in influencing the decisions of women for entrepreneurial outcome.

This systematic literature review has focused on the "role of financial inclusion in the women entrepreneurship development" by adopting a combination of ADO (Paul & Benito,2018) & TCM (Paul et al.,2017) approaches (Kumar,2022). The rationale for adopting the ADO-TCM approach in this SLR is to derive a structured future research agenda and the necessary direction to conduct the future systematic review in the financial inclusion focused women entrepreneurship research domain.

The specific research objectives are

- To examine the current profiles and trends of the role of Financial Inclusion in Women Entrepreneurship Research
- To devise the current and evolving thematic & conceptual structures of the role of Financial Inclusion in Women Entrepreneurship Research
- To identify the gaps, potential future research options & policy level implications in the Financial Inclusion focused Women Entrepreneurship Research domain

2. LITERATURE REVIEW

2.1 RESOURCE BASED THEORY IN FINANCIAL INCLUSION CONTEXT

The Resource Based theory which is propounded by Barney (1991) explains the critical role of resources in the establishment of the business and developing sustained competitive advantage. Although resource-based theory is primarily applicable to the firm level competitive strategy, the current systematic review on the basis of previous conceptual approach of Farooq et al. (2024) has applied the theoretical lenses of resource-based theory to the financial inclusion and women entrepreneurship research context. Financial products can be considered as the keystone resources to establish any enterprise. The bundle of financial products like micro savings, affordable credit, insurance, pension and digital banking products act as keystone resources for improving the financial conditions of the vulnerable group like woman belonging to the BoP (Mushtaq et al.,2023; Farooq et al.,2024). Coming to the resource from a resource-based context, financial resources like micro savings and micro credit are valuable in the sense that without these resources, women from the BoP segment can neither attain financial stability or establish any enterprises. Similarly, these resources are non-substitutable since any other non-financial resources can't replace them. Although financial inclusion products can be customised such as change in interest rate in the micro credit products, introduction of zero balance-based savings account to meet specific requirements of the target customers, its key characteristics like small ticket size loan (micro credit) or tiny deposit (micro savings) can't be imitated by any kind of mainstream financial service product. Although these resources on a generalised approach are not rare, non-availability of these resources can impede the financial and socio-economic growth of the vulnerable communities. So, these resources are rare from an inclusive finance perspective.

2.2 FINANCIAL INCLUSION & EMPOWERMENT OF WOMEN ENTREPRENEURS

Several research studies have prolifically studied how financial inclusion acts as the key driver in the women entrepreneurship development and identified the positive relationship between the usage of affordable financial products and women entrepreneurial growth (Swain & Wallentin,2009; Brody et al.,2017; Goel & Madan,2019; Mahmud,2023; Farooq et al.,2024). Availability of finance promotes entrepreneurial activity and helps to achieve sustained economic growth (King & Levine,1993). Financial inclusion provides multiple avenues to microentrepreneurs in their business operations specifically with respect to the expenditure and investment decisions (Mahato & Jha,2023). The availability of formal financial services boosts economic empowerment of women at the BoP level by engaging individuals in different sustainable livelihood activities (Sethi & Acharya,2018; Sahu et al.,2021; Mahato & Jha,2023).

2.3: INSTITUTIONAL THEORY IN FINANCIAL INCLUSION CONTEXT

Institutional theory describes the role of external institutions in setting regulations in influencing the operation of the business enterprise as the enterprise has to operate within the rules and regulations set by external agencies and its own social standards, principles and ethics (Scott & Meyer,1994; Scott,1995). Institutional void is often noticed in a market due to complex interplay between the informal setup (customs, traditions) and formal institutions (government, laws, regulatory bodies) (McKague et al.,2015; Agarwal et al.,2018). Scott's (1995) concept of three tier institutional legitimacy viz. cognitive, normative and regulative has helped to understand how the enterprises fill the institutional void of the market in a complex institutional dynamic. The institutional theory with reference to the concept of

institutional legitimacy is strongly related to inclusive ecosystem development as entrepreneurship flourishes in the BoP market with the holistic confluence of cognitive, normative and institutional legitimacy (Mair et al.,2012; Wright et al.,2005).

Different research studies across the world have found the role of favourable regulatory, cognitive and normative factors in influencing the entrepreneurship development (Bruton et al.,2013).

Favourable policies, regulations and entry conditions in microfinance settings have a positive impact on the entrepreneurial growth in many developing economies (Khavul et al.,2013). Financial innovations in microfinance on account of change in technology and regulation have proliferated the entrepreneurial growth (Bruton et al., 2015).

Thus, role of the institution is pivotal in accelerating the financial inclusion among women belonging to the BoP segment and provides a building block for the entrepreneurial venture.

3. METHODOLOGY

"Systematic literature review (SLR)" approach is considered as the appropriate measure for this study in order to produce a high-quality synthesis of women entrepreneurship & financial inclusion literature. Since the contemporary literature lacks an integrative framework of the extant knowledge (Mihalache & Mihalache,2016; Vrontis et al.,2020) barring few bibliometric and systematic research work (Atiase,2018; Mustaq et al.,2023; Mahato et al.,2023), this study has used PRISMA framework to scrutinize articles to conduct the SLR (Moher et al.,2015). Further this literature review has adopted an integrative framework of "ADO (Antecedents-Decisions-Outcomes)" of Paul & Benito (2018) and "TCM (Theories-Contexts-Methods)" of Paul et al. (2017) to identify the key research gap and future research opportunities (Tyagi et al.,2024). The combined framework of ADO-TCM provides a holistic review on the topical domain like women entrepreneurship development and its relationship with financial inclusion (Paul & Benito,2018).

3.1. RESEARCH SCOPE

Studies focusing on financial inclusion and women entrepreneurship from November 1999 to June 2024 have been included for a comprehensive review. The rationale for choosing this time period is as per the extant literature findings that the progress of this domain has gained attention post new millennium (the year 2000 onward). This study is carried out to get an overview of how financial inclusion has empowered the women entrepreneurs. Further, encapsulating the role of key antecedents, drivers and outcome of women entrepreneurship from financial inclusion initiatives has provided future policy level implications (Srivastava et al., 2023).

3.2. REVIEW PROTOCOL

The study has used the well-established "Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA)" approach for systematic finding and selecting the relevant literature (PRISMA 2020). The PRISMA framework has four stages: (a) identification, (b) screening, (c) eligibility and (d) inclusion (Lee et al.,2021).

3.2.1: IDENTIFICATION

Article search process started with key word search in the SCOPUS database (Srivastava et al., 2023). The reason for using the SCOPUS database is for its extensive coverage across different domains and more than seventy percent more sources compared to other established database like Web of Science (Lo'pez-Illescas et al.,2008; Chadegani et al.,2013; Brzezinski,2015). The keywords search stage involved a Boolean search using combination and variation of keywords with reference to research objective. The initial keyword "financial inclusion" or "women entrepreneurship" generated 6,657 research documents comprising of research articles, books, books chapter, conference proceedings and reviews. Further the search process was more customized with the different combination of keywords such as "financial inclusion" & "entrepreneurship", "financial inclusion" & "women entrepreneurship", "financial inclusion" & "women empowerment", "financial inclusion" & "women entrepreneur", "micro finance" & "women entrepreneurship", "micro finance" & "women empowerment", "access to finance" & "women entrepreneurship", "access to finance" & "women empowerment", "access to credit" & "women entrepreneurship", "access to credit" & "women empowerment", "inclusive finance" & "women empowerment", "digital finance" & "women empowerment".

This resulted 530 research documents published in the English language covering a range of domains such as social science, economics, gender studies, business management, strategic management, financial services and social entrepreneurship. The keyword search process was based on the search within criteria of "Article title, Abstract, Keywords" from SCOPUS database.

3.2.2: SCREENING

In line with the previous SLRs within the field of financial inclusion and women entrepreneurship (Baral et al.,2022; Kivalya & Caballero-Montes,2023), this research study omitted books, books chapter, conference proceedings and reviews leaving only 409 research articles. The review was further screened to peer-reviewed journals of ABDC (Australian Business Deans Council) list resulting in 152 research articles. The criteria for selecting only the ABDC journals was due to listing of these journals based on their rigor of work rather than a citation score (Srivastava et al.,2023). Further 19 duplicate articles were excluded thereby a total of 133 articles remaining for the study.

3.2.3: ELIGIBILITY

In this phase, full text review of all the 133 screened articles were done to identify the relevancy of the articles with respect to the research objectives. Articles primarily focusing on the application of financial inclusion in the women entrepreneurship development such as impact of financial inclusion on women entrepreneurship development, microfinance- the promotional tool for women empowerment, credit access and entrepreneurial growth among women, role of digital finance in harnessing entrepreneurial growth were included for the systematic review process. As a result, 36 articles with the more generalized approach to finance or entrepreneurship were excluded, thereby making final eligible tally to 97 research articles.

3.2.4: INCLUSION

For a holistic systematic literature review coverage, backward tracking approach was adopted for not missing out any relevant article covering important concept (Mohamed et al.,2021). Thus, four additional articles were included with 101 articles for the final study. An excel sheet was prepared to provide a summary of the articles being shortlisted for the review, highlighting the author, article title, journal name, publishers, year of publication, theory, context, country, abstract of the research (Srivastava et al.,2023).

The details of the article search strategy are shown in the following flow diagram.

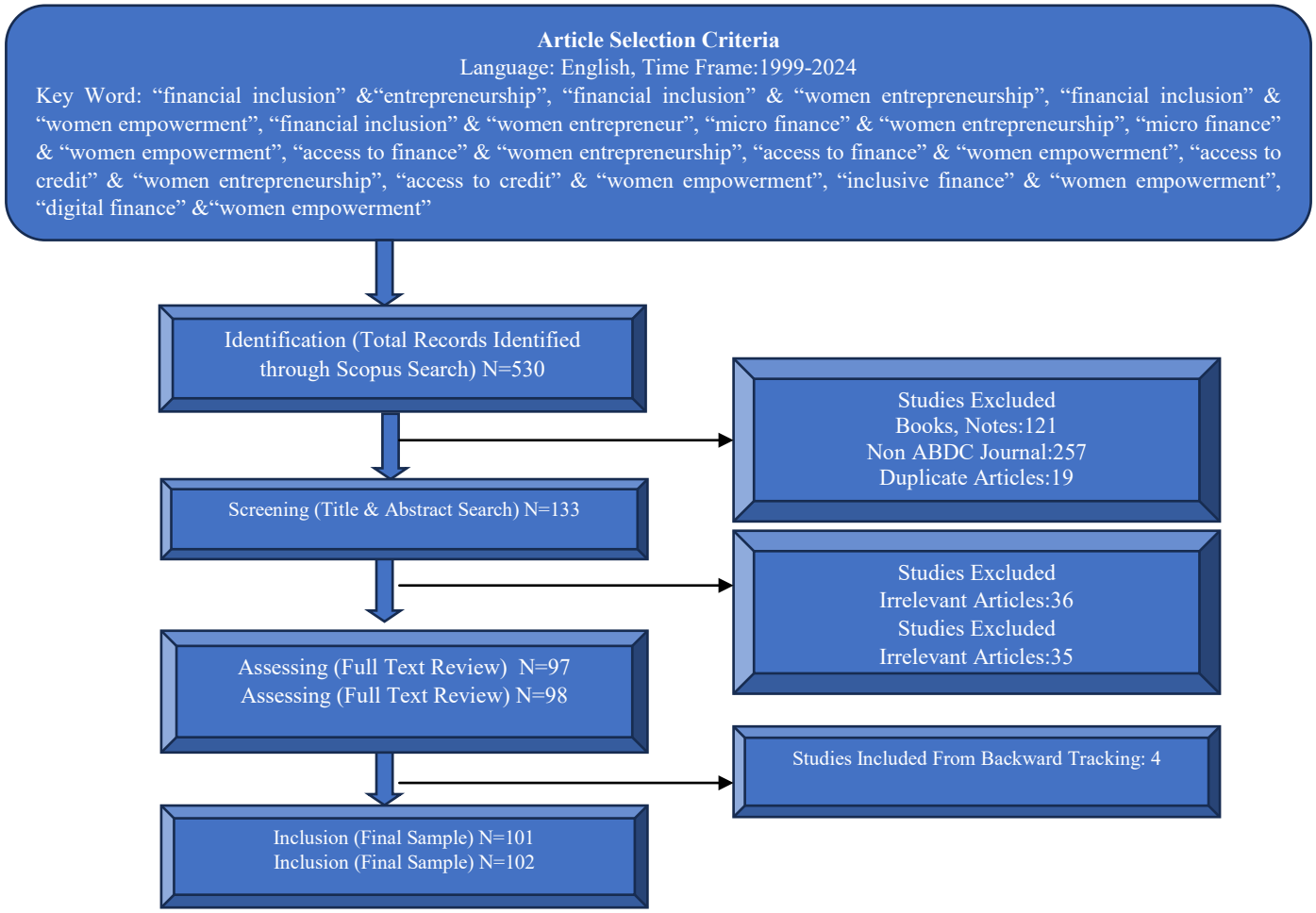

Figure 1: Articles Selection Process using PRISMA Flow Diagram

4. RESULTS & DISCUSSION

The current research has mapped the literature by adopting descriptive analysis tools to capture the strength and weakness of the extant work as well as the concurrent research trend. Further the ADO framework is applied for building the construct between financial inclusion and women entrepreneurship while the TCM framework has been used to illustrate the structured insights on the theoretical, contextual and methodological drivers underlying the

relationship between "financial inclusion" and "women entrepreneurship" (Paul et al.,2023).

4.1 DESCRIPTIVE ANALYSIS

The descriptive analysis process provides an overview about how the financial inclusion and women entrepreneurship research domain has progressed over the last two and half decades. The technical characteristics of the reviewed studies (Y-O-Y Publication Details, Leading Countries in terms of geographical coverage, Publication Outlet and Citation Count) have been carried in the descriptive analysis to interpret the nature of research focusing the financial inclusion and women entrepreneurship domain, the scholarly output of the research carried out in this domain over the time and any possible research gap.

4.1.1: Y-O-Y (Year on Year) Publication Summary

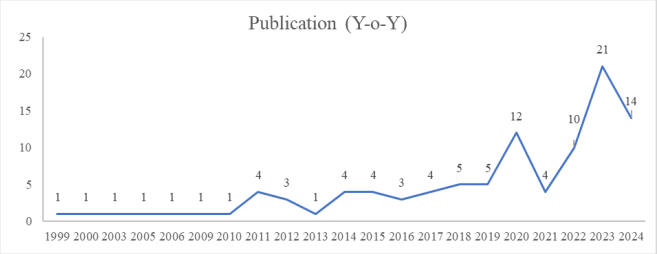

Figure 2: Y-O-Y Publication Statistics

The Y-O-Y publication statistics shown in Figure 2 indicates that the phenomenal increase in the number of articles covering financial inclusion focused women entrepreneurship research during the last four years (2020-24). This implies that financial inclusion and women entrepreneurship domain is gaining attention in the post covid era and research in this segment is currently in the growth stage.

4.1.2: Leading Countries/Regions (Geographical Coverage)

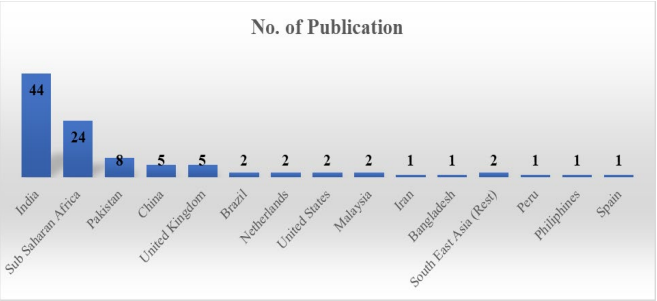

Figure 3: Geography Wise Publication Trend

In terms of geographical coverage, India is the most examined country with 44 publications out of total 101 studied research articles (approximate 44 percent) followed by Sub Saharan Africa with 24 publications (approximately 24 percent). However, rest of the developing economies have negligible research contribution with single digit publication count which indicates the requirement of more focused studies across the globe for cross learning.

4.1.3: Publication Outlet

Since financial inclusion and women entrepreneurship domain is an interdisciplinary field of management studies, social science, economics, entrepreneurship, digital technology and public policy, the peer reviewed articles are published across the varied ABDC journals. The detailed publication count of the leading journals is also provided below

TABLE 1: Leading Journal wise Publication Trend

Journal	Category	No. of Articles	Percentage
World Development	A	9	8.91%
International Journal of Social Economics	B	8	7.92%
Journal of Financial Economic Policy	B	4	3.96%
Development and Change	B	3	2.97%
Equality, Diversity and Inclusion	B	3	2.97%
Gender in Management	C	3	2.97%
International Journal of Gender and Entrepreneurship	C	3	2.97%
Journal of Small Business and Enterprise Development	C	3	2.97%
Benchmarking: an international journal	B	2	1.98%
Indian Growth and Development Review	B	2	1.98%
International Journal of Management	C	2	1.98%
Journal of Business Research	A	2	1.98%
Journal of Development Studies	A	2	1.98%
Journal of Entrepreneurship in Emerging Economies	C	2	1.98%
Journal of the Knowledge Economy	C	2	1.98%
Management Research Review	C	2	1.98%
Small Business Economics	A	2	1.98%
Others	ABDC	47	46.53%

4.1.4: Citation Count

The citation count is carried out to assess the impact of the research work among the academicians as well as Practioners. It provides the details about how the future research is influenced from the extant research work. Even if the financial inclusion and entrepreneurship research has just gained the momentum in the last decade (2014-24),61 out of 101 articles (approximate 60 percent) have received more than 10 citations. The low citation count in comparison to other emerging management field such as consumer behaviour, social media marketing, international business,

artificial intelligence and machine learning is due to the fact that this field of research was majorly focused on the BoP segment and researchers are gradually focusing in this field with the opportunity of interdisciplinary research gaining momentum in varied areas such as entrepreneurship, gender studies, digital technology The detailed citational analysis are given in Table 2.

TABLE 2: List of Author Wise Research Articles having >50 Citation Count

Author	Journal	Citations
Kabeer (1999)	Development and Change	2455
Van Rooyen et al. (2012)	World Development	317
Pitt et al. (2006)	Economic Development and Cultural Change	267
Ashraf et al. (2010)	World Development	210
Sharma D. (2016)	Journal of Financial Economic Policy	199
Swain & Wallentin (2009)	International Review of Applied Economics	190
Mushtaq & Bruneau (2019)	Technology in Society	181
Ghosh & Vinod (2017)	World Development	170
Panda (2018)	Gender in Management	160
Ganle et al. (2015)	World Development	157
Agier & Szafarz (2013)	World Development	149
Halkias et al. (2011)	Management Research Review	128
Chliova et al. (2015)	Journal of Business Venturing	122
Mahmud (2003)	Development and Change	121
Brody et al. (2017)	Journal of Development Effectiveness	106
Weber & Ahmad (2014)	World Development	95
Atiase et al. (2018)	Journal of Small Business and Enterprise Development	85
Franck A.K. (2012)	International Journal of Gender and Entrepreneurship	84
Burgess et al. (2005)	Journal of the European Economic Association	73
Ajide (2020)	Journal of Financial Economic Policy	62
Chatterjee et al. (2018b)	Management Decision	58
Garikipati (2012)	Development and Change	58
Isaga (2019)	International Journal of Gender and Entrepreneurship	57
Datta (2015)	World Development	52

4.2 ADO-TCM FRAMEWORK DEVELOPMENT

An integrating framework (Figure 7) is developed from the synthesis of the findings from this literature review. The ADO & TCM approach is used combinedly for an encompassing review of the financial inclusion and women entrepreneurship research domain (Paul et al.,2023). ADO provides the details of "what is known" from the systematic literature review about a particular construct whereas TCM explains about "how it is known" by furnishing detailed overview of the theory, context and methodology adopted in the studied literatures (Khatri & Duggal,2022). The combined approach has provided an overarching review insights by overcoming the shortcoming of each process (Paul et al.,2023).

4.2.1: What is known (Findings from the ADO Framework)

The "ADO (Antecedents, Decisions & Outcomes)" approach is used to organise the research findings by building the construct between the variables in a structured way (Lim et al.,2021). "Antecedents" are the key factors behind a particular phenomenon underlying in a construct whereas "Decisions" explain the dimensional structure of that construct (Paul & Benito,2018). "Outcomes" are the final consequences arising from the positive, negative or neutral relationship between the variables of a construct (Khatri & Duggal 2022). ADO framework is particularly useful to study the interrelationships between the variables in a construct.

4.2.1.A: Antecedents

Out of total 101 research articles studied,87 research articles have highlighted the role of institutions as the key antecedent to drive the financial inclusion ecosystem and product usage from women entrepreneurship context. Utilizing the concept of institutional theory (Scott 1995), this research has differentiated antecedents into three categories: (i) cognitive, (ii) normative, and (iii) regulative.

The number of research articles illustrating the importance of different antecedents with respect to financial inclusion and women entrepreneurship context are given below.

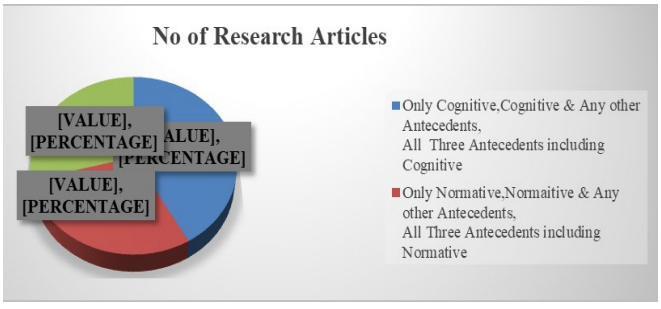

Figure 4: Research Articles focusing exclusively one of antecedents, any two & all three antecedents

4.2.1.A1: Cognitive Antecedents

Different cognitive antecedents such as Self-efficacy, Self-esteem, Self-regulation, Intrinsic motivation, Self Confidence have shaped the environment for the holistic usage of different inclusive finance products and benefits

from women entrepreneurship development context. Various research studies have highlighted the role of the "community finance" in shaping the cognitive antecedents of financial inclusion and women entrepreneurship development which is evident from the success stories of the Indian SHGs (Datta,2015; Mohapatra & Sahoo,2016; Brody et al.,2017; Anand et al.,2020). Similarly, "microfinance", which is based on group lending, has also highlighted the role of cognitive antecedents in thriving entrepreneurial growth of the group (Goel & Madan,2019; Nayak et al.,2020; Pal et al.,2022; Kandpal,2022).

4.2.1.A2: Normative Antecedents

Normative elements are primarily the values and norms. Values are the conceptions for setting standards whereas norms provide the modus operandi to achieve those standards (Atiase,2018;). In the current systematic literature review context, sustainable business approaches like repayment of loan as per amortization schedule, S-shaped growth approach for risk minimization of business are the key values under normative antecedent category. Utilization of the financial resources and capacity building tools as per guidelines set the norms which fall under the normative antecedent category. Various research studies (Garikipati,2012; Laha & Kuri,2014; Weber & Ahmad,2014; Goel & Madan,2019; Mahato & Jha,2023) have highlighted the exemplary cases of women entrepreneurs belonging to the BoP segment across the globe setting the values and adhering the institutional financial inclusion norms under the normative antecedent category for a sustainable entrepreneurial growth.

4.2.1.A2: Regulative Antecedents

Regulative elements are the rules, guidelines and the legal standards set by the regulative agencies or the governments to operate in the market. Dedicated policy, effective governance, special provisions in the financial products such as reduced loan interest rate, flexible loan repayment schedule, affordable savings and deposit schemes, massive awareness about the schemes are the key regulative antecedents which have set the base for thriving the financial inclusion focused women entrepreneurship research in the developing economy context (Mushtaq & Bruneau (2019); Nayak et al. (2020); Chakraborty & Chatterjee (2021); Pal et al. (2022).

The antecedent wise breakup of different research articles is given below

TABLE 3: Category Wise Research Articles on Antecedent Basis

Category of Antecedents	No. of Articles
Only Cognitive	17
Only Normative	12
Only Regulative	14
Cognitive & Normative	17
Cognitive & Regulative	15
Normative & Regulative	2
Cognitive, Normative & Regulative	10

During the entire systematic review, it is found that the cognitive antecedents have emerged as the most significant antecedents in the financial inclusion and women entrepreneurship context. However, the interaction of cognitive antecedents with normative and regulative antecedents also holds significance as 44 out of 87 institutional theory related articles (approximate 51 percent) have discussed the interaction of cognitive, normative and regulative antecedents related context.

The systematic review also found other antecedents such as resource and motivation related antecedents. However, these antecedents have been covered under the broader purview of institutional related antecedents such as motivation to start any enterprise under the cognitive antecedent category and utilization of financial resources as per norms under the normative antecedent category.

4.2.1.B: Decisions

"Decisions" are the dimensional structures of a construct (Paul & Benito,2018). This systematic review has observed that asset creation or ownership, livelihood activities and entrepreneurial ventures are the well discussed and most explored dimensions of women entrepreneurship from the financial inclusion perspective. A total of 32 research articles have highlighted about the "Asset Creation & Livelihood Activities" decision aspects. Similarly,19 research articles have highlighted about the "Entrepreneurial Venture" decision aspects.

As per the studied literature, it is observed that the cognitive and normative antecedents have influenced in the decision-making process of the individual entrepreneurs by providing the necessary impetus to harness the entrepreneurial skills among the women for asset creation, livelihood and enterprise development (Mahmood,2011; Datta,2015; Brody et al.,2017; Goel & Madan,2019; Mushtaq & Bruneau,2019; Agarwal et al.,2020; Pal et al.,2022). Regulative antecedents have discussed the impact of the government bodies in acting as enablers through appropriate financial inclusion and entrepreneurship development policy formulation and implementation which positively influences the decision-making process of women entrepreneurs for asset creation, livelihood activities and entrepreneurial ventures (Atiase,2018; Panda,2018; Milana & Ashta,2020; Ningombam & Bordoloi,2024).

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4.2.1.C: Outcomes

"Outcomes" are the consequences emerging out of the operation or non-operation of a particular antecedent under a construct and its eventual decision-making process (Paul & Benito,2018). The different literatures studied in this research have most often used a combination of women empowerment, poverty alleviation and entrepreneurial growth as the outcomes for assessing the impact of financial inclusion on women entrepreneurship (Mahato & Jha,2023).

Cognitive and normative antecedents have a prolific impact on the outcome of women empowerment as well as poverty alleviation as per the studied literature. Cognitive antecedents create an intrinsic motivation among the women to empower themselves and fight against the poverty. Similarly, the normative antecedents create a set of values and norms through which the women achieve their goal of empowerment and poverty eradication. A total of 29 research articles have highlighted about the "Women Empowerment" outcome aspects. Similarly, 20 research articles have highlighted about the "Poverty Alleviation" outcome aspects.

Regulative antecedents like dedicated financial inclusion and entrepreneurship development policy such as PMJDY & PMMY of India, National Rural Support Programme of Pakistan, Ajo of Nigeria have acted as the stimulant in the women entrepreneurial growth (Simba et al.,2023; Sahu et al.2024).Financial incentives such as interest subvention in different schemes like PMMY & NRLM of India have provided the necessary impetus for thriving the women entrepreneurship (Datta,2015; Brody et al.,2017; Sahu et al.,2024).Effective governance has provide an enabling medium for the women entrepreneurial growth (Sharma,2016; Brody et al.,2017; Goel &Madan,2019). However, institutional void in terms of ineffective, incapable and unstable government has inhibited the women entrepreneurial growth which is evident from the majority cases of African countries as per the studied literature (Siringi,2011; Wekwete,2014; Atiase et al.,2018). A total of the 23 research articles have focused on the women entrepreneurial growth aspects

4.2.2: HOW IT IS KNOWN (FINDINGS FROM THE TCM FRAMEWORK)

The TCM (Theory, Context & Methodology) framework is used to carry out the theoretical underpinning, context of the research setting and the key methodologies adopted to explain the underlying construct. It allows the critical evaluation of the theories for understanding how these underlying theories in the research are being applied in different context. It identifies the key research gap and directions for the future research (Mishra et al.,2021).

4.2.2.A: Theory

Researchers have applied different theories for explaining the catalytic role of financial inclusion with reference to women entrepreneurship development. Majority of the studied literature have not explicitly stated any theoretical framework; however, the current systematic review evaluated all the 101 research articles from a theoretical lens and found that the financial inclusion and women entrepreneurship research is primarily based on four major theories viz. institutional theory, resource-based theory, agency theory and diffusion of innovation theory.

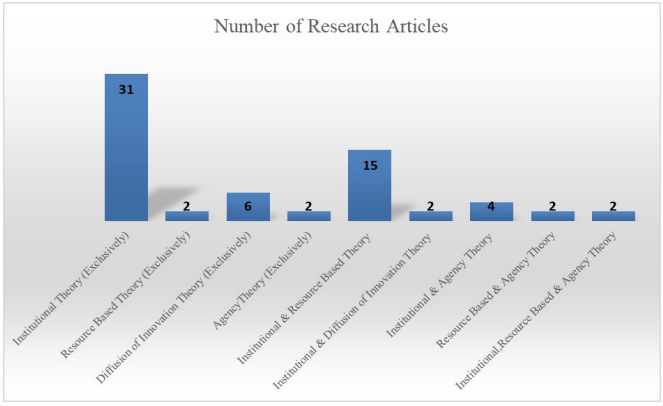

Figure 5: Number of Research Articles focusing "Key Theories"

4.2.2.A1: Institutional Theory in Financial Inclusion & Women Entrepreneurship Context

Various research studies in the current systematic review have highlighted how the institutional theory has set the norms and regulations for the BoP level women enterprises to operate. Different cognitive factors such as self-efficacy, self-esteem, self-regulation, self-confidence, intrinsic motivation have shaped the building block for the holistic usage of different inclusive finance products which in turn influences the mindset of women to pursue any entrepreneurial activities (Mahmud,2003; Swain & Wallentin,2009; Ghosh & Vinod,2017; Atiase,2018).The cases of Indian SHGs is an illustrative example about how the women has integrated the cognitive factors in the financial inclusion and women entrepreneurship context (Datta,2015; Mohapatra & Sahoo,2016; Brody et al.,2017;

Anand et al.,2020). Similarly, the current study also observes how the normative factors like financial inclusion norms being adhered by the women for pursuance of the entrepreneurial activities (Garikipati,2012; Laha & Kuri,2014; Weber & Ahmad,2014; Goel & Madan,2019; Mahato & Jha,2023). This regulative factors such as dedicated financial inclusion and entrepreneurship development policies across the globe has provided a conducive environment for women entrepreneurship (Datta,2015; Brody et al.,2017; Anand et al.,2020; Simba et al.,2023; Farooq et al.,2024; Sahu et al.,2024).

4.2.2.A2: Resource Based Theory in Financial Inclusion & Women Entrepreneurship Context

Resource Based theory highlights how resource acts as a pivotal factor in the establishment of the business and firm's competitive advantage in the market (Barney,1986). The current systematic review found how different financial products viz. micro credit, micro savings and micro insurance has set the base for any entrepreneurial activities among women entrepreneurship (Mumtaz,2000; Ashraf et al.,2010; Weber & Ahmad,2014; Mushtaq & Bruneau, 2019; Nayak et al.,2020). The customization in financial product such as affordable interest rate, interest subvention, flexible loan repayment cycle has acted as a boost for women entrepreneurial activities as evident from the success stories of Indian financial inclusion focused entrepreneurship development scheme- PMMY and the financial inclusion focused livelihood programme-DAY-NRLM (Datta,2015; Brody et al.,2017; Sahu et al.,2024).

4.2.2.A3: Agency Theory in Financial Inclusion & Women Entrepreneurship Context

Agency theory primarily describes the confluence between the two parties viz. the principal who formulates guidelines and the agent who performs task. The success of this ecosystem lies with the avoidance of interest conflict between agent and principal (Mitchell and Meachem,2011). The current systematic review has identified the efficient harmony between the "principal" and "agent" in case of Indian SHGs ecosystem for a sustainable women entrepreneurship growth (Brody et al.,2017; Anand et al.,2020; Nayak et al.,2020). However, the current research has also found the industrial conflict which impedes the women entrepreneurial growth in different African economy cases (Siringi,2011; Atiase et al.,2018; Brixiová et al.,2020).

4.2.2.A4: Diffusion of Innovation Theory in Financial Inclusion & Women Entrepreneurship Context

Diffusion of Innovation theory describes how an idea or product creates propulsion and diffusion in the society (Rogers,1962). This is particularly applicable in the current financial inclusion focused women entrepreneurial ecosystem where digital finance has played a key role in the women entrepreneurship development. Several research studies have identified that how women have adopted the digital financial inclusion approach in their entrepreneurial set up over the period (Yang et al.,2022, Ding et al.,2023; Sreenu 2023). The current research has also identified the constraints primarily the reluctance approach among women for adopting digital technology (Sreenu 2023; Hasan et al. 2023).

This research has also identified role of Motivation Theory in the women entrepreneurship development context, however considering the broader dimension of motivation in influencing the cognitive factors of the institutional theory, this theory is not discussed here.

4.2.2.B: Context

Context refers to the circumstances that leads to conduct research (Paul et al.,2017). This review has found some of the key emerging research areas at the confluence of financial inclusion and women entrepreneurship across different geographies by reviewing the 101 research studies.

TABLE 4: Geographic Trend in Emerging Areas of Research

Key Emergent Areas	Country/Region	No. of Paper
Women Empowerment & Microcredit	Bangladesh	2
	India	3
	Pakistan	3
	South East Asia (Rest)	1
	Sub Saharan Africa Region	5
	United Kingdom	1
	United States of America	1
Women Empowerment & Financial Inclusion	India	8
	Pakistan	1
	South East Asia (Rest)	2
	Sub Saharan Africa Region	4
Women Entrepreneurship & Financial Inclusion	India	10
	Latin America	1
	Sub Saharan Africa Region	2
Financial Inclusion & Entrepreneurship	China	2
	India	2
	Latin America	1
	Pakistan	1
	Spain	1
	Sub Saharan Africa Region	3
	United Kingdom	2
Women Entrepreneurship & Community Finance	India	10
	Sub Saharan Africa Region	2
Women Entrepreneurship & Digital Finance	China	3
	India	1

Key Emergent Areas	Country/Region	No. of Paper
	Iran	1
	Netherlands	1
	Sub Saharan Africa Region	2
Financial Inclusion & Entrepreneurship Policy	India	4
	Pakistan	1
	South East Asia (Rest)	1
	Sub Saharan Africa Region	1
	United Kingdom	1
Women Entrepreneurship & Regulatory Policy	India	1
	Sub Saharan Africa Region	4
	United States of America	1
Women Entrepreneurship & Credit Access	India	3
	Latin America	1
	Pakistan	1
	South East Asia (Rest)	1
Misc. (Women Empowerment &Caste)	India	2
	Netherlands	1
	Sub Saharan Africa Region	1
	United Kingdom	1

Asian continent is the epicentre of the research study with India as the leading country in the financial inclusion and women entrepreneurship research with 44 research studies on India thereby covering approximate 44 percent of the total study. The Sub-Saharan Africa region has contributed with 24 research studies (appx. 24 percent of the study). The other developing regions of the world such as LATAM region, MENA region & Eastern Europe have contributed significantly a smaller number of research studies indicating the requirement of focused research for these regions.

4.2.2.C: Methodology

Following is the research approaches being adopted in the studied literature of this systematic review

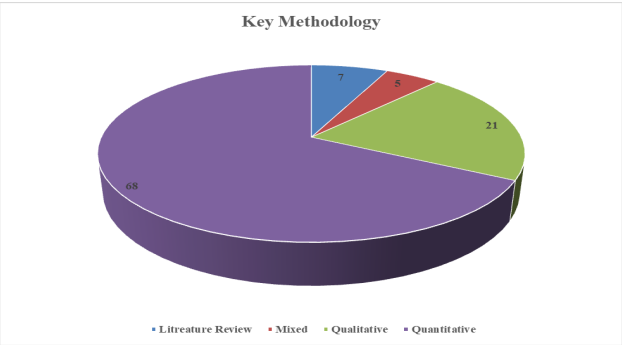

Figure 6: Number of Research Articles as per adopted Research Methodology

As per the SLR,68 studied articles have adopted the quantitative approach followed by 21 research articles adopting the qualitative approach whereas mixed approach comprises in case of 5 studied articles. This systematic review has also included 7 review articles to understand the contemporary research trend in the SLR & Bibliometric analysis.

The details of key research tools used in different research methodology are as follows

TABLE 5: List of Key Methodological Tools Applied

Method	Key Tools	Articles
Qualitative	Ethnography	6
	Case Study	5
	fsQCA	3
	Content Analysis	2
	Focus Group Discussion & Interview	1
	Phenomenology	2
	Grounded Theory	1
	Sub Total (Qualitative)	**20**
Quantitative	Regression	49
	SEM	6
	ANOVA	4
	MANOVA	1
	Chi Square Test	2
	PCA	2
	Descriptive Analysis	2
	Factor Analysis	1
	Multi Source Information Fusion (Big Data Analysis)	1
	Sub Total (Quantitative)	**68**
Mixed	Ethnography & Descriptive Analysis	1
	Focus Group Discussion & Variance Analysis	1
	Focus Group Discussion & Regression	1
	Case Study & ANOVA	1
	Content Analysis, Descriptive & Factor Analysis	1
	Sub Total (Mixed)	**5**
Literature Review	SLR	4
	Meta-analysis	1
	Systematic Review & Thematic Analysis	1
	Bibliometric Analysis	1
	Sub Total (Review))	**7**

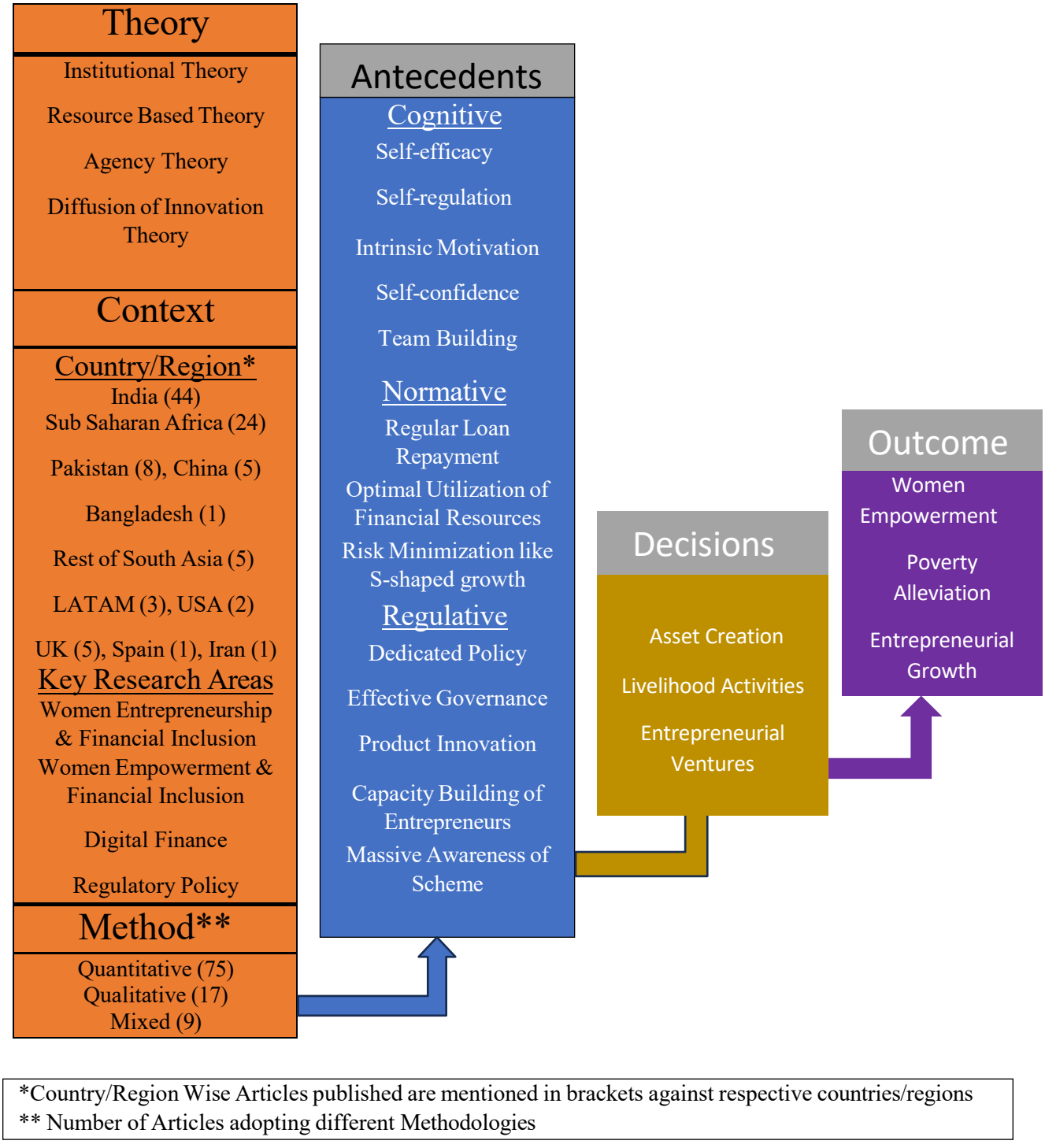

Figure 7: A Holistic Review finding from the ADO-TCM Framework

4.3: IMPLICATION FOR THE FUTURE RESEARCH (WHERE SHOULD BE HEADING)

By conducting systematic literature review of the 101 research articles, various research gaps have emerged which can be converted into future research opportunities. With the ADO framework as the foundation, this research study has set the future research scope upon which the prospective researchers may conduct their future studies. Thus, the current ADO framework acts as an indicator for the future research or in other words "Where should be Heading".

4.3.1: Antecedents

The current systematic review has observed that the present era of financial inclusion and women entrepreneurship research is driven by cognitive, normative and regulative antecedents. Future research can benefit from the role of cognitive, normative and regulative antecedents from an institutional perspective. However, very few research has been carried on the role of cognitive antecedents like self-efficacy, self-esteem, motivation from an individual behaviour perspective as per the findings of the 101 selected articles (Brody et al.,2017; Anand et al.,2020; Agarwal et al.,2020; Nayak et al.,2020).

Similarly, the role of micro credit in the women entrepreneurship context is well studied in all the selected research articles for this systematic review, but financial inclusion as a domain beyond microcredit and its applicability to women entrepreneurship development is a less focused area. The role of savings as the stimulant for the women entrepreneurship development is well studied from an Indian research context. However, very few research articles across the globe has carried out research in this context except only 3 research articles mentioning the role of savings product in case of women entrepreneurship development in Peru (Daher,2022), Philippines (Ashraf,2010) and Kenya (Bettinelli et al.,2024). Thus, the future research agenda can be on the role of financial products beyond microcredit like micro savings, micro insurance and digital financial services on women entrepreneurship development.

Digital finance also plays a crucial role in the women entrepreneurship development (Yang et al.,2022; Sreenu,2023). However, the constraints faced by the women entrepreneurs in adopting digital technology, role of micro and macro environment in promoting digital financial products among women entrepreneurs are some of the less focused research areas in the financial inclusion and women entrepreneurship research domain. Thus, behavioural finance, public policy, social innovation are some of the upcoming transdisciplinary research areas in financial inclusion and women entrepreneurship research domain.

4.3.2: Decisions

This study has also found some research gaps in the decision stages which are as follows

Most of the women enterprises created through the institutional financial inclusion support are small scale in nature. There is no defined approach or appropriate business model about how to upscale these enterprises which is evident from different cross-sectional studies (Sharma,2016; Chatterjee et al. 2018a; Nayak et al.,2020). Thus, building of a scalable business model can become the upcoming research in the financial inclusion and women entrepreneurship research domain. Similarly, various studies have highlighted the requirement of appropriate financial and non-financial product design for a scalable women entrepreneurship business model, but the development of any product innovation framework is yet to emerge (Mumtaz,2000; Ashraf et al.,2010; Weber & Ahmad,2014; Mushtaq & Bruneau,2019; Nayak et al.,2020).

4.3.3: Outcomes

The overall objective of the financial inclusion mission from the women entrepreneurship perspective is about how to transform the small-scale women enterprises from the BoP segment self-sustainable. Business model like SHGs of India has made the small-scale women enterprises self-sustainable (Datta,2015; Mohapatra & Sahoo,2016; Brody et al.,2017; Simba et al.,2023). Yet, there is absence of appropriate policy about how to transform these women enterprises sustainable without any institutional support which different studied literatures have highlighted (Sharma,2016; Brody et al.,2017; Chatterjee et al.2018a; Anand et al.,2020; Nayak et al.,2020). The women enterprises in other developing counties are still in the stage of institutional support for sustainable business operations. So, the next phase of policy research for the developing economies across the world would be to replicate the Indian financial inclusion institutional support model for the early stage of women entrepreneurship development. The Indian policy research should primarily focus on formulating the business model of without institutional support for the established women enterprises, however, the researchers should also carry out research on the customised support requirement in the different growth phases of the matured women enterprises specifically in the Indian context.

4.4: FUTURE DIRECTIONS FOR RESEARCH (HOW TO CONDUCT THE RESEARCH)

Future research agenda (Where should be heading) is derived from the ADO framework in the previous section. However, it is vital for the researchers about “How to conduct the Research” i.e. the future research direction. This systematic literature review has used the TCM approach to devise the future research guidelines.

4.4.1: Theory

The contemporary financial inclusion research domain lacks an underlying theory for better understanding of the concept from a socio-economic perspective since financial inclusion as a discipline is based on practice (Ozili,2020). This systematic review also found similar findings as majority of the studied literature have not explicitly stated any theoretical framework; however, the current systematic review has evaluated all the 101 research articles from a theoretical lens and found that the financial inclusion and women entrepreneurship research is primarily based on four theories viz. institutional theory, resource-based theory, agency theory and diffusion of innovation theory, but, the research is heavily influenced by the institutional theory (approximate 53 percent of the study). However, the future research

agenda being focused on the individual behaviour perspective, researchers should also use the concept of behavioural theory and motivation theory in their future study. The future study should also conduct focused research on the confluence of institutional theory, resource-based theory, agency theory and diffusion of innovation theory to establish any kind of innovative theoretical framework in the financial inclusion and women entrepreneurship development domain. The concept of upper echelon theory (Hambrick & Mason,1984) along with agent theory can also be applied to study the principal and agent relationship between the institution and women group specifically in the community finance context. The diffusion of innovation theory should be applied in a broader context across the globe for a prolific overview on the scope of digital finance in the women entrepreneurial growth. The theories of social innovation (Logue,2019) and the concept of social entrepreneurship (Goyal et al.,2015) should also be applied in designing scalable business model for women entrepreneurs.

4.4.2: Context

The financial inclusion and women entrepreneurship is heavily dominated by India with approximate 44 percent of the total study. There should be more focus on developing quality research on other developing economies such as LATAM region, MENA region, South East Asian region barring India & Eastern Europe to get a detailed overview of the financial inclusion in thriving women entrepreneurship. The Indian study should focus more on the advanced trans disciplinary research context such as scope of digital inclusive finance in upscaling the women enterprises, concept of financial product innovation and social entrepreneurship in designing sustainable women entrepreneurship development.

4.4.3: Method

The uneven representation of the research methodology implies that the contemporary financial inclusion and women entrepreneurship research is either using the primary survey or large-scale secondary data for the analysis implying to carry out more qualitative & mixed research approach to get an exhaustive ground level understanding of the phenomena. The absence of framework-based review methodology the SLR based literature review articles can also become the future scope of research in the emerging systematic literature review research.

5. POLICY LEVEL IMPLICATION FROM THE CURRENT SYSTEMATIC REVIEW

This research study had found the evidence of favourable public policy in shaping the financial inclusion focused women entrepreneurship growth of any country. The current systematic review had also revealed the focal point of financial inclusion and women entrepreneurship research with reference to India. This systematic review had identified the government driven innovative inclusive finance schemes as the key strategy for the women entrepreneurial growth in India. Further the focused livelihood and women entrepreneurship development policies of the government has transformed the women entrepreneurship landscape of the India. The regulative antecedents highlighted in this systematic study provided illustrative information on the role of effective governance of Indian institutions in driving the cognitive and normative factors of the individual women entrepreneurs. On the other hand, this study has also found the cases of institutional void in many parts of Africa which has affected the financial and entrepreneurial growth of the women. Thus, there is of outmost requirement to replicate the Indian financial inclusion and entrepreneurship policies exhaustively for replication of the Indian success story across other developing economies and future suggestive policy level remedial strategies for the sustainable growth of the Indian BoP level women entrepreneurial ecosystem.

6. IMPLICATION FOR FUTURE RESEARCH

6.1: THEORETICAL IMPLICATION

This article offers some of the key insights for future research and SLR.

The combined framework of the ADO-TCM has generated scholarly and comprehensive insights for a holistic understanding of the financial inclusion ecosystem from women entrepreneurship development context. The findings from the ADO framework will enable researchers for treating cognitive, normative and regulative antecedents as mediating or moderating variables to study how the financial inclusion initiatives act as stimulating factor on women entrepreneurial growth. The overarching review of the ADO framework can serve as a blueprint to develop construct for quantifying any plausible relation between financial inclusion & women entrepreneurship development.

The findings of the TCM clearly identifies the different theories that can be applied for upcoming research in this emerging field of financial inclusion and women entrepreneurship development. The highlighted gaps of a smaller number of scholarly research articles across the globe barring India can act as signposts for future research. Further the TCM framework also highlights the requirement of the application of behavioural theory, innovation theory and the concept of social entrepreneurship in trans disciplinary emerging research context. Similarly, focused application of qualitative or mixed methodology in the future research will provide a nuanced understanding of the ground level financial and entrepreneurial challenges of the women entrepreneurs as the contemporary quantitative methodology dominated research studies have either tried to only establish the correlation between financial inclusion and women entrepreneurship development or quantified the success of

any large-scale government intervention by quantifying the data.

6.2: PRACTICAL IMPLICATION

This systematic review holds significance for the public policy practitioners as it provides a pool of literature on the financial inclusion from women entrepreneurship context which they can utilize in formulating future entrepreneurship policy focused on women (Khatri & Duggal,2022). Practitioners and regulatory bodies can also build effective institutional structure and enabling regulatory environment for the growth of the women entrepreneurship through financial inclusion intervention in line with the findings of this SLR.

This research imparts an understanding of how BoP level women entrepreneurship operates which the service providers can integrate in their policies and processes to develop gender focused affordable and accessible financial products/services for the entrepreneurial growth. This study also provides key managerial implications in highlighting the upcoming industry focused research areas such as adoption of digital financial inclusion for women entrepreneurial growth, product innovation framework and design of scalable and sustainable business model for the women entrepreneurs.

7. LIMITATIONS

Although this Systematic Literature Review imparts key insights for the scholars and policy practitioners in the financial inclusion and women entrepreneurship domain, it has few limitations.

First, the relevant article searching criteria was based on search string comprising relevant keywords. Thus, there are chances of missing any relevant article during the manual searching process. Second, grey literature (doctoral thesis, dissertations, working papers and policy documents/briefs) and other non-peer-reviewed articles were not included in this systematic review which aligns with the quality level scholarly outcome (Srivastava et al.,2023). However, policy documents/briefs provide the detailed understanding on the emerging practices specifically in the financial inclusion context which is a heavily practice oriented discipline. Third, the criteria to select only articles from the English language might have led to miss any significant article from other languages although the current study had covered the major developing economies of three subcontinents viz. Asia, Africa and Latin America.

8. CONCLUSION

This research has contributed to the financial inclusion and women entrepreneurship domain in several ways. It contributes to the scholarly research domain by carrying out the systematic literature review to analyse the catalytic effect of financial inclusion in women entrepreneurship development unlike the contemporary research focusing either on financial inclusion or women entrepreneurship development. For this, the PRISMA approach is applied to systematically review empirical studies examining the correlation between financial inclusion & women entrepreneurial growth. Moreover, this research carried out systematic review of 101 research articles from the peer-reviewed journals of “ABDC (Australian Business Deans Council)” only for scholarly output since articles are listed in the ABDC journals based on their rigor of work rather than a citation score (Srivastava et al.,2023).

This study can be considered as one of the pioneer research studies in applying the ADO-TCM framework, one of the emerging frameworks based systematic review, to the financial inclusion and women entrepreneurship research arena. The ADO-TCM framework imparts a holistic summary of the current state of research in this field and signal the way forward. The ADO approach revealed the role of cognitive, normative and regulative antecedents as the key enablers in the entrepreneurial decision of women as well as shaping the role of financial inclusion for a favorable outcome of women entrepreneurship development. Further, the TCM approach highlighted the requirement of theoretical framework for a better intellectual discourse in the financial inclusion and women entrepreneurship research.

DECLARATION

I, [Nayan Krushna Samantray], hereby confirm that the manuscript titled "[Title of the Paper]" authored by [Author(s) Full Name(s)], has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to [Name of the Journal/Conference].

I/we declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

ANNEXURE

Bottom of the Pyramid segment originally refers to appx. 2.5 billion people with acute poverty having a daily income of <= 2.15 U$D/day for the population. Further, people with daily income of <= 3.65 U$D/day as per the latest Multidimensional Poverty Index of 2023 by United Nations (UNDP,2023). The theory and practice of bottom (base) of the pyramid (BoP) concept rose into prominence since new millennium with the C.K. Prahalad’s pathbreaking article “The Fortune at the Bottom of the Pyramid” (Aggarwal et al.,2018). This novel idea has emphasized of serving the poor by addressing their unmet business needs while safeguarding the profitability of businesses (Prahalad & Hart,2002).

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Exploring the Dynamics of Internal Resource Allocation within Diversified Firms: An Analysis of Investment Patterns and Performance Effects in the Indian Capital Market

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ABSTRACT

This study provides a comprehensive analysis of resource allocation within diversified firms, focusing on resource allocation, headquarters' informational advantage, and its impact on firm performance. The study integrates finance and strategic management perspectives. It explores internal resource allocation's bright and dark sides, emphasizing past growth opportunities and regulatory interventions. The role of informational asymmetry and opacity was found within the firm, along with the existence of the dynamic capability. The detailed analysis found a quadratic relationship between resource allocation and performance while analysing the performance effect. However, this relationship was found to be the nature of diminishing returns after a certain threshold, underscoring the need for strategic decision-making and dynamic capability development. This study contributes to a nuanced understanding of resource allocation within diversified firms, underscoring the importance of considering both high- and low-growth investment opportunities.

Keywords: Internal capital market Growth opportunities Resource allocation opacity.

1. INTRODUCTION

This study comprehensively examines resource allocation within diversified firms, uniquely integrating the finance and strategic management perspectives. It explores both the bright side (Almeida et al., 2015; Khanna & Tice, 2001; Stein, 1997) and dark sides (Glaser et al., 2013; Ahn & Denis, 2004; Scharfstein, 1998) of internal resource allocation, emphasizing the role of past growth opportunities and regulatory interventions. The findings highlight the importance of considering both high and low-growth investment opportunities and reveal the role of cross-subsidization (Rajan et al., 2000) and opacity within diversified firms (Dietrich, 2007). Furthermore, this study illuminates the informational advantage of headquarters in internal resource allocation and its impact on firm performance.

The current study focuses on Indian private firms, sub-classified as business groups(affiliated) and standalone (non-affiliated), actively participating in the internal capital market via their subsidiaries. Although related-party transactions are a crucial aspect of the internal capital market, the current investigation was confined to internal investments made by promoters, loans issued and received from promoters, and other affiliated groups. Concerns about information asymmetry within firms, especially at the headquarters level, have been raised. This study views internal resources as multidimensional from a strategic management perspective, with weak links (investment in low-growth opportunity firms) representing dynamic and absorptive capabilities (Ng 2007).[7] It focuses on the financial-tangible internal resources used for internal fund allocation (Busenbark et al., 2017 & Mathews & Robinson, 2008), considers financial slack (Cestone & Fumagalli, 2005). Research confirms that headquarters have an informational advantage, and internal resource allocation favors firm performance, which is directly linked to the wealth creation of the firm (Teece et al., 1997) and a function of product innovation and process innovation (Zott, 2003). This study also highlights a quadratic relationship between internal resource allocation and performance, which exhibits diminishing utility (Lovallo et al., 2020).

The contributions of this study to the literature are two-fold. First, the study combines the perspectives of finance and strategic management to examine the bright and dark side of internal resource allocation, offering insights into the influence of past growth opportunities and regulatory interventions. This contributes to a nuanced understanding of resource allocation within diversified firms. Second, findings underscore the importance of considering high-growth and low-growth investment opportunities, highlighting the role of cross-subsidization and opacity within diversified firms. Furthermore, it sheds light on the informational advantage of headquarters in internal resource allocation and its impact on firm performance.

The remainder of this paper is organized as follows. Section 2, develop the main hypothesis, supported by the literature.

[7] Ng(2007, pg 1496) states that the firm can achieve arbitrage opportunities through diversification and expansion with the help of the interaction of three pillars of growth: the strength of dynamic capabilities, alertness to weak ties and absorptive capacity.

Section 3 explains the data and variables used in the analysis. Sections 4 and 5 present empirical results. Section 7 presents the details of the robustness check, section 8 presents the managerial implications, and Section 9 concludes.

2. LITERATURE REVIEW AND HYPOTHESIS

Shin and Stulz (1998) defined an efficient internal capital market as prioritizing allocating funds to segments with the best investment opportunities, reducing their sensitivity to their own and other segments' cash flows, and adjusting the allocation when other segments have better opportunities. Affiliation benefits arise in a centralized control system (Stein, 1997), allowing efficient resource deployment within groups with low transaction costs, especially during costly external capital markets (Khanna & Palepu, 2000). Thus, the hypotheses focus on (a) the role of growth opportunities in internal resource allocation and (b) the impact of performance on fund allocation,

a Growth opportunity and internal allocation of funds:

An internal capital market of multiple business lines allows managers to redeploy capital from divisions with poor investment opportunities to those with good investment opportunities without compromising the overall capital budget. Centralized control depends on management characteristics and internationalization, which develop the boundaries of centralized control systems (Feldman, 2021).

However, the trade-off between agency and information asymmetry determines investment efficiency, which is influenced by favoritism and the information hypothesis (Duchin & Sosyura, 2013). The internal reallocation of resources directly affects shareholder wealth and firm value (Scharfstein & Stein,2000). Firms tend to prefer internal to external resources because of the lower costs associated with internally raised capital.

In contrast, Glaser et al. (2013) argue for the inefficiency or dark side of the internal capital market. The flip side of winner picking (Stein, 1997) is loser picking, in which firms with relatively fewer investment opportunities invest more internally. Scharfstein and Stein (2000) argue that the rent-seeking behaviour of divisional managers leads to investment in bad investment opportunities, and Rajan et al. (2000) call this behaviour “cross-subsidization”. Ozbas and Scharfstein (2010) compare the investment behaviour of standalone businesses with business groups and find that standalone businesses are more responsive to industry Q than the investment of “unrelated” segments of conglomerate firms, explaining the nature of underinvestment or overinvestment. Thus, the first hypothesis is as follows:

- *The firm with greater growth opportunities receives less internal capital transfer than fewer growth opportunities (H1)*

b Performance effects and the internally allocated funds

Internal resources play a crucial role in shaping a firm's behaviour and performance (Montgomery, 1994). Financial slack, which is considered an internal resource (Mathews & Robinson, 2008), acts as a highly liquid asset for internal capital market transactions, providing resource flexibility for fund allocation (Boutin et al., 2013; Cestone & Fumagalli,2005). When funds are internally allocated, two mechanisms come into play: resource picking and capability building, which contribute to the firm's economic rent and performance (Makadok, 2001). Capability building, particularly absorptive capacity, is vital for resource deployment within the internal capital market (Zahara & George, 2002). Absorptive capacity is a firm's ability to transform and implement external knowledge and enhance its core competitiveness through acquisition, assimilation, transformation, and exploitation (Zahara & George, 2002). Absorptive capacity’s managerial role influences firm performance (Zahra & Hayton, 2008). Absorptive capacity contributes directly or indirectly to financial performance over different time spans (Kostopoulos et al., 2011). Higher absorptive capacity is a firm’s dynamic capability.

The relationship between firm performance and dynamic capability is indirect (Lovallo et al., 2020; Zott, 2003). Zott (2003) links firm performance to revenue generation, representing product quality (innovation and cost) and quantity of output produced. In contrast, Busenbark et al. (2022) argue for a direct link between firm performance and internal fund allocation, aligned with the behavioral theory of the firm. However, Lichtenthaler (2016) and Lovallo et al. (2020) suggest that long-term internal resource allocation might negatively impact firm performance despite protecting the firm from exogenous shocks (Martinez et al., 2019).

The internal capital market hypothesis highlights how capitalizing internal fund allocation within diverse firms provides a competitive financial advantage over non-diversified firms (Rudolph & Schwetzler, 2013). Dynamic capabilities within firms emphasize the importance of unrelated diversification (Miller, 2003), further reinforced by weak ties considered low-growth opportunity firms (Granovetter, 1983; McFadyen & Canella, 2004). However, it is also considered a firm’s strategic behaviour by restricting its borrowing capacity through the opacity of the transaction (Dietrich, 2007). The informational advantages of the headquarters regarding its subsidiaries enhance the organization's dynamic capabilities, enabling it to seek new resource combinations and increase its absorptive capacity. Maximizing internal efficiency through heterogeneous resources strengthens a firm's dynamic capabilities (Ng, 2007). Based on the literature, the second hypothesize is framed as follows:

- *The internal resource allocation to the low growth opportunity firm exhibits the dynamic capabilities within the firm level, which improves the performance of the firm and becomes negative after the threshold point (H2)*

3. SAMPLE AND THE VARIABLES

a Sample Selection

The Prowess database (managed by the CMIE-Center for Monitoring Indian Economy) was used to extract the financial information, ownership categorization, and industry affiliation of list companies in the Indian capital market. Depending on the ownership classification and equity concentration, enterprises in India are further classified into the government sector, Indian private sector, foreign private sector, and various associations and cooperatives. Private companies (standalone businesses) and group-affiliated companies (business group enterprises) are further divisions of the Indian private sector. For this research, only the Indian private sector over three years of age was included. Firms from the banking and other financial industries were excluded from the final sample.

The sample includes 1420 standalone firms with 11769 firm-year observations, and 733 business group firms from 380 business group houses with 6388 firm-year observations. The number of observations in subsequent analyses may vary, depending on the availability of certain variables. A two-digit NIC code with 96 industries was used for the broader structure of industry affiliation and reclassified the 96 industries in Table 1–the Fama-French 17 industry portfolio classification.

TABLE 1 : Fama – French 17 industry classification

		Standalone firm		Business group firm		Total	
SL	**Fama-French Classification**	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
1	Food	655	5.57%	504	7.89%	1,159	6.38%
2	Mines	148	1.26%	332	5.20%	480	2.64%
3	Oil and Petroleum Products	27	0.23%	36	0.56%	63	0.35%
4	Textiles, Apparels & Footwear	856	7.27%	428	6.70%	1,284	7.07%
5	Consumer Durables	862	7.32%	226	3.54%	1,088	5.99%
6	Chemicals	912	7.75%	648	10.14%	1,560	8.59%
7	Consumer Non-durables	621	5.28%	346	5.42%	967	5.33%
8	Construction	776	6.59%	504	7.89%	1,280	7.05%
9	steel	751	6.38%	346	5.42%	1,097	6.04%
10	Fabricated products	182	1.55%	59	0.92%	241	1.33%
11	Machinery and Business Equipment	1,068	9.07%	604	9.46%	1,672	9.21%
12	Automobiles	224	1.90%	412	6.45%	636	3.50%
13	Transportation	264	2.24%	169	2.65%	433	2.38%
14	Utilities	54	0.46%	81	1.27%	135	0.74%
15	Retails	2,277	19.35%	554	8.67%	2,831	15.59%
17	Others	2,092	17.78%	1,139	17.83%	3,231	17.79%
	Total	11,769	100.00%	6,388	100.00%	18,157	100.00%

Note: we excluded No 16 as it includes Banks, Insurance companies and other financials

b Variable definitions

Internal capital market: The main focus of the analysis is intragroup movement at the firm level. As per the regulatory norms in India, reporting group-related activities on the firm's balance sheet is mandatory. Like Santioni et al. (2020),[8] the researcher used intragroup transactions reported in the balance sheet to construct proxies for the internal capital market. Thus, construct ICM_Asset, which is equal to the investment in group companies and loans (both long- and short-term) given to the group companies extracted from the asset side of the balance sheet deflated by the firms' total assets. ICM_Loan_Given is equal to the loan given to the group companies extracted from the asset side of the balance sheet deflated by total assets. ICM_Invest_Grp is the ratio of investment in the group of companies deflated by the firm's total assets. ICM_Loan_Rec equals long-term loans received from promoters, directors, and other loans from subsidiaries and group-associated business enterprises deflated by the firm's total assets.

The researcher also examined the nature of intragroup loans by analyzing ICM_NetLoan, which is the difference between the total loan given[9] (ICM_Loan_Given- asset side of the balance sheet) and the total loan received[10] (ICM_Loan_Rec-liability side of the balance). Finally, ICM_Networth is calculated as the difference between ICM_Asset and ICM_Loan_Rec. However, equity transfer between firms

[8] Santioni et al. (2020) paper focused on the internal capital market of an Italian business group

[9] Total loan given = Long-term loan provided to the group companies +short term loans provided to the group companies.

[10] Total loan received = Long-term loans received from the promotors, directors, and other loans received from the subsidiaries and group-associated business enterprises.

was not incorporated, as reporting is not mandatory as per Ind-As.[11] Thus, the proxies used to measure internal capital market transactions are

ICM_Asset= ICM_Invest_Grp + ICM_Loan_Given –(1)

ICM_Networth = ICM_Asset – ICM_Loan_Rec -----(2)

ICM_NetLoan= ICM_Loan_Given- ICM_Loan_Rec –(3)

Growth opportunities: The proxies Tobins_Q(Q) at the business level and Industry_Q at the industry level were used to estimate growth opportunities. According to empirical studies, Tobin's Q is a good proxy for assessing firm's growth (Asker et al., 2015; Agarwal et al., 2011; Shin &Park, 1999). The market value of equity over the book value of equity is used to compute Tobins_Q(Q). Q outlines the perceived growth potential of the market. Industry Q is the median Q of the j^{th} firm operating in the same industry in that year (Iskenderoglu, 2021). The sign of the coefficient determines whether a firm invests in more growth opportunities or low-opportunity firms (Francis et al., 2013). For the robustness analysis, Marginal_Q (Bolton et al., 2011) was used as an alternative measure for growth opportunities. Marginal _Q was used to check whether Tobins_Q or Industry_Q created any noise and selection bias in the measurement, as pointed out by Chevalier (2004) Marginal_Q who provides insight into the efficiency and profitability of investment decisions by comparing the market value of equity to the cost of expanding company's assets.

Firm performance: Firm profitability is divided into ROA, industry-adjusted ROA, and Adjusted ROA in accordance with Lovallo et al. (2020). After decomposition, the adjusted ROA (Adj_ROA) was used as a proxy for measuring company performance. The following steps were used to calculate the Adjusted ROA(Adj_ROA): First, single-segment firm-level ROA was determined. Using the Fama-French 17 industry categorization, the second stage includes estimating Industry_ROA, derived as the median of ROA single segment businesses' j industries. Thus, Adj_Roa is calculated as follows:

$Adj\_ROA_{(j,t)} = Industry\_ROA_{(j,t)} - ROA_{(j,t)}$ --4)

Thus, Adj_ROA is the difference between industry-adjusted ROA and single-segment firm-level ROA, the dependent variable used to test the performance effect (Hypotheis2).

Firm characteristics: The explanatory variables are firm-specific. The variable definitions are as follows: Firm size (Size) is the natural logarithm of the total assets. Net working capital (NWA) is calculated as net working capital, excluding cash and cash equivalents over total assets. Asset tangibility (PPE) is measured as the plant, property, and equipment on total assets. Cash holding is measured as Cash and Cash equivalents (Cash) over total assets. Cash flow (CashFlow) refers to earnings before interest and tax plus depreciation over total assets, and leverage (Lev) equals total debt over total assets. Firm age (Age) is calculated as the actual firm age based on the year of incorporation

4. RESULTS AND ANALYSIS

Univariate analysis

The descriptive statistics for the key variables after winsorisation at the 5% and 95% levels are presented in Table 2. Based on ownership structure. Panels A and B of Table (2) show the diverse nature of the standalone and business group firms, which summarizes the firm's characteristics of the sample. With a maximum age of 159 years, firms affiliated with business groups were discovered to be the oldest, whereas the maximum age of stand-alone firms is 144. [12]

Business group firms were found to be larger (Size), with a mean value of 4.762, and highly leveraged. 54.5% Of total assets include long-term and short-term debt (Lev), and 28.4% include Plant, Property and Equipment (PPE). The growth opportunities at the firm level (Q) and industry level (Industry_Q) are greater for business groups than for standalone firms. The counterpart standalone firms are smaller than business groups by size 2.532 (Size) and 50.2% of leverage on their total assets (Lev). The descriptive statistics show that standalone firms invest more in their current assets, such as net working capital (NWC) and cash holdings (Cash).

Panels C and D present descriptive statistics of the proxies used in the internal capital market. Similar to business group companies, standalone businesses access the internal capital market through subsidiaries' internal resources. The primary distinction between business group firms and standalone firms regarding the nature of internal transactions is that the former's subsidiaries are listed, while the latter is not.

Business group firms invest more in their group-affiliated firms (ICM_Invest_Grp) than standalone firms. The loans received (ICM_Loan_Rec) from the group affiliated firm of business group firms are 5.6%, whereas the standalone firm receives 6.0% of its subsidiaries. The Business group firms are the key players in the internal capital market, with a net worth (ICM_Networth) of 13.7%.

[11] https://www.mca.gov.in/Ministry/pdf/INDAS110.pdf

[12] The Bombay Burmah Trading Corporation, Limited (BBTCL)is the oldest company in the sample. BBTCL was established in 1863 and is the group-affiliated firm of the Waida group. Waida group is one of the oldest conglomerates in India, having a presence in FMCG, real estate, textile, chemicals and food processing. Some of the group companies of Waida group are Britannia (105-year-old), Bombay Dyeing Ltd (143-year-old and so on). The other oldest business groups include the DCM, Mafatlal, Birla, Tata, and OP Jindal groups. Similarly, the oldest standalone firm is Thacker & Company Ltd (established in 1878), Tyroon Tea Co. Limited (established in 1890), and Cheviot Limited (established in 1897).

TABLE 2: DESCRIPTIVE STATISTICS														
	Panel A: Standalone Firm							Panel B: Business Group Firm						
	N	Mean	SD	Min	Max	p50	p75	N	Mean	SD	Min	Max	p50	p75
Q	8555	1.637	1.685	0.084	6.433	0.989	2.121	5981	2.274	2.394	-0.008	9.236	1.387	3.014
Industry_Q	11769	1.162	0.443	0.550	2.123	1.149	1.399	6388	1.230	0.477	0.576	2.259	1.173	1.522
ROA	11596	0.032	0.057	-0.093	0.155	0.025	0.062	6341	0.038	0.064	-0.097	0.169	0.034	0.075
Adj_ROA	11596	-0.003	0.056	-0.122	0.122	0.001	0.023	6341	-0.005	0.061	-0.131	0.126	-0.002	0.026
NWC	11757	0.099	0.209	-0.287	0.551	0.073	0.223	6388	0.015	0.178	-0.360	0.359	0.007	0.128
CashFlow	11606	0.106	0.077	-0.013	0.271	0.102	0.154	6343	0.116	0.076	-0.016	0.279	0.109	0.165
Cash	10646	0.037	0.052	0.001	0.200	0.015	0.042	6330	0.027	0.038	0.001	0.145	0.012	0.032
Lev	11769	0.502	0.262	0.031	0.953	0.526	0.702	6388	0.545	0.230	0.140	0.979	0.554	0.712
PPE	10975	0.254	0.186	0.005	0.630	0.234	0.388	6255	0.284	0.185	0.012	0.634	0.270	0.425
Size	11769	2.532	1.825	-0.976	5.499	2.641	3.949	6388	4.762	1.767	1.248	7.836	4.790	6.104
Age	11769	32.103		4	144	31	38	6388	44.589		3	159	39	57
	Panel C: Internal Fund Allocation - Standalone Firm							Panel D: Internal Fund Allocation - Business Group Firm						
	N	Mean	SD	Min	Max	p50	p75	N	Mean	SD	Min	Max	p50	p75
ICM_Networth	7373	0.067	0.159	-0.187	0.498	0.018	0.108	5265	0.137	0.175	-0.039	0.605	0.068	0.200
ICM_Asset	5739	0.123	0.167	0.000	0.602	0.049	0.163	4987	0.155	0.182	0.001	0.648	0.081	0.218
ICM_Invest_Grp	5115	0.093	0.134	0.000	0.483	0.032	0.115	4757	0.121	0.147	0.000	0.525	0.061	0.171
ICM_NetLoan	5430	-0.005	0.098	-0.259	0.197	0.000	0.030	3704	0.030	0.076	-0.100	0.238	0.007	0.048
ICM_Loan_Given	3252	0.060	0.081	0.000	0.295	0.023	0.081	3058	0.056	0.080	0.000	0.292	0.017	0.070
ICM_Loan_Rec	3034	0.080	0.118	0.001	0.452	0.028	0.091	1321	0.059	0.095	0.000	0.363	0.019	0.061

Note: This table represents the descriptive statistics of variables from 2010 to 2019, which is winsorized at a 5 % level. Variable description is reported in Annexure 1

Table (3) explains the correlation matrix prepared after winsorizing the data at the 5 % level. The correlation coefficient of firm characteristics variables, such as NWC, CashFlow, Cash, Lev, PPE, Size and Age explains that the sample is free from multicollinearity issues. Growth opportunity proxies, such as Q and Industry_Q, are negatively correlated with Lev, explaining the market perception of the leverage effect on firm fundamentals. ROA is highly correlated with cash flow, as both are linked to earnings generated within the firm.

The table reports the correlation statistics. *, ** and *** denote significance level at 10%, 5% and 1% level respectively.

TABLE 3 : CORRELATION MATRIX											
Variables	Q	Industry_Q	ROA	Adj_ROA	NWC	CashFlow	Cash	Lev	PPE	Size	Age
Q	1										
Industry_Q	0.276***	1									
ROA	0.38***	0.108***	1								
Adj_ROA	-0.357***	0.001	-0.974***	1							
NWC	0.014**	-0.003	0.249***	-0.274***	1						
CashFlow	0.363***	0.101***	0.856***	-0.815***	0.084***	1					
Cash	0.045***	-0.041***	0.146***	-0.157***	0.042***	0.092***	1				
Lev	-0.047***	-0.053***	-0.288***	0.306***	-0.494**	-0.054**	-0.190**	1			

					*	*	*				
PPE	-0.066***	0.059***	-0.060***	0.113***	-0.387***	0.147***	-0.178***	0.223***	1		
Size	0.243***	0.122***	0.165***	-0.123***	-0.225***	0.225***	-0.213***	0.189***	0.128***	1	
Age	0.044***	0.028***	0.045***	-0.015***	-0.057***	0.046***	-0.059***	0.0120*	0.103***	0.262***	1

Q is Tobins Q at the firm level, calculated as the market value of equity minus total asset deflated by total asset; Industry_Q is the median of Q of the j^{th} firm operating within the same industry; Adj_ROA is the Industry_ROA- ROA.

Firm characteristics include: Net working capital (NWA) was calculated as net working capital excluding cash and cash equivalent over total assets. Asset tangibility (PPE) is measured as plant, property and equipment upon total assets. Cash holding is measured as Cash and Cash equivalent (Cash) over total assets. Cash flow (CashFlow) is the earnings before interest and tax plus depreciation over total assets, and leverage (Lev) equals total debts over total assets. Firm size (Size) is the natural logarithm of total assets. Firm age (Age) is calculated as the actual firm age based on the year of incorporation.

b. Investment – growth opportunity relationship

This empirical analysis investigated the relationship between investment and growth opportunities in the internal capital market. The main research question focuses on how proxies for growth opportunities predict a firm's decision on internal resource allocation. This study adopted the definition of an efficient internal market, as Shin and Stulz (1998) suggested, which allocates funds based on growth opportunities (Q at the firm level and Industry_Q at the industry level). The primary prediction is that growth opportunities drive a firm's allocation of funds through the internal capital market. To test the prediction (Hypothesis 1), this study used a specification similar to that used in previous research by Gugler et al. (2013), Carlin et al. (2006), and Shin and Stulz (1998):

$$INV_{it} = \beta_0 + \beta_1 IVOPP_{it} + \delta X_{it} + \alpha_{it} + \varepsilon_i \quad (5)$$

In Eq(5), INV_{it} represents investment through internal allocation, $IVOPP_{it}$ denotes investment opportunities, and X_{it} is the control variable. ε_i represents the error terms, and α_{it} indicates the panel effect. This study used two proxies for investment, ICM_Networth and ICM_NetLoan, and growth opportunities are represented by Q and Industry_Q.

The internal bargaining process at the firm level determines how resources are distributed, which is impacted by the growth potential of the previous year. While analyzing firm-level data, panel data reflect this dynamic characteristic, creating an endogeneity problem (Wintoki et al., 2012). To address the issue of endogeneity in the dynamic panel data, the study included one-year lagged dependent variables and two-year lags for endogenous independent variables (Q and Industry_Q). Firm fixed effects control for firm heterogeneity. Dynamic panel estimation with the two-step System GMM method addressed heterogeneity and endogeneity concerns and removed finite sample biases (Blundell et al., 2001). Thus, Eq (5) can be rewritten as

$$INV_{it} = INV_{i,t-1} + \beta IVOPP_{it} + \beta IVOPP_{it-1} + \delta X_{it} + \alpha_i + \varepsilon_{it} \quad (6)$$

For estimation purposes, the firm fixed effect was removed from Eq (6) after the first differencing on the dependent variable and lagged by two for the endogenous variable. Thus, obtain the following:

$$(INV_{i\,t-1} - INV_{i\,t}) = \gamma(INV_{i\,t-1} - INV_{i\,t-2}) + \beta\,(IVOPP_{it} - IVOPP_{it-1}) + \beta\,(IVOPP_{it-1} - IVOPP_{it-2}) + \delta X_{it} + \alpha_i + \varepsilon_{it} \quad (7)$$

TABLE 4 : Investment - Growth Opportunity Relationship

The table reports the investment growth-opportunity relationship using the specification : (INVi t-1 -INVi t) =γ(INVi t-1 - INVi t-2)+ β (IVOPP it - IVOPP it-1)+ β (IVOPP it-1 - IVOPP it-2) + δXit+αi+ε it
. *, ** and *** denote significance level at 10%, 5% and 1% level respectively

	1	2	3	4	5	6	7	8	9	10	11	12
VARIABLES	ICM_ Networth	ICM_ Networth	ICM_ NetLoan	ICM_ NetLoan	ICM_ Networth	ICM_ Networth	ICM_ NetLoan	ICM_ NetLoan	ICM_ Networth	ICM_ Networth	ICM_ NetLoan	ICM_ NetLoan
	Panel A: Full Sample				**Panel B : Business group firms**				**Panel C: Standalone Firms**			
$DV_{(L1)}$	0.839***	0.768***	0.478***	0.432***	0.847***	0.716***	0.473***	0.340***	0.729***	0.748***	0.439***	0.402***
	(0.022)	(0.030)	(0.033)	(0.033)	(0.016)	(0.021)	(0.016)	(0.012)	(0.022)	(0.023)	(0.019)	(0.024)

$Q_{(t0)}$	0.000		-0.001		-0.001		-0.000		0.0001		-0.003***	
	(0.001)		(0.001)		(0.001)		(0.000)		(0.001)		(0.001)	
$Q_{(t-1)}$	-0.002**		-0.003***		-0.002***		-0.003***		-0.000		0.001***	
	(0.001)		(0.001)		(0.001)		(0.001)		(0.001)		(0.001)	
$Q_{(t-2)}$	-0.001**		-0.003***		0.001		-0.001**		-0.001		-0.000	
	(0.000)		(0.001)		(0.001)		(0.000)		(0.000)		(0.000)	
Industry_$Q_{(t0)}$		0.002		-0.003**		0.004*		-0.004***		0.001		-0.005***
		(0.002)		(0.002)		-0.002		(0.001)		(0.002)		(0.002)
Industry_$Q_{(t-1)}$		-0.007**		-0.005**		-0.009***		-0.005***		-0.005**		-0.003*
		(0.003)		(0.002)		(0.003)		(0.001)		(0.003)		(0.002)
Industry_$Q_{(t-2)}$		0.003		-0.001		0.002		-0.002*		0.003		-0.000
		(0.003)		(0.002)		(0.002)		(0.001)		(0.002)		(0.002)
NWC	-0.009	-0.054***	-0.048***	-0.065***	0.002	-0.039***	-0.050***	-0.052***	-0.048***	-0.068***	-0.063***	-0.077***
	(0.012)	(0.015)	(0.011)	(0.013)	(0.010)	(0.013)	(0.007)	(0.008)	(0.010)	(0.012)	(0.009)	(0.011)
PPE	-0.032***	-0.058***	-0.0523***	-0.054***	-0.039***	-0.058***	-0.039***	-0.030***	-0.042***	-0.037***	-0.022**	-0.018
	(0.012)	(0.016)	(0.013)	(0.013)	(0.009)	(0.012)	(0.007)	(0.007)	(0.012)	(0.012)	(0.010)	(0.012)
Cash	0.085*	0.120**	0.101**	0.104**	0.043	0.092**	0.097***	0.073**	-0.073*	0.067*	-0.059*	0.008
	(0.045)	(0.052)	(0.048)	(0.048)	(0.037)	(0.043)	(0.029)	(0.030)	(0.039)	(0.041)	(0.034)	(0.034)
CashFlow	-0.034	0.005	0.094***	0.063**	0.032	0.021	0.071***	0.028**	-0.023	0.038*	0.115***	0.087***
	(0.021)	(0.025)	(0.022)	(0.025)	(0.020)	(0.024)	(0.012)	(0.012)	(0.018)	(0.021)	(0.014)	(0.022)
Lev	-0.019***	-0.032***	-0.041***	-0.047***	0.006	-0.022**	-0.012**	-0.028***	-0.019***	-0.034***	-0.055***	-0.073***
	(0.007)	(0.009)	(0.008)	(0.009)	(0.007)	(0.009)	(0.005)	(0.006)	(0.007)	(0.008)	(0.007)	(0.008)
Size	0.010***	0.013***	0.011***	0.011***	0.005***	0.012***	0.005***	0.008***	0.013***	0.013***	0.009***	0.014***
	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)
Observations	7,355	8,690	4,758	5,719	3,636	3,856	2,345	2,494	3,719	4,834	2,413	3,225
No of Co_code	1,395	1,644	1,119	1,360	616	645	503	530	779	999	616	830
AR 1 (p)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR 2(p)	0.867	0.362	0.304	0.881	0.96	0.593	0.719	0.745	0.592	0.443	0.419	0.187
Sargan (P-value)	0.203	0.179	0.304	0.469	0.558	0.313	0.509	0.869	0.382	0.138	0.243	0.499

Table 4 presents the regression results for Eq (7), where Panels A, B, and C represent the full sample, business group firms, and stand-alone firms, respectively. Eq (7) uses two proxies for investment ($INV_{i,t}$) – ICM_Networth and ICM_NetLoan–and growth opportunities ($IVOPP_{i,t}$) – Q and Industry_Q. The coefficient of the lagged dependent variable ($INV_{i,t-1}$) is positive and significant, indicating a dynamic investment adjustment process. The Sargan chi-square statistic indicates model fit. Second-order serial correlation is more important as it detects autocorrelation in level, which is insignificant in all models, indicating that the models are not misspecified.

Q represents market perception, and a negative and significant coefficient value indicates a firm's tendency to invest more in low-growth opportunity firms than in high-growth opportunity firms (Francis et al.,2013; Scharfstein, 1998). The Q value was found to be more sensitive to the internal allocation of resources. The coefficient value of $Q_{(t-1)}$ is in the ranges between -0.002 and -0.003(columns 1 and 3) for the full sample and columns 5 and 7 for the business group firms (Panel B), significant at 1 % and 5 % levels. This behaviour is more evident when ICM_NetLoan, especially for $Q_{(t-2)}$ for both the full sample and business group firms.

The results in Panels B and C of Table 4 highlight the distinctive characteristics of the business groups and standalone firms. Compared with standalone firms, business group firms tend to invest more in low-growth opportunity firms. The current year, Industry_Q (column 6), also received attention from the business group firm, which is positive and significant. However, loan disbursements rely heavily on low-growth opportunity businesses. The coefficient values of lagged Q and Industry_Q indicate that' the decisions primarily depend on the previous year's investment opportunities, explaining the dynamic nature of the firm's investment behaviour.

Firm characteristics explain the nature of diversity and opacity in firm behaviour (Dietrich, 2007). The Plant, Property and Equipment (PPE) were considered a measure of asset tangibility (Boutin et al., 2013), and the leverage (LEV) was found to be negative and significant at 1 % and 5 % levels, indicating the firm-facing constraints in accessing external resources. At the same time, headquarters' strategic decision to tighten the firm's borrowing capacity becomes an

obstacle for external financiers. The positive and significant coefficient value of Size (log of total assets) at a 1 % level explains the diversity behaviour and why larger firms attract more investment. Thus, establish the informational advantage hypothesis at the headquarters level.

The findings show that firm-specific investment opportunities (Q) are more important for internal resource allocation than industry-specific opportunities for investment (Industry_Q). However, the company will also consider Industry_Q when investing in group firms ICM_Invest_Grp. Thus, according to these findings, the internal capital market is inefficient because businesses choose to invest in low-group-opportunity firms (Glaser et al., 2013; Ahn & Denis, 2004; Scharfstein, 1998). The current study also supports the importance of time-variant studies in determining whether the firm's behaviour supports ICM efficiency or inefficiency.

Hence, accepting the first hypothesis, stating the general tendency of a firm to invest more in low-growth opportunity firms than in high-growth opportunity firms. This behaviour is evident in the case of business group firms.

Performance effect and internal investment

Hypothesis 1 states that firms tend to invest in low-growth opportunity firms along with opacity behaviour. Hypothesis 2 explored the informational advantage of headquarters on the firm's dynamic capability and tested whether opacity exists at the firm level. This study referred to the dynamic capabilities approach of Zahara and George (2002), which suggests that a firm's increased profitability is evidence of maximizing its internal efficiency (Ng, 2007). However, Lovallo et al. (2020) provide a different perspective, suggesting that the performance effect on internal allocation is complex and shows long-term behaviour with diminishing utility. The following equation is used to test the second hypothesis and incorporate the quadratic independent variable (INV_{it}) to test the diminishing utility of internally received funds:

$$Performance_{it} = \beta_0 + \beta_1 INV_{it} + \beta_1 inv_{it}^2 + \delta X_{it} + \alpha_{it} + \varepsilon_{it} \quad (8)$$

ICM variables—the dependent variables of hypothesis 1—ICM_NetLoan and ICM_Loan_Rec—were used as independent variables in the bidirectional analysis to test the second hypothesis. Based on the dynamic panel GMM estimator, the following equation is formulated:

$$Performance_{it} = Performance_{i\,t-1} + \beta\Delta INV_{it} + \beta\Delta INV_{it-1} + \beta INV_{it}^2 + \delta X_{it} + \alpha_i + \varepsilon_{it} \quad (9)$$

$$Adj\_ROA_{it-1} - Adj\_ROA_{it)} = \gamma(Adj\_ROA_{t-1} - Adj\_ROA_{it-2}) + \beta\Delta (ICM\_Loan_{it} - ICM\_Loan_{it-1}) + \beta \Delta (ICM\_Loan_{it-1} - ICM\_Loan_{it-2}) + \beta (ICM\_Loan_{it})^2 \quad (10)$$

$$Adj\_ROA_{it-1} - Adj\_ROA_{it)} = \gamma(Adj\_ROA_{t-1} - Adj\_ROA_{it-2}) + \beta\Delta (ICM\_Loan\_Rec_{it} - ICM\_Loan\_Rec_{it-1}) + \beta \Delta (ICM\_Loan\_Rec_{it-1} - ICM\_Loan\_Rec_{it-2}) + \beta (ICM\_Loan\_Rec_{it})^2 \quad (11)$$

Furthermore, the study introduced two-year lagged independent variables to assess the strength of the transmission of funds on a firm's profitability. The assumption is that internally received funds positively affect a firm's profitability through unrelated diversification. This study explores whether investing in low-growth-opportunity firms reflects firm's dynamic capability and consequently improves its performance due to opacity in firm behavior at the headquarters level.

TABLE 5: PERFORMANCE EFFECT

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Adj_Roa	Adj_Roa	Adj_Roa	Adj_Roa	Adj_Roa	Adj_Roa
	Full Sample		**Business Group**		**Standalone Firm**	
$DV_{(L1)}$	0.1188***	0.1299***	0.0808***	0.1448***	0.1242***	0.1277***
	(0.0101)	(0.0166)	(0.0009)	(0.0126)	(0.0085)	(0.0156)
$\Delta ICM\_Loan\_Rec_{(t0)}$	0.0051***		0.0000		0.0060***	
	(0.0006)		(0.0001)		(0.0004)	
$\Delta ICM\_Loan\_Rec_{(t-1)}$	0.0043***		0.0046***		0.0032***	
	(0.0007)		(0.0000)		(0.0004)	
$\Delta ICM\_Loan\_Rec_{(t-2)}$	0.0014***		-0.0014***		0.0022***	
	(0.0005)		(0.0001)		(0.0003)	
LoanRec_Sqr	-0.0016***		-0.0054***		-0.0008***	
	(0.0005)		(0.0002)		(0.0002)	
$\Delta ICM\_NetLoan_{(t0)}$		0.0042***		0.0031***		0.0048***
		(0.0010)		(0.0007)		(0.0007)
$\Delta ICM\_NetLoan_{(t-1)}$		0.0029***		0.0020***		0.0040***
		(0.0009)		(0.0006)		(0.0007)
$\Delta ICM\_NetLoan_{(t-2)}$		0.0000		-0.0022***		0.0021***
		(0.0009)		(0.0006)		(0.0007)
NetLoan_Sqr		-0.0033**		-0.0099***		-0.0005
		(0.0016)		(0.0034)		(0.0008)
Firm Characteristics	Yes	Yes	Yes	Yes	Yes	Yes

Observations	1,372	3,875	442	1,772	930	2,103
Number of Co_code	453	1,031	142	430	311	601
AR 1 (p)	0.001	0.000	0.023	0.000	0.000	0.000
AR 2(p)	0.619	0.696	0.872	0.925	0.499	0.446
Sargan (P-value)	0.501	0.299	0.999	0.2451	0.499	0.144
Standard errors in parentheses	*** p<0.01, ** p<0.05, * p<0.1					

The results of the analysis are presented in Table 5. Columns 1 and 2 of table 5 show the output of the full-sample analysis, where ΔICM_Loan_Rec and ΔICM_NetLoan are independent variables. The coefficient values of $\Delta ICM\_Loan\_Rec_{(t0)}$, $\Delta ICM\_Loan\_Rec_{(t-1)}$, and $\Delta ICM\_Loan\_Rec_{(t-2)}$ in column 1 indicate that firm performance significantly increases after receiving internally available funds. The coefficients are positive and significant, indicating that investing in a low-growth-opportunity firm explores the firm's dynamic capability, which positively impacts the profitability. Similarly, in Column 2, the ΔICM_NetLoan coefficient values are found to be positive and significant, explaining the positive impact on profitability. Columns 3 and 4 of Table 5 present the results for business group firms using ICM_Loan_Rec and ICM_NetLoan as the independent variables. The negative and significant coefficient value of (t-2) in these columns indicates a declining performance trend. However, this tendency was not observed for the standalone firms (Columns 5 and 6).

This study also examined the quadratic term of the independent variable, which is negative and significant. This aligns with the findings of Lovallo et al. (2020) and supports the idea that moderate or large resource allocation positively affects firm performance but diminishes after a certain point.

Based on the analysis and results, the researchers concluded that internally allocated funds in low-growth firms explain the nature of cross-subsidization and demonstrate a firm's strategy for improving its dynamic capability and directly enhancing profitability. This study confirms the presence of diminishing utility in the performance effect, indicating that the impact of resource allocation on firm performance weakens after a specific threshold. Overall, this analysis provides valuable insights into the relationship between internal fund allocation, dynamic capabilities, and firm performance, highlighting the importance of opaque behaviour and unrelated diversification in this context.

5. ROBUSTNESS CHECK :

a. Propensity score matching method

The main participants in the internal capital market are typically business group firms. However, this study includes standalone firms because of their involvement in ICM through their subsidiaries. The heterogeneity of firm characteristics introduces the possibility of selection bias. To address this concern, propensity score matching, a nonparametric matching technique, was employed to facilitate causal inference in non-experimental settings by constructing a control group similar to the treatment group (Rosenbaum & Rubin, 1984). Since standalone firms' participation in the internal capital market is relatively limited compared to that of business group firms, a control group was created using observed covariates

A kernel-matching estimator with common support for covariates was employed to create a control group. The balancing test results are shown in Table 6, along with the matching covariates. After matching, the mean values of each covariate for both groups were no longer statistically different, thus addressing potential biases. As a result of the matching process, a subsample of 10,517 firm-year observations is generated. This subsample includes 976 standalone firms matched with covariates from 5,531 firm-year data points of business group firms and 4986 firm-year observations from 665 affiliated business group firms.

TABLE 6 : RESULTS OF BALANCING

	Before matching			After matching		
Variables	Treated	Control	t-value	Treated	Control	t-value
Q	1.770	2.219	-10.950***	1.772	1.821	-1.360
Industry_Q	1.201	1.219	-2.020**	1.201	1.191	1.130
NWC	0.073	0.179	15.12***	0.072	0.068	1.250
Cash	0.030	0.026	4.310***	0.030	0.031	1.200
Lev	0.512	0.541	-6.320***	0.512	0.508	0.940
*** p<0.01, ** p<0.05, * p<0.1						

The propensity scores matching method addressed selection bias, and a more comparable control group of standalone firms was created. This technique enables the drawing of meaningful and reliable conclusions about the impact of regulatory interventions on both business groups and standalone firms' internal capital market behaviour

b. Alternative measure of growth opportunities – Marginal_ Q

In line with Bolton et al. (2011), Marginal Q is adopted as an alternative measure of growth opportunities. Marginal Q provides valuable insights into the efficiency and profitability of investment decisions by comparing the market value of equity to the cost of expanding a company's assets. Table 7 presents the results obtained by estimating firm behaviour using Marginal Q.

TABLE 7 : ROBUSTNESS CHECK WITH ALTERNATIVE MEASURE

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ICM_Networth	ICM_NetLoan	ICM_Networth	ICM_NetLoan	ICM_Networth	ICM_NetLoan
	Full Sample		**Business Group**		**Matched Standalone Firm**	
$DV_{(L1)}$	0.8188***	0.5644***	0.8014***	0.4618***	0.6966***	0.5347***
	(0.0215)	(0.0357)	(0.0205)	(0.0221)	(0.0182)	(0.0209)
$Margin\_Q_{(t0)}$	0.0002	0.0002**	0.0000	0.0002***	0.0001	0.0000
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
$Margin\_Q_{(t-1)}$	-0.0003**	-0.0000	-0.0005***	-0.0002***	-0.0002**	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
$Margin\_Q_{(t-2)}$	-0.0001	-0.0005***	0.0000	-0.0003***	-0.0001*	-0.0005***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
NWC	-0.0147	-0.0395***	-0.0156	-0.0919***	-0.0591***	-0.0429***
	(0.0124)	(0.0126)	(0.0129)	(0.0099)	(0.0120)	(0.0098)
PPE	-0.0292**	-0.0212	-0.0405***	-0.0347***	-0.0442***	-0.0258*
	(0.0127)	(0.0142)	(0.0132)	(0.0091)	(0.0127)	(0.0132)
Cash	0.0919*	0.0307	0.2016***	0.1184***	0.0334	-0.0051
	(0.0503)	(0.0562)	(0.0512)	(0.0414)	(0.0418)	(0.0462)
CashFlow	-0.0216	0.0648***	0.0254	0.0741***	-0.0015	0.0752***
	(0.0221)	(0.0228)	(0.0238)	(0.0188)	(0.0203)	(0.0177)
Lev	-0.0119	-0.0279***	0.0030	-0.0299***	-0.0344***	-0.0430***
	(0.0074)	(0.0079)	(0.0091)	(0.0068)	(0.0084)	(0.0071)
Size	0.0071***	0.0044***	0.0055***	0.0055***	0.0134***	0.0072***
	(0.0016)	(0.0013)	(0.0014)	(0.0008)	(0.0018)	(0.0013)
Observations	6,085	3,833	3,047	1,913	3,038	1,918
Number of Co_code	1,313	1,010	603	465	710	545
AR 1 (p)	0.000	0.000	0.000	0.000	0.000	0.000
AR 2(p)	0.821	0.936	0.943	0.636	0.558	0.627
Sargan (P-value)	0.179	0.265	0.365	0.375	0.467	0.499
Standard errors in parentheses		*** p<0.01, ** p<0.05, * p<0.1				

Models 1 and 2 in Table 7 are based on full sample analysis, while Models 3-6 are based on a subsample generated through propensity score estimates (as discussed in Section 7b).

As per Hypothesis 1, the expected coefficient value of Marginal Q is negative and significant, supporting the behaviour of cross-subsidization. To test this, the key internal capital markets variables, such as ICM_Networth and ICM_NetLoan were used as the dependent variables in

the analysis and it found that Marginal Q (t-1) and Marginal Q (t-2) play a crucial role in a firm's decision-making process regarding resource allocation. As predicted, the results in Table 7 support this hypothesis, especially for the subsample generated through propensity score matching estimates. Both business group firms (Models 3 and 4) and matched standalone firms exhibit similar patterns in their internal resource allocation processes.

Employing Marginal Q as an alternative measure for growth opportunities provides additional support for cross-subsidization among firms operating in the internal capital market. These consistent findings across different models and samples further validate the research conclusions and reinforce the importance of considering alternative growth opportunity measurements to understand firms' internal fund allocation strategies.

6. MANAGERIAL IMPLICATION

This study's findings have several important managerial implications for firms operating in the Indian capital market.This study reveals that firms tend to invest more in low-growth opportunities, which may not always be the most efficient use of resources. Prioritizing investments in high-growth opportunities can enhance a firm's long-term performance and value creation. However, managers should be cautious, as this study found that performance may decline after a certain threshold limit in internal allocation (Hypothesis 2). To counter this, leveraging the informational advantages of headquarters and building dynamic capabilities is crucial for adapting to changing market conditions and identifying efficient resource allocation strategies. The study also highlights the significance of strategic decision-making in resource allocation, dynamic capability development, and transparency. Considering these implications, managers can make informed and effective decisions that contribute to a firm's long-term success and profitability.

7. RESEARCH LIMITATIONS/IMPLICATIONS

The study focuses solely on Indian private sector firms, which may limit the generalizability of the findings to other contexts or countries. The study used internal fund transfers between the subsidiaries (data reported in the Balance sheet). Related Party Transactions (RPT), which is one of the crucial parts of internal resource allocation, were not incorporated in the study.

8. CONCLUSION

Unlike other studies, this study performed a multidimensional analysis of intra-group transactions, which are a part of internal fund allocation through the internal capital market. The study highlights the behaviour of business groups and standalone firms separately. Thus, the results indicate the importance of market perception (Tobin's Q) when deciding fund allocation. Specifically, the firm's growth opportunity indicator from the previous year is relevant in decision-making. The study did not stop the analysis by highlighting the "cross-subsidization." Further analyzed the firm's behaviour based on the "dynamic capability view" and highlighted that internal fund allocations foster firm performance in terms of profitability. Thus, the study highlights that business group firms allocate more funds to low-q firms than high-q firms. This tendency became evident after the regulatory interventions. Moreover, supports Hypothesis 1, stating that firms in India allocate internal funds to more low-q firms than to high-q firms. These characteristics are common to constrained and non-constrained firms that allocate more to low-Q firms than high-Q firms.

9. DECLARATION

I, Anu Antony, hereby confirm that the manuscript titled **Exploring the Dynamics of Internal Resource Allocation within Diversified Firms: An Analysis of Investment Patterns and Performance Effects in the Indian Capital Market**," authored by myself, has not been submitted for publication, review, or consideration to any other journal, conference, or publication venue.

I affirm that this work is original and is not under consideration elsewhere. All the authors listed have approved the manuscript and agreed to its submission to [Name of the Journal/Conference].

I/we declare that all necessary permissions have been obtained for any third-party materials included in the manuscript, and appropriate citations and acknowledgments have been made where required.

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India's Pursuit of Self-Reliance in the Incense Industry: The Critical Role of Bamboo Round Sticks

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ABSTRACTS

The Indian incense industry, with an annual turnover of ₹8,500 crore and employment of over 3 lakh individuals, plays a vital cultural and economic role. However, the industry's heavy dependence on imported bamboo sticks and raw agarbatti has raised concerns about its self- reliance and sustainability. Key challenges include the limited availability of suitable bamboo species (Bambusa tulda), technological incompatibilities with Indian bamboo characteristics, inefficient waste utilization, and intense global competition. This review examines the efforts by the Government of India to address these challenges, particularly through the restructured National Bamboo Mission (NBM). The NBM has focused on quality planting materials, reclassification of bamboo as agricultural produce, and financial incentives for bamboo round stick manufacturing units. Other initiatives include the establishment of bamboo industrial parks, advancements in waste utilization technology, and the adoption of high-speed agarbatti manufacturing machines. Policy measures such as increased import duties and restrictions on raw agarbatti imports have also bolstered domestic production and employment. The review concludes that while these initiatives have made significant progress, further efforts are required to expand bamboo plantations, bridge technological gaps, and enhance waste utilization. Strengthening the bamboo value chain will reduce import dependency, promote rural livelihoods, and ensure sustainable growth, positioning India as a global leader in the incense industry.

Keywords: Indian incense industry, Bamboo value chain, Self-reliance, Waste utilization, Rural livelihoods, Sustainable growth.

1. INTRODUCTION

Incense sticks hold a significant place in India's cultural and religious landscape, being widely used across temples, mosques, churches, monasteries, and homes for rituals, ceremonies, and offerings. Beyond religious practices, their use as room fresheners and in aromatherapy underscores their universal appeal and functionality. The Indian incense industry, with an annual turnover of ₹8,500 crore and export revenue of ₹1,000 crore, is a vital contributor to the economy. It employs approximately 3 lakh individuals, 80% of whom are women, making it a critical source of livelihood, particularly in rural and tribal areas. Despite its cultural and economic importance, the industry faces significant challenges in achieving self-reliance, primarily due to its dependency on imported bamboo sticks.

India, despite being the second-largest bamboo resource holder globally, imports 95% of its bamboo sticks from countries like China and Vietnam. This dependency persists despite considerable investments in the bamboo sector, such as the ₹15,000 crore annual budget allocation under the National Bamboo Mission (NBM). Factors like limited commercial-scale bamboo cultivation, high wastage during manufacturing, and the unavailability of harvested bamboo for industrial use have constrained the industry's growth. Notably, bamboo cultivation under government programs (covering 361,791 hectares from 2007 to 2018) has not translated into sufficient raw material for incense manufacturing, further exacerbating the issue.

These inefficiencies have led to significant costs, with the industry spending ₹500–600 crore annually on bamboo procurement. The decline in domestic bamboo stick production has also impacted employment, particularly for rural and tribal women in the Northeastern states, where this activity previously provided jobs for over 2.5 lakh individuals. Additionally, logistical challenges and regulatory barriers limit the effective utilization of bamboo resources, leaving the industry dependent on imports and vulnerable to supply chain disruptions.

This review explores the pressing challenges within India's incense industry, focusing on the bamboo value chain and its critical role in achieving self-reliance. By analyzing the constraints in bamboo cultivation, processing, and utilization, the paper aims to provide actionable insights for fostering sustainability and competitiveness. The review also highlights potential solutions, such as promoting commercial bamboo cultivation, integrating waste utilization in manufacturing, and strengthening domestic production capacity. Addressing these challenges is imperative for ensuring the long-term growth and sustainability of India's incense sector while enhancing its contribution to the rural economy and global markets.

2. THE INCENSE VALUE CHAIN IN INDIA

The incense value chain in India revolves around four key ingredients: bamboo sticks, charcoal powder with adhesive materials, flavoring materials, and packaging materials. There are two main types of incense sticks: (1) Perfumed agarbatti, where raw sticks are dipped in perfumed oil, and (2) Masala batti, where self-fragranced ingredients are directly coated on bamboo sticks. Bamboo sticks, the central core of incense sticks, vary in length from 6 to 15 inches

depending on the product, with standard sizes being 8 or 9 inches. The outer coating is typically made using charcoal powder and natural adhesives from plants like Sal resin, Litsea chinensis, and Michilus macrantha. Additionally, natural aromatic substances and chemical fragrances are added for flavoring before packaging and marketing.

The incense production process has seen significant advancements over the past 15 years. Traditional manual rolling on wooden planks has evolved into high-speed, sensor-based machines capable of producing up to 300 sticks per minute. Initially, handmade square bamboo sticks were widely used, but their fibrous texture hindered efficiency. These sticks were polished manually to remove fibers, allowing women workers to increase daily output from 2– 3 kg to 15–20 kg using pedal-operated machines. The introduction of round bamboo sticks further revolutionized the industry, enabling the adoption of fully automatic machines and boosting productivity to 100 kg per worker per day.

2.1 Ingredient Contribution to the Value Chain

The cost structure of incense sticks highlights significant disparities in value addition. Perfumed incense sticks, which retail at approximately ₹533/kg, derive only 4% of their total value from bamboo sticks and 3.5% from masala (a mixture of charcoal powder and adhesives). The majority of the value—over 90%—comes from perfuming, packaging, and marketing. For instance, while a raw agarbatti stick costs ₹0.08, the final perfumed stick retails for ₹0.87, underscoring the high-value processes controlled by manufacturers.

2.2 Shift in Bamboo Stick Production

After the flowering of Melocanna baccifera bamboo in the Northeastern states between 2004 and 2012, India's incense industry began importing round bamboo sticks, primarily from China. Chinese manufacturers utilized Moso bamboo, abundant in South China, to produce uniform round bamboo sticks, which are now the industry standard. Over 95% of India's bamboo stick requirements are imported from China, Vietnam, and Indonesia. However, increased import duties on bamboo sticks (raised from 10% to 25% in June 2020) have created opportunities for domestic entrepreneurs to establish bamboo round stick production units, offering competition to imported products.

2.3 Growth and Opportunities in the Indian Incense Industry

India's incense industry is dominated by major players like ITC, Cycle, Moksh, and Mysore Scents. Exports account for ₹1,000 crore of the ₹8,500 crore industry, with key importers being the USA, UK, Malaysia, and Nigeria. The industry's growth is supported by low labor costs, government initiatives to promote bamboo cultivation, and advancements in automation. The development of high-speed machines and the adoption of round bamboo sticks have significantly enhanced worker productivity. These innovations, coupled with the availability of raw materials and a growing global demand, position India's incense industry to maintain a projected growth rate of 15% annually.

Despite these advancements, challenges remain, including the need for increased self-reliance in bamboo stick production. Addressing these bottlenecks through policy support, technological upgrades, and localized bamboo cultivation can further strengthen the value chain, ensuring sustainable growth and competitiveness in domestic and international markets.

3. STATUS OF SELF-RELIANCE ON BAMBOO STICK IN THE INDIAN INCENSE INDUSTRY

Historically, India was self-reliant in the entire incense value chain. Bamboo sticks, a key ingredient, were sourced from the Northeastern states, primarily Tripura, and supplied to incense manufacturers in South India. Tripura alone fulfilled approximately 60% of the bamboo stick requirements of the Indian incense industry until 2012. The state's bamboo stick production provided employment to over 1.5 lakh locals, mostly women, who used Melocanna baccifera bamboo to produce square bamboo sticks. These were hand-rolled with charcoal dough to create raw agarbatti (Annual Progress Report, TBM 2014-15).

The introduction of machine-based production marked a shift in industry trends, increasing the demand for polished, fiberless bamboo sticks, which enhanced production efficiency. Manual production capacity rose from 2–3 kg to 25 kg per person per day with the advent of pedal- operated machines. However, the flowering of Melocanna baccifera from 2004 to 2012 reduced the availability of this bamboo variety, which was valued for its strength, straightness, and low fiber content. This decline disrupted the supply of handmade square bamboo sticks, forcing the industry to seek alternatives.

3.1 Rise in Bamboo Stick Imports

From 2007 to 2016, India increasingly relied on imported bamboo sticks to meet its growing demand. Imports rose from 2,000 MT in 2007 to 20,000 MT by 2016. Concurrently, raw agarbatti imports, primarily from Vietnam and China, grew exponentially from 1,564 MT in 2010–11 to 82,750 MT in 2014–15 (Table 1). The reduction in customs duty on bamboo for the agarbatti industry from 30% to 10% in 2011 further accelerated this trend, making imports more attractive. This reliance on imports led to significant unemployment in bamboo- producing regions of the Northeast and raw agarbatti manufacturing states like Andhra Pradesh, Karnataka, Bihar, and Odisha.

To address these concerns, the Government of India increased the import duty on bamboo sticks from 10% to 25% in 2020, discouraging imports and creating opportunities for domestic entrepreneurs to establish bamboo

stick production units (Economic Times, 2019). However, import volumes remain substantial, with India importing 73,772 MT of bamboo sticks in 2023– 24 (till August), valued at ₹505.68 crore (Export-Import Data Bank, Ministry of Commerce).

3.2 Supply of Bamboo Sticks by Tripura vs. Imports

The supply of bamboo sticks from Tripura has declined significantly since 2012 due to the reduced availability of Melocanna baccifera. Table 1 illustrates the decreasing domestic supply and the corresponding rise in imports:

TABLE 1. Supply vs. Imports in Tripura for Bamboo Sticks

Financial Year	Bamboo Stick Supply by Tripura (MT)	Import of Bamboo Stick (MT)	Import of Raw Agarbatti (MT)
2006-07	20,508	3,092	NA
Financial Year	**Bamboo Stick Supply by Tripura (MT)**	**Import of Bamboo Stick (MT)**	**Import of Raw Agarbatti (MT)**
2010-11	23,178	2,069	1,564
2014-15	6,291	18,753	82,739
2015-16	4,063	20,342	69,340

(Source: TBM Annual Progress Report 2014–15; Export-Import Data Bank)

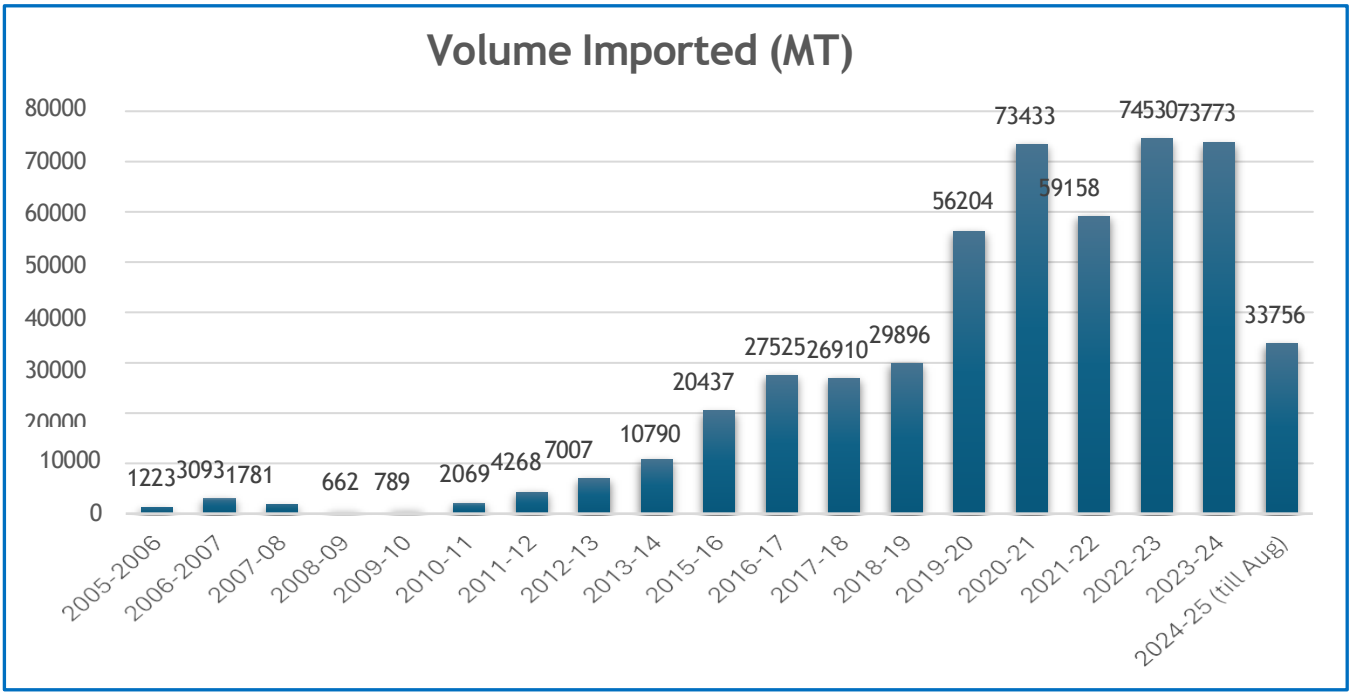

Figure 1. Import of bamboo stick by India from 2006 to 2024

3.3 Economic and Strategic Implications

From an economic perspective, outsourcing the low-value component of bamboo sticks while focusing on high-value perfumed agarbatti production for export maximizes profitability. However, India's 95% dependency on imported bamboo sticks poses vulnerabilities during international crises, which could disrupt the domestic supply chain. Notably, 70% of incense sticks produced in India are consumed domestically, and any disruption could lead to unmet local demand.

To ensure self-reliance, India must optimize its vast bamboo resources and integrate them into existing value chains. Currently, only 12% of bamboo processed yields usable sticks, while

40% is wasted as knots, small sticks, slivers, powders, and dust. This waste can be efficiently converted into briquettes or pellets, offering an opportunity to diversify bamboo-based products and strengthen the industry's sustainability.

Achieving self-reliance in bamboo stick production requires strategic investments in domestic bamboo cultivation, improved processing technologies, and waste management solutions. By leveraging its bamboo resources effectively, India can reduce import dependency, revitalize rural employment, and ensure the long-term sustainability of its incense industry.

4. EFFORTS BY THE GOVERNMENT OF INDIA TO STRENGTHEN THE BAMBOO SECTOR

The Government of India has undertaken several initiatives to strengthen the bamboo sector and reduce dependency on imports, particularly for the incense industry. These measures, spearheaded by the National Bamboo Mission (NBM) and supported by changes in trade policies, aim to enhance domestic bamboo production, promote value addition, and revitalize rural employment.

4.1 Restructured National Bamboo Mission (NBM)

The National Bamboo Mission, operating under the Ministry of Agriculture and Farmers Welfare, was restructured to align with the industrial requirements of bamboo-based products. Key policy measures include:

- **Bamboo Plantation:** The NBM has prioritized the cultivation of commercial and industrial bamboo species, issuing a list of suitable species for plantation. Financial support is provided only for bamboo cultivation in non-forest areas to promote sustainable practices.
- **Enhanced Productivity:** Efforts are underway to increase bamboo garden productivity from the current 1–2 MT per hectare to 10 MT per hectare. This aims to bridge the demand-supply gap in the domestic market.
- **Innovation and Value Addition:** The mission emphasizes innovation, product development, value addition, and bamboo preservation to improve the overall quality and usability of bamboo-based products.
- **Cluster-Based Activities:** To reduce import dependency, the NBM focuses on cluster- based value addition activities in regions where the required bamboo species are readily available.
- **Expanding Bamboo Cultivation:** The mission targets covering 105,000 hectares with superior quality planting materials, ensuring a steady supply of bamboo for industrial applications.

4.2 Changes in Export-Import Policies

To discourage imports and protect domestic enterprises:

- **Increased Import Duty:** In 2020, the Central Board of Indirect Taxes and Customs (CBIC) raised the import duty on bamboo sticks from 10% to 25%, making imported bamboo less competitive and encouraging domestic production.
- **Restricted Import of Raw Agarbatti:** In 2019, the Ministry of Commerce categorized raw agarbatti under the "Restricted" category, requiring importers to obtain government licenses. As a result, raw agarbatti imports have now reduced to negligible levels, bolstering the domestic agarbatti manufacturing sector.

4.3 Special Focus on Northeastern States

Recognizing the significant bamboo resources of the Northeastern States (NES), the central government has prioritized their development:

- **Commercial Bamboo Plantations:** Efforts are being made to promote large-scale bamboo cultivation in NESs, focusing on commercial and industrial applications.
- **Strengthening the Bamboo Value Chain:** In collaboration with the Asian Development Bank, ₹800 crore is being invested in NESs to develop bamboo-related infrastructure and skills. A substantial portion of this funding is earmarked for activities that directly benefit the incense industry, such as value addition and cluster development.

The Government of India's initiatives, through the restructured NBM, revised trade policies, and focused development in the Northeast, demonstrate a comprehensive approach to achieving self-reliance in the bamboo sector. These measures aim to reduce import dependency, enhance domestic production capacity, and ensure the sustainable growth of bamboo-based industries, including incense manufacturing.

5. KEY CHALLENGES IN ACHIEVING SELF-RELIANCE IN BAMBOO STICK PRODUCTION

The Indian bamboo stick manufacturing industry faces several challenges that hinder its growth and self-reliance. These issues revolve around the non-availability of suitable raw materials, limitations in technology, inefficient waste utilization, and intense global competition.

a. Non-Availability of Suitable Raw Material

The most suitable bamboo species for round stick production in India is Bambusa tulda, which is primarily found in the Northeastern States (Jenner, 2023). Other bamboo species, such as Bambusa stictus and Bambusa bambus, are available in other parts of the country but are unsuitable for round stick manufacturing due to their physical properties. Entrepreneurs attempting to use these alternatives often face low recovery rates and suboptimal output.

Transporting raw bamboo from the Northeast to other regions is economically unviable due to its bulkiness and low recovery rate (12–15%). This geographical limitation prevents entrepreneurs from setting up new bamboo round stick manufacturing units in non- Northeastern regions, further restricting production capacity.

b. Inappropriate Technology

Most machines used for round stick production in China and Vietnam are designed for processing Moso bamboo, a

monopodial species with characteristics suited to their technology. In contrast, Indian bamboos are sympodial, harder, and have greater wall thickness, uneven straightness, and variable diameters. These differences result in lower productivity and frequent operational inefficiencies when Chinese machines are used with Indian bamboo.

As of November 2024, the National Bamboo Mission (NBM) dashboard reports an annual production capacity of 17,174 MT of round bamboo sticks in India, with actual production at 10,913 MT. However, field reports from manufacturers indicate that actual production may be even lower, as many units have ceased operations due to these challenges. The total domestic production remains significantly below the annual demand of 75,000 MT.

c. Waste Utilization

The inefficiency in the bamboo round stick production process leads to substantial waste generation. With only 12–15% recovery of usable bamboo sticks, approximately 40% of the bamboo material is wasted as powder, knots, small sticks, and slices. Addressing this waste requires additional machinery to process it into commercially viable by-products such as briquettes or pallets. Effective waste utilization could supplement the financial viability of bamboo stick production and promote sustainable operations.

d. Global Competition

The price of round bamboo sticks in India has stabilized at ₹100–110 per kg, with a domestic demand of 75,000 MT per year. However, competing countries like China and Vietnam can supply sticks at similar prices due to their advanced production processes and lower operational costs. This global competition places immense pressure on Indian manufacturers, who struggle to sustain their operations amidst high production costs and lower productivity.

To achieve self-reliance in bamboo stick production, India must address these challenges by investing in region-specific bamboo cultivation, developing technology suited to Indian bamboo characteristics, and promoting waste utilization through innovative solutions. Strengthening the domestic bamboo value chain and enhancing productivity will enable Indian manufacturers to compete effectively on a global scale while fostering sustainability and reducing import dependency.

6. POSSIBLE SOLUTIONS FOR ACHIEVING SELF-RELIANCE IN BAMBOO STICK PRODUCTION

To address the challenges in the bamboo stick manufacturing industry and promote self- reliance, the Government of India has implemented several initiatives focusing on quality planting material, favorable policies, technological advancements, and market regulation. These measures aim to strengthen the bamboo value chain, enhance production efficiency, and promote sustainable growth.

a. Development of Quality Planting Material

The National Bamboo Mission (NBM) has prioritized the development of quality planting materials through accredited small, big, and high-tech nurseries. These nurseries are monitored by state bamboo development agencies and the Department of Biotechnology for quality assurance. As part of the restructured NBM, 212 nurseries have been established, producing approximately 260 lakh bamboo seedlings. Based on the standard norm of 420 plants per hectare, this supply could support bamboo plantations on 52,000 hectares. However, as of now, only 1,328 hectares have been reported under bamboo plantation due to delays in site inspections by implementing agencies. Addressing these administrative delays can significantly increase the coverage of bamboo plantations, ensuring a steady supply of raw materials.

b. Declaring Bamboo as Agricultural Produce

Previously classified as a Non-Timber Forest Produce (NTFP) under the Indian Forest Act (IFA) of 1927, bamboo faced movement restrictions. In 2017, the central government reclassified bamboo grown in non-forest areas as agricultural produce, removing the requirement for transit permits. This policy shift has facilitated the commercial cultivation and industrial utilization of bamboo, transforming it into a viable cash crop.

c. Focus on Bamboo Stick Production

To boost bamboo stick manufacturing, the government has introduced several initiatives:

- **Subsidy for Bamboo Round Stick Units:** The restructured NBM offers a 50% subsidy on capital investment for bamboo round stick manufacturing units, with an additional 10% subsidy for units established in the Northeastern States.
- **Bamboo Industrial Parks:** Dedicated industrial parks are being developed to support bamboo-based enterprises, focusing on round stick production, value addition, and waste utilization.
- **Technological Support:** Advanced machinery and techniques for waste utilization, such as producing briquettes and pellets from bamboo waste, are being introduced to make the industry globally competitive.

d. Adoption of High-Speed Agarbatti Manufacturing Machines

Indian manufacturers have successfully adopted automatic raw agarbatti manufacturing machines that utilize round bamboo sticks. These machines align with international standards, achieving production capacities of up to 100 kg per day per machine by one worker. This technological upgrade has significantly improved productivity and competitiveness in the incense sector.

e. Creation of a National-Level MIS

The National Bamboo Mission has developed an open-access Management Information System (MIS) that provides comprehensive data on bamboo round stick units operating

across India. This platform facilitates market access, enabling seamless buying and selling of bamboo sticks, and fosters a collaborative and competitive environment among stakeholders. The MIS also serves as a valuable tool for tracking production and market trends, enhancing transparency and efficiency in the bamboo value chain.

f. Regulating Imports of Cheap Materials

Through import restrictions and policy interventions, the government has effectively curbed the influx of cheap raw materials, such as round bamboo sticks and raw agarbatti, from foreign markets. Measures such as increased import duties and licensing requirements for raw agarbatti imports have balanced the domestic market, generating employment and boosting the export of value-added incense products. These initiatives collectively address the key challenges in the bamboo stick production sector. By ensuring the availability of quality planting materials, promoting industrial bamboo cultivation, advancing manufacturing technologies, and regulating imports, India is steadily moving toward self-reliance in bamboo stick production. These efforts not only strengthen the domestic incense industry but also create employment opportunities and enhance its global competitiveness.

7. CONCLUSION

The Indian incense industry, a cultural and economic powerhouse, faces significant challenges in achieving self-reliance, particularly in its bamboo value chain. With annual revenues of ₹8,500 crore and employment of over 3 lakh individuals, the industry's reliance on imported bamboo sticks and raw agarbatti has exposed its vulnerabilities, especially during global disruptions. Key challenges include the limited availability of suitable bamboo species (Bambusa tulda), incompatibility of available technologies with Indian bamboo characteristics, high wastage rates, and stiff global competition. The restructured National Bamboo Mission (NBM) has implemented critical measures to address these issues. Initiatives include the development of quality planting materials, reclassification of bamboo as agricultural produce for easier movement, and financial incentives such as subsidies for bamboo round stick units. Establishing bamboo industrial parks, promoting technologies for waste utilization, and adopting high-speed agarbatti manufacturing machines have enhanced efficiency and competitiveness. A national-level Management Information System (MIS) has further streamlined market access and improved stakeholder collaboration. Policy interventions, such as increased import duties on bamboo sticks and restrictions on raw agarbatti imports, have balanced domestic production and international competition, boosting local employment and exports. For long-term sustainability, India must expand bamboo plantations with suitable species, address technological gaps, and utilize bamboo waste efficiently. These efforts will strengthen the incense value chain, reduce import dependency, and promote rural livelihoods, positioning India as a global leader in the incense industry while fostering economic and environmental resilience.

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