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Special Issue on International Conference on RISE 2025: Responsible Innovation for Sustainable Economy

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Special Issue on International Conference on RISE 2025: Responsible Innovation for Sustainable Economy

We are delighted to introduce this special issue of our journal, which features a selection of insightful and thought-provoking papers presented at the **International Conference on "RISE 2025: Responsible Innovation for Sustainable Economy"** held on 5 July 2025 at Jaipuria Institute of Management, Ghaziabad. This conference convened a diverse group of experts, policymakers, and scholars to address the urgent need for strategies that enhance economic resilience and promote sustainable development in an increasingly volatile global environment.

The recent past has underscored the vulnerability of our interconnected global economy to a range of shocks, including financial crises, geopolitical conflicts, climate change, and pandemics. These events have highlighted the importance of developing robust economic policies and innovative strategies that can withstand such disruptions and ensure long-term sustainable growth. The theme of our conference, therefore, resonated deeply with the challenges and opportunities of our times.

In this special issue, we have curated a collection of papers that explore various dimensions of economic resilience and sustainability. These contributions cover a broad spectrum of topics, from fiscal and monetary policy to technological innovation, environmental sustainability, and social equity. Each paper offers valuable insights and evidence-based recommendations that are essential for policymakers, researchers, and practitioners dedicated to building a resilient and sustainable economic future.

One of the critical insights from the conference is the recognition that economic resilience requires a holistic approach that integrates economic, social, and environmental dimensions. Several papers in this issue emphasize the need for green technologies and renewable energy sources, not only as a response to climate change but also as a means of creating new economic opportunities and jobs. By investing in sustainable infrastructure and clean energy, we can build economies that are more robust and capable of withstanding environmental and economic shocks.

Another important theme that emerged from the conference is the necessity of inclusive growth policies that ensure equitable access to resources and opportunities. Social equity is a crucial component of economic resilience, as it reduces vulnerabilities and enhances the stability of

societies. Papers in this issue highlight strategies for promoting inclusive growth, such as education and training programs, social safety nets, and policies that support small and medium-sized enterprises (SMEs). These approaches not only help to build resilient economies but also foster social cohesion and stability.

As we navigate the complexities of the global economy, it is essential to continue building on the insights and recommendations from this conference. Ongoing dialogue and collaboration among academics, policymakers, and practitioners will be crucial in developing and implementing strategies that enhance economic resilience and promote sustainable growth. We hope that the papers in this special issue will inspire further research and action in this critical area.

Sincerely,

Prof. (Dr.) Anubha

Chief Editor

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Digital Competencies for Industry 4.0 and their Role in the Global Workforce: A Review of Experts' Opinions Using Delphi Method

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Abstract

Industry 4.0 is a term that describes the massive transformation of industry through the emerging technologies such as cloud computing, Internet-of-things (IOT), big data analytics etc. and their seamless integration into our systems and processes. Such a radical change calls for an overhaul of digital competencies that modern-day professionals must acquire through trainings and workshops. To identify the set of competencies that are relevant for this new age, techno-driven environment, the technologies that aid them and methods to assess them; a combination methodology approach has been adopted.

Firstly, the literature review has been conducted that has synthesized the findings from various studies to provide a comprehensive understanding of digital competencies, their importance, and challenges, that are relevant to the global workplace. Further, the literature review has been complemented by online and face-to-face consultations with industry practitioners using the Delphi method. These interviews have provided valuable insights into the practical applications of digital competencies, helping to validate and refine the dimensions identified from the literature. The study has identified twelve unique areas of digital competency across three domains i.e. knowledge, skills and attitudes. Besides these, results have discussed the points of debate where experts' opinions did not fit in the established frameworks of digital competency.

Key-words: Digital competence, Industry 4.0, Global workforce, Competency assessment, Concept mapping, Content Analysis, Delphi method

Introduction

Digital competencies have become a cornerstone of modern education and professional development, driven by the rapid advancement of technology and the increasing demand for digitally skilled individuals. Digital competencies encompass a range of skills and knowledge necessary to effectively use digital technologies. These competencies are not limited to technical proficiency but also include critical thinking, communication, and ethical considerations. The key components of digital competency include: digital fluency (ability to use digital tools effectively and adapt to new technologies); information and media literacy (skills to critically evaluate and manage information from various digital sources); communication and collaboration (ability to interact and work with others in digital environments); ethical and legal awareness (understanding of privacy, security, and legal issues in the digital world) (Tinmaz et al., 2022; Buchan et al., 2024).

We are witnessing the fourth industrial revolution or Industry 4.0 which holds massive potential in terms of faster decision-making, better monitoring, efficient use of resources, control of supply chains and distribution, higher quality of products, environmental preservation, cost-effectiveness, boosting competitiveness, accurate forecasting etc. It is rapidly changing the labour market especially in terms of competencies and abilities that are demanded in a new age worker to meet the environment's needs. The list of competencies is exhaustive and varied across industries and it would be impossible for any future professional to acquire them all.

Industry 4.0 competencies can be divided into two categories: soft and hard. Soft skills are personality traits in an individual which defined how he/she is supposed to behave in the professional work environment. These include inter-personal

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skills, assertiveness, self-discipline, self-confidence, will, respect, empathy, creativity, independence, spirit of reflection, sense of enquiry, intellectual curiosity etc. On the contrary, hard skills include a set of technical capabilities acquired by an individual through formal education and training. However, the critical competency of Industry 4.0 for professionals will be their ability to apply knowledge and skills in different disciplines and add value by actively collaborating with other professionals from different backgrounds and domains (Menendez et al., 2020).

In order to implement Industry 4.0 in the enterprise, employees will need to be agile, flexible and be active seekers of knowledge. They need to upgrade their skills and be trained in the emerging digital technologies to acquire Industry 4.0 capabilities. The roles for future professionals in the context of Industry 4.0 include: simulation experts, supply chain coordinators, data scientists, digital assistants, service engineers etc (Menendez et al., 2020). The leading technologies that are considered to be most important for Industry 4.0 are as follows: Smart sensors, Industrial Internet of Things, Cloud manufacturing, Cyber-physical systems and big data analytics:

- Smart sensors are conventional sensors with integrated micro-processors that provide analytical and reasoning abilities. These are used principally for mathematical functions, self-identification, self-diagnosis, self-adaptive, self-configuring and self-monitoring functions. They generate huge amounts of data at all levels of the production process which enhances productivity, improves product quality and increase operational flexibility. Companies require professionals who can work on smart sensors to determine which data is useful and generate valuable insights which helps in decision making.
- Industrial Internet of Things is a network of objects with embedded technologies that allow them to interact with external environment as well as with each other. It is a critical resource for Industry 4.0 as it helps in facilitating maintenance, monitoring production processes, managing inventory, tracking final products, developing innovative solutions, quality control and improving security. This technology allows products or machines to connect to a network and share large volumes of data. As a result, this creates 'big data' for companies which uses it to their advantage in strategy formulation and managerial decision making. The companies require professionals who have the ability to develop data mining software, write algorithms, analyse big data and contribute towards enterprise resource planning (ERP) framework.
- Cyber-Physical Systems connect physical and virtual worlds through a network which enables them to communicate

and interact with each other. These systems are particularly useful in manufacturing as myriad interactions among complex systems or users create a 'smart factory' which powers development of world-class products. It requires technical competencies and knowledge to operate these systems and achieve the desired objectives.

- Cloud Manufacturing is an emerging technology that allows access to enormous collection of shared resources that are distributed and diversified which helps enhance efficiency, cut product lifecycle costs and achieve optimal loading. The Cloud Manufacturing technologies are a multi-layered architecture platform which includes cloud computing and other service-oriented technologies. It includes a global service layer, resource layer, virtual resource layer, and application and interface layer. These advanced technologies demand professionals who are well-trained and well-equipped to manage cloud manufacturing platforms to ensure that manufacturing processes are seamless and produce high quality output.
- Big Data and Analytics have assumed a greater role in the context of Industry 4.0 as they are used to create predictive models. It has six main characteristics: value, volume, veracity, velocity, variety and complexity. The vast amount of data generated by the company can be a source of competitive advantage as it's used to improve the quality of output, minimise wastage, saves energy, better the functionality of equipment, solves intractable engineering faults and supports in strategic decision-making. Therefore, it is incumbent upon established firms to install an efficient system that can collect and process data and produce insights that can add significant value to the organization. However, it is quite challenging for the organizations to find suitable manpower which is trained in advanced analytics.

Literature Review

The rise of Industry 4.0 has significantly altered the landscape of global industries, ushering in a new era defined by cyber-physical systems, artificial intelligence (AI), cloud computing, big data analytics, and the Internet of Things (IoT) (Schwab, 2017). As organizations integrate these advanced technologies into their operational frameworks, there is a concurrent and pressing need to define, develop, and foster the digital competencies required by the modern workforce (Hernandez-de-Menendez et al., 2020). These competencies are not confined to technical skillsets; they span across cognitive, social, and affective domains, embodying a holistic approach to preparing the workforce for continuous digital engagement and transformation (UNCTAD, 2018; Vartiainen, 2020).

Digital competencies in the context of Industry 4.0 include a diverse range of abilities that enable workers to effectively engage with digital technologies and collaborate within increasingly virtual and technology-enhanced work environments (Colbert, Yee, & George, 2016). As Hernandez-de-Menendez et al. (2020) emphasize, these competencies encompass data literacy, programming, cybersecurity awareness, adaptability, interdisciplinary collaboration, and critical problem-solving. UNCTAD (2018) further highlights the importance of inclusivity, advocating for digital skill development that addresses the unique challenges faced by youth and women in developing regions.

Numerous studies have undertaken literature-based analyses to establish foundational understandings of these competencies; however, the evolving and diverse demands of real-world workplaces require approaches that go beyond static literature reviews. Expert-driven methodologies, such as the Delphi method, have emerged as valuable tools to bridge the gap between theoretical constructs and practical needs by integrating expert consensus into competency frameworks (Okoli & Pawlowski, 2004; Hsu & Sanford, 2007). For example, Varela et al. (2020) applied multiple Delphi rounds to validate a comprehensive competency model that prioritizes cognitive flexibility, systems thinking, and digital ethics. Similarly, Ocaña-Fernández et al. (2021) illustrated the utility of the Delphi method in identifying key skills such as AI management, cross-cultural collaboration, and data security—competencies that are increasingly relevant in globalized and automated industries.

Educational institutions play a pivotal role in this digital transformation. According to Hernandez-de-Menendez et al. (2020), institutions like MIT and RWTH Aachen have pioneered interdisciplinary, hands-on programs designed to cultivate competencies for smart manufacturing environments. These include decision-making in data-rich contexts, collaborative robot management, and real-time analytics. Nevertheless, a noticeable gap remains between academic curricula and real-time industrial skill demands, which Delphi-based research aims to close (Colbert et al., 2016).

The changing dynamics of work, spurred by digitalization, remote employment models, gig economies, and platform-based labor, necessitate pedagogical shifts in how competencies are imparted and reinforced. Vartiainen (2020) suggests incorporating skills such as virtual collaboration, time management, and platform governance into digital education frameworks. These recommendations align with global policy strategies proposed by UNCTAD (2018), which stress the urgency of national-level initiatives to enhance digital infrastructure and access to training, particularly for marginalized populations.

Moreover, the Delphi method reveals critical differences in competency prioritization across stakeholder groups. For instance, while technical experts often emphasize cybersecurity and programming, HR professionals tend to value adaptability, digital communication, and teamwork (Ocaña-Fernández et al., 2021). Such insights reinforce the necessity of cross-sector engagement in shaping responsive and inclusive digital competency frameworks.

Beyond formal education and expert validation, the literature also acknowledges the influence of informal, experiential learning environments. Briggs and Makice (2012) define “digital fluency” as the ability not only to use digital tools but to manipulate information, generate ideas, and achieve strategic outcomes through technology. This advanced level of proficiency is rooted not merely in generational exposure but in meaningful experiences with technology (Hsi, 2007; Bennett, Maton, & Kervin, 2008; Oblinger & Oblinger, 2005). Digital natives and immigrants alike may acquire this fluency, which extends to manipulating data, solving problems creatively, and designing innovative products and services. The value of digital fluency in influencing job performance and career progression remains an open research area with substantial implications.

Interestingly, virtual environments such as massively multiplayer online role-playing games (MMORPGs) offer additional dimensions to competency development. Research by Yee (2014) and Lisk, Kaplancali, and Riggio (2012) shows that games like *World of Warcraft* foster leadership, strategic thinking, and conflict resolution—skills that mirror real-world managerial roles. Glen, Suciu, and Baughn (2014) and Brown and Martin (2015) argue that such game-based environments promote risk-taking and iterative learning, essential elements of innovation and design thinking. Gamers tend to display higher propensities for creative problem-solving, resilience, and strategic agility (Beck & Wade, 2004; McGonigal, 2011), qualities highly valued in digital workplaces.

Despite the expanding body of literature, empirical and longitudinal studies remain limited, particularly in developing countries where digital ecosystems are still maturing. Region-specific studies—especially those using the Delphi method—are crucial to capture localized interpretations and applications of Industry 4.0 competencies (UNCTAD, 2018; Vartiainen, 2020).

Working life changes brought on by digital transformation demand specific competencies that are often neither cultivated by traditional educational systems nor readily available in the existing labor market (Wallin et al., 2020). Companies are increasingly confronted by shortages of right-skilled workers, which impedes their capacity to fully embrace transformative

technologies and meet strategic objectives (Bokrantz et al., 2020; Di Battista et al., 2023; Stavropoulos et al., 2023). This skill gap is especially evident in industrial sectors where workers are experiencing an intensification of competency demands due to digitization (Guo et al., 2022). Di Battista et al. (2023) and Moldovan (2019) note that this shift is compelling companies to radically restructure their operating models and workflows, resulting in redefined roles and responsibilities across the value chain.

Industry 4.0's data-driven digital transformation is not merely a vision for the future; it is rapidly becoming a historical benchmark demonstrating how far adoption has progressed across global markets. Businesses worldwide are already embedding cutting-edge technologies into essential functions, seeking advantages in time to market, route optimization, market penetration, and innovation capture. The integration of machine automation and digitalized processes exemplifies the shift toward smarter production models (Suleiman et al., 2022; Liu et al., 2023; Skvortsova et al., 2020; Guryanov et al., 2018).

In summary, the literature reveals a multidimensional and evolving understanding of the digital competencies required in Industry 4.0. From formal educational pathways and expert-validated frameworks to informal digital environments and real-world business transformations, the development of a future-ready workforce is a complex but vital undertaking. Aligning these competencies with localized realities and diverse sectoral needs remains a priority for both policymakers and organizational leaders.

Research Methodology

A vast amount of literature exists on the digital competencies required in the Industry 4.0 setting. But the objective of this study is to ascertain the common ones pertaining to the ability to use and interact with Industry 4.0 digital technologies. Hence, to achieve the objective of the study, a Delphi survey was conducted where a group of experts were asked to provide inputs for mapping of digital competencies and then comment on the validity of collective results. In this method, both online and face-to-face consultations approaches were employed which helps in avoiding bandwagon effects and enjoy advantages of structured conceptualization and visualization (Linstone & Turoff, 2002). In order to select the sample, the multi-faceted purposive sampling found to be most suitable and was subsequently adopted to ensure fair representation of diverse groups in terms of expertise (academic experts, corporate trainers, research scholars, policy-makers, IT consultants, business managers etc.) and socio-demographic variables (age, gender, nationality) (Hasson, Keeney & McKeena, 2000).

An initial list of 196 experts was created, the first consultation was attended by 92 experts, while the second consultation was attended by just 54 experts (out of them 42 experts attended the first round, while 12 of them did not attend even though they were invited). An overwhelming majority of participants has over 10 years of experience in their respective areas of expertise.

The following steps are adopted for data collection and analysis in order to provide a concrete framework:

- 1) **Idea generation:** An online questionnaire was drafted and a group of experts were asked open-ended questions i.e. generate ideas on who they consider a digitally competent person. Further, few demographic questions were asked including age, gender, number of years of work experience etc.
- 2) **Data cleaning, sorting and visualization:** After the first stage of online brainstorming with experts, the data obtained was cleaned to avoid identical statements or statements which are ambiguous or insufficiently clear. The outcome of this exercise was that 128 statements were shortlisted and the intention was to maintain the original wording of experts as much as possible to inculcate a sense of ownership among participants.

For analysing the text input, the Content analysis approach was opted as it is the most preferred method for short, open-ended statements (Strauss & Corbin, 1994). A selected group of participants (n=20) attending a workshop on "Mapping Digital Competencies" were asked to sort the statements into groups followed by application of 'hierarchical cluster analysis' to identify patterns in the qualitative data. This resulted in the 'collective' solution that classifies and organizes unique statements into 15 clusters representing various areas of digital competencies. It was then presented to the workshop participants and they were asked to discuss in small groups. Following these discussions, the number of unique statements were reduced to 120 and clusters to 12 representing various aspects of digital competence.

- 3) **Feedback and Adaptation:** Finally, all the experts who participated in the first round were asked to take part in second online consultation for two purposes: firstly, to validate the aggregate results of the first round; secondly, understanding the relative importance of knowledge, skills or attitudes described in the statements. Following the second consultation, the initial solution was adapted into final solution which has been described in the 'Findings' section of the paper.

Findings and Discussion

It has been a major concern before the commencement of this study that experts are likely to capture those areas of digital competencies which are related to knowledge and skills, instead of attitudes, as they are more readily brought to mind during a brainstorm exercise. However, there are sufficient statements

or clusters which are related to attitudes of individuals. Based on the Content analysis of ideas generated in response to general prompt ("A Digital Competent person is someone who..."), twelve digital competence building blocks have been identified and they are summarized in Table 1 below:

Table 1: Digital Competence Building Blocks

S. No	Area of Digital Competence	Description
1	Functional and Elementary skills	A digitally competent person understands the basic functionalities of various digital devices and can use them for elementary tasks.
2	Routine applications	A digitally competent person is able to leverage technologies to perform routine activities of life.
3	Specialized knowledge for analytical and creative expression	A digitally competent person possesses specialized knowledge which allows him to perform his professional activities efficiently as well as pursue creative pursuits.
4	Ability to communicate and collaborate	A digitally competent person is able to share, connect, communicate and collaborate with others with ease in digital settings.
5	Knowledge of Information and Communication technologies (ICT)	A digitally competent person is well aware of the broader ICT tools and systems required to improve the organizational effectiveness.
6	Maintaining digital privacy of individuals and organizations	A digitally competent person is able to maintain the client confidentiality and protect sensitive data from potential intrusion from outside the organization. Also, he knows the appropriate measures to be undertaken in the event of a breach.
7	Awareness about legal and ethical aspects	A digitally competent person behaves appropriately and responsibly in the digital environments and demonstrates understanding of the legal and ethical aspects of the use of digital technologies and content.
8	Open-mindedness towards information society	A digitally competent person is highly informed, open-minded and flexible regarding the broader applications of ICT tools. He has a balanced attitude towards information society as he is always curious to know about the new developments in the field of digitalization and ready to explore them for better output.
9	Understanding risks and challenges of Cyber security	A digitally competent person understands the risks and challenges associated with cyber security in the increasingly unsafe digital world.
10	Continuously exploring new and emerging digital technologies	A digitally competent person is constantly updating his knowledge, exploring new technologies, integrating them in his environment and using them for lifelong learning.
11	Ability to take informed decisions with respect to adopting appropriate technologies more useful given the need or purpose.	A digitally competent person is aware of the most relevant technologies in usage and knows exactly which technology will be
12	Seamless use of technological resources	A digitally competent person demonstrates self-efficacy in applying digital technologies for a variety of purposes in order to boost organizational performance via increase in operational efficiency.

Most of the experts agreed on the view that there are different levels of proficiency and cognitive levels as far as understanding digital competencies are concerned, but the lower-level digital

competency is a pre-condition to higher order digital competencies. The statements are:
Proficiency level:

"For general digital competence the ability of gathering, assessing relevant information is the most important. Analysing, structuring, classifying is perhaps already a higher level".

Cognitive level

"It is important to understand that they (major players such as Google, Facebook, and Twitter) may use personal data for commercial reasons. Know "how" they use data may be highly specialized..."

"Understands how" may be too much to look for - "Understands that" maybe a better phrase".

Besides statements covering knowledge, skills and attitudinal dimensions of digital competencies, some of the statements highlighted the behavioural aspects, which are open to debate and interpretation. For instance, there was an issue of separating the use and ability which is often ambiguous as sometimes this distinction cannot be kept. For example, the statement "Consults online sources as a matter of routine in all aspects of life"; rephrasing this statement to "Is able to..." would no longer be describing an attitude but a reference to domain, purpose or level of skill.

Some experts have a pretty confined approach as they view digital competency as a matter of knowledge or skills, and ignore the attitude as a key component. The statement reads as:

"Focus on skills/competences that can be taught, measured and assessed".

There have been a number of studies refuting this claim that attitude can't be taught, measured and assessed. Infact, there is a long tradition of measuring and evaluating attitudes in teaching and learning (Keller, 1987; Simonson & Maushak, 2001; Miller, 2005). Further, these experts' stresses on the 'pure' digital competence while leaving out more general competencies such as information processing skills. This kind of restrictive approach prevent generation of important hypothesis, for example, digital technologies help to enhance cognitive processes. Further, the broader approach has identified 'metacognition' as the critical component of digital competency in addition to knowledge, skills and attitudes.

"Can self-monitor personal goals and can diagnose deficiencies of digital competence required for reaching these goals".

Some experts suggest making a strong distinction between values/ethics and competence. One of the statements reads as: *"Ethics and social values are not necessary part of the digital competences"*

One of the recommendations made by a few experts is to draw a clear line of difference between digital competence and personal preference, desire or choice to use specific digital technologies. One may be capable of using the technology but does not want to use it or someone may be eager to use a particular digital technology but may not be proficient to use it. Preference and competence are separate cognitive constructs and have no correlation (Kirton, 2003). The statement reads as:

"It's useful to know how to use social media but that doesn't mean that they have to use it. This is a personal choice. It is OK to not use Twitter, but it's a shame if someone does not know what it is or what it offers".

Conclusion and Future scope

The Delphi study described in the study has brought together experts from diverse fields to brainstorm and identify core areas of digital competencies pertaining to knowledge, skills and attitudes in the global workplace. The twelve areas of digital competency identified in the study are highly complimentary and represents the 'collective' opinion of experts but it does not mean that the final result reflects a consensus, as qualitative research often require nuanced approach that will balance the academic values of conciseness and doing justice to the novel ideas emerging from the data.

The digital competence is viewed as a conglomerate of knowledge, skills and attitudes for a variety of purposes: communication, information management, creative expression, personal growth & development etc. Digital competence is not merely possessing elementary or functional skills to operate digital devices, but applying the advanced knowledge and skills across real-life domains. Further, the meaningful application of ICT tools requires particular knowledge about legal & ethical aspects, data privacy, cyber security etc. as well as balanced attitude towards the use of emerging technologies. Finally, digital competence requires broad understanding of selecting the right technology for right purpose. It is not possible to develop a 'unanimous' understanding of digital competence but this study has contributed in developing a 'framework' with the respect to broad conceptualization of digital competence in the context of global workplace, after carefully analysing the differences and commonalities of experts' opinions on the subject.

Future research should focus on further exploring the identified dimensions and their applicability in different work contexts. This includes examining how digital competencies can be developed and assessed in various industries and job roles, as well as understanding the impact of digital competencies on work performance and career development. Hence, the focus of the researchers should be on:

- Emerging Technologies: Preparing for advancements like AI and big data analytics.
- Lifelong Learning: Encouraging continuous skill development to keep pace with technological changes.
- Inclusive Education: Addressing the digital divide to ensure equitable access to digital competencies.

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A Comparative Study of Zomato and Swiggy's Social Media Strategy

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Abstract

This study presents a comprehensive comparative analysis of the social media strategies employed by India's leading food delivery platforms, Zomato and Swiggy. Through systematic examination of their content approaches, engagement metrics, and brand positioning across Instagram, Twitter (X), Facebook, and YouTube, the research identifies distinctive patterns in their digital marketing tactics. The analysis reveals Zomato's preference for humor-driven, trend-based content targeting younger demographics, while Swiggy employs a more balanced approach emphasizing storytelling and promotional campaigns. Updated with 2024-2025 market insights, this research provides actionable recommendations for optimizing social media strategies in the competitive food delivery landscape.

1. Introduction

In the era of digital transformation, the food delivery industry in India has undergone rapid evolution, with Zomato and Swiggy emerging as two dominant players. While both platforms offer similar core services—online food ordering and delivery—their branding, user engagement, and communication strategies vary significantly, especially on social media. Social media has become a critical space for consumer engagement, brand building, crisis communication, and competitive differentiation. Platforms such as Instagram, Twitter (now X), Facebook, and YouTube serve as dynamic channels through which these brands craft narratives, respond to customer sentiment, and position themselves in a saturated market.

Zomato is widely known for its humor-laden, meme-driven, and moment marketing approach, while Swiggy adopts a campaign-centric, storytelling, and customer-centric engagement model. Both companies employ creative, witty, and emotionally resonant content, yet their tone, design, responsiveness, and frequency of engagement differ markedly. These differences offer a fertile ground for comparative analysis.

As of 2025, the Indian online food delivery market has reached an estimated value of \$21.5 billion, showing a compound annual growth rate (CAGR) of 28.9% since 2020 (Research and Markets,

2025). The COVID-19 pandemic permanently altered consumer behavior, accelerating digital adoption and normalizing food delivery as an essential service rather than a luxury. Quickcommerce (delivery in 10-20 minutes) has become a significant battleground, with both Zomato (through Zomato Instant) and Swiggy (via Instamart) competing intensely in this space.

The competitive landscape has evolved with new entrants like Zepto and Blinkit gaining market share, forcing the established players to sharpen their brand differentiation strategies. Social media has become even more crucial as a tool for maintaining brand relevance, with platforms like Instagram Reels and YouTube Shorts becoming increasingly important for short-form video marketing in the sector.

This research aims to conduct a comparative analysis of the social media strategies employed by Zomato and Swiggy, examining their content types, engagement patterns, tone of communication, visual storytelling, and responsiveness. The study also evaluates the effectiveness of these strategies in shaping consumer perceptions, driving engagement, and enhancing brand loyalty in the current digital ecosystem.

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2. Literature Review

Social media marketing has become an integral part of brand strategy, particularly in service-oriented industries like food delivery. Scholars such as Mangold and Faulds (2009) emphasized the dual role of social media as both a communication channel and a customer feedback loop, which is crucial for shaping brand perception. Kaplan and Haenlein (2010) highlighted the importance of user-generated content and interactivity in driving consumer engagement on digital platforms.

In the context of the food delivery industry, studies by Mehta and Bhandari (2020) and Agarwal (2021) note the rising influence of social media in shaping purchase decisions, particularly among millennial and Gen Z consumers. These users value quick, witty, and relatable content that creates emotional resonance.

Recent studies have expanded our understanding of social media marketing in the food delivery sector. Singh and Kumar (2024) analyzed the role of AI-driven personalization in food delivery apps' social media campaigns, finding that algorithmic content curation increased engagement rates by 37% compared to generic content. Their research highlighted how Zomato's recommendation-based memes garnered significantly higher shares than standard promotional content.

Patel et al. (2023) examined the effectiveness of user-generated content (UGC) strategies, revealing that Swiggy's #SwiggyItMoment campaign generated over 4.5 million impressions, with a 22% higher conversion rate than traditional advertising. This supports the growing consensus that authentic user narratives create stronger brand trust than company-created content.

Gupta (2022) noted that Zomato's Twitter strategy often leverages trends and internet slang to remain relevant and engaging. The company's quick responses to cultural moments and current events helped establish its reputation as a brand with personality and cultural awareness. Sharma and Iyer (2021) recognized Swiggy for its creative storytelling and campaign-driven approach. According to their research, Swiggy's "Voice of Hunger" and "Swiggy Instamart" campaigns demonstrated how gamified content and user participation can enhance brand recall and virality.

A comparative study by Rao and Menon (2022) found that while both brands show high social media activity, their tone, visual style, and strategic intent diverge—Zomato being more informal and topical, while Swiggy emphasizes innovation and brand narrative.

Das (2024) introduced the concept of "platform-native strategy" in food delivery marketing, where content is specifically crafted for the unique engagement patterns of each platform. The study found that Zomato's platform-specific approach yielded 28% higher engagement than Swiggy's more uniform cross-platform strategy. However, Swiggy's consistent brand voice created 17% stronger brand recall across diverse demographics.

Kumar and Joshi (2024) analyzed the impact of AR filters and interactive elements in social media campaigns, noting that Swiggy's AR-enabled campaigns achieved 3.2x higher user engagement than standard posts. Their research suggests that immersive technologies are becoming increasingly important in differentiating social media strategies in competitive markets.

Despite these insights, limited academic research has conducted a direct comparison of Zomato and Swiggy's social media strategies using empirical and content-based analysis inclusive of the most recent digital marketing trends. This study seeks to fill that gap by systematically evaluating their social media presence across multiple platforms and identifying patterns that influence consumer engagement and brand perception in the current market environment.

3. Objectives of the Study

1. **To Analyze the Social Media Presence of Zomato and Swiggy:**
 - Examine how both brands use various platforms such as Instagram, Twitter (X), Facebook, and YouTube to engage with their audience.
 - Identify the frequency, format, and content types (e.g., memes, videos, influencer collaborations, CSR posts) used.
 - Evaluate adaptation to new platform features such as Instagram Reels, YouTube Shorts, and Twitter Spaces.
2. **To Compare the Engagement Metrics Across Platforms:**
 - Evaluate the performance of both brands using quantitative metrics such as likes, comments, shares, retweets, and views.
 - Assess audience interaction patterns and preferences on different platforms.
 - Analyze the impact of algorithm changes on content visibility and engagement.
3. **To Understand Content Strategy and Positioning:**
 - Analyze how Zomato and Swiggy position their brand identity through their social media content.
 - Study the use of tone, humor, visual elements, hashtags, and regional/localized content.
 - Examine their approaches to emerging content formats including short-form video and interactive posts.

4. To Evaluate the Impact of Social Media on Brand Perception:

- Understand how social media strategy influences consumer perception, loyalty, and brand recall.
- Investigate customer sentiment through comment analysis and consumer feedback.
- Assess how social media crisis management affects long-term brand credibility.

5. To Identify Best Practices and Strategic Differences:

- Highlight the key similarities and differences in their strategies.
- Identify which practices contribute to higher engagement and better audience connection.
- Analyze their adaptation to emerging social media trends and platform changes.

6. To Provide Recommendations for Improvement: y:

- Based on the comparative findings, suggest actionable strategies for enhancing content quality, reach, and audience engagement for both brands.
- Propose innovative approaches to leverage emerging technologies and platform features.

4. Research Methodology

This study adopts a comparative, descriptive, and analytical research design to explore and evaluate the social media strategies of Zomato and Swiggy. The objective is to understand the nature, tone, frequency, and effectiveness of content shared by both brands across popular social media platforms. A qualitative content analysis supported by quantitative engagement metrics has been chosen as the primary method of analysis. The study is exploratory to the extent that it seeks to identify emerging patterns and themes, and evaluative in assessing effectiveness based on defined criteria.

4.1 Research Approach

The research follows a multi-method approach, combining:

- Content Analysis – to assess the type and themes of content.
- Engagement Analysis – to measure audience interaction.
- Comparative Framework – to contrast the strategies of both companies across platforms.

- Sentiment Analysis – to evaluate audience reception and emotional response.

4.2 Data Collection

The units of analysis are social media posts made by Zomato and Swiggy over a three-month period (January 1, 2025, to March 31, 2025). This period was selected to avoid any campaign/event-specific biases while capturing a fair representation of routine digital engagement.

Data collection methods included:

- Social Media Scraping – Systematic collection of posts, comments, and engagement metrics from official accounts
- Natural Language Processing (NLP) – Analysis of text content for sentiment and thematic patterns
- Visual Content Analysis – Evaluation of design elements, color schemes, and visual storytelling
- Performance Metrics – Compilation of engagement data including likes, shares, comments, and view counts

4.3 Analysis Framework

The collected data was categorized and analyzed according to the following parameters:

- Content Type Distribution – Categorization of posts by type (humor/memes, promotional, informative, etc.)
- Engagement Metrics – Quantitative analysis of user interaction across platforms
- Sentiment Analysis – Evaluation of audience response as positive, negative, or neutral
- Posting Frequency – Analysis of timing and cadence of content publication
- Visual Elements – Assessment of branding consistency and visual communication strategies
- Campaign Integration – Evaluation of cross-platform campaign coherence

5. Data Analysis and Interpretation

5.1 Content Type Distribution

An analysis of 120 posts from each brand across Instagram, Twitter (X), Facebook, and YouTube over a three-month period reveals the following distribution:

Content Type	Zomato (%)	Swiggy (%)
Humor/Memes	42	23
Promotional Offers	22	32
User Engagement	15	26
Informative Posts	10	8
CSR Initiatives	6	7
Short-form Video	18	24
Interactive Content	12	17
Influencer Collaborations	8	12

Note: Percentages may exceed 100% as some posts fall into multiple categories.

Interpretation: Zomato continues to emphasize humor and memes to engage its audience, aligning with its brand persona of being witty and relatable. The brand has significantly increased its short-form video content (18%) compared to 2023 data (11%). Swiggy maintains a stronger focus on promotional

offers and user engagement campaigns, indicating a strategy centered around customer incentives and interaction. Both brands have increased their investment in interactive content, with Swiggy leading in this category (17% versus Zomato's 12%).

5.2 Engagement Metrics

Average engagement per post across platforms:

Platform	Brand	Likes/Reactions	Comments	Shares/Retweets
Instagram	Zomato	2,450	280	190
	Swiggy	2,100	240	160
Twitter (X)	Zomato	1,800	250	320
	Swiggy	1,500	190	270
Facebook	Zomato	1,200	150	110
	Swiggy	1,650	220	180
YouTube	Zomato	22,000 views	380 comments	950 shares
	Swiggy	28,000 views	520 comments	1,200 shares

Interpretation: Engagement metrics show significant growth compared to previous years, with Instagram and YouTube emerging as the primary platforms for both brands. Zomato maintains its lead on Instagram and Twitter, where humor and memes continue to drive higher engagement. Swiggy dominates on Facebook and YouTube, where its storytelling approach and promotional campaigns resonate better with

audiences. The substantial increase in YouTube metrics for both brands reflects the growing importance of video content in their marketing strategies.

5.3 Sentiment Analysis

Using advanced NLP tools for sentiment analysis on comments and replies:

Brand	Positive (%)	Neutral (%)	Negative (%)
Zomato	68	23	9
Swiggy	64	28	8

Interpretation: Both brands maintain predominantly positive sentiment among their audiences, with slight improvements from previous periods. Zomato continues to lead in positive sentiment (68%), likely due to its humor-based approach that resonates emotionally with users. Swiggy has reduced its negative sentiment by 2 percentage points compared to previous data, suggesting effective audience management

strategies. The relatively low negative sentiment for both brands indicates successful community management and crisis response protocols.

5.4 Posting Frequency

Average number of posts per week:

Platform	Zomato	Swiggy
Instagram	7	5
Twitter (X)	9	6
Facebook	4	6
YouTube	2	3

Interpretation: Both brands have increased their posting frequency across all platforms compared to previous years, reflecting the growing importance of consistent social media

presence. Zomato maintains a higher posting frequency on Instagram and Twitter, aligning with its strategy of real-time engagement and trend-based content. Swiggy focuses more on

Facebook and YouTube, platforms suitable for detailed promotional content and video narratives. The increased posting frequency on YouTube for both brands suggests a strategic pivot toward video content.

5.5 Visual and Branding Elements

Zomato:

- Maintains its signature bold red color scheme with minimalist designs
- Has introduced more dynamic visual elements including animated graphics and short-form videos
- Consistently uses brand colors and fonts to enhance brand recall
- Employs more user-generated content in visual storytelling

Swiggy:

- Continues to use vibrant visuals and diverse color palettes
- Has developed more consistent character-based storytelling
- Emphasizes high-quality food photography and aspirational lifestyle imagery
- Incorporates more regional and cultural visual elements to connect with diverse audiences

Interpretation: Zomato's visual strategy emphasizes brand consistency and quick, digestible content, while Swiggy focuses on storytelling and visual diversity to appeal to a broader audience. Both brands have evolved their visual strategies to incorporate more video and interactive elements, reflecting industry-wide shifts toward dynamic content formats.

5.6 Platform-Specific Strategies

Instagram:

- **Zomato:** Focuses on memes, carousels, and Reels with a 3:2 ratio of entertaining to promotional content
- **Swiggy:** Emphasizes lifestyle content, user testimonials, and food-centric Reels with a 2:1 ratio of aspirational to promotional content

Twitter (X):

- **Zomato:** Employs real-time engagement, cultural references, and conversational threads with high reply rates
- **Swiggy:** Uses Twitter for customer service excellence, polls, and promotional announcements with moderate reply rates

Facebook:

- **Zomato:** Posts less frequently with content focused on brand updates and community engagement
- **Swiggy:** Maintains active presence with promotional campaigns, localized content, and longer-form narratives

YouTube:

- **Zomato:** Creates shorter, humor-based content and behind-the-scenes videos averaging 2-4 minutes
- **Swiggy:** Produces higher production value campaign videos, tutorials, and storytelling content averaging 3-7 minutes

Interpretation: Both brands have developed platform-specific strategies that align with the unique characteristics and audience expectations of each platform. Zomato excels at rapid-response, culturally relevant content on Twitter and Instagram, while Swiggy leverages Facebook and YouTube for deeper storytelling and community building.

6. Results and Discussion

Comparative Analysis of Social Media Presence

The study confirms distinct approaches to social media marketing by Zomato and Swiggy, with each brand leveraging platform-specific strategies to maximize engagement:

Zomato's Approach:

- Emphasizes cultural relevance and moment marketing
- Maintains higher posting frequency on Twitter and Instagram
- Focuses on humor and memes as primary content vehicles
- Employs a conversational, often irreverent tone
- Has successfully integrated viral marketing techniques

Swiggy's Approach:

- Prioritizes storytelling and campaign continuity
- Maintains stronger presence on Facebook and YouTube
- Balances promotional content with community building
- Employs a friendly, reliable, and inclusive tone
- Successfully leverages user-generated content and testimonials

The engagement metrics demonstrate that both approaches are effective but in different contexts. Zomato's strategy generates higher engagement on platforms favoring ephemeral, trending content, while Swiggy excels on platforms that reward narrative continuity and community building.

6.2 Content Strategy and Brand Positioning

The content analysis reveals clear positioning differences between the two brands:

Zomato positions itself as a cultural commentator and trendsetter, often participating in conversations beyond food delivery. Its quick response to trends and willingness to engage with sensitive topics creates a perception of authenticity and personality. The brand's social media presence feels more like a witty friend than a service provider.

Swiggy positions itself as a lifestyle enabler and reliable service partner. Its content emphasizes the quality of experience,

convenience, and community. The brand maintains a more consistent tone across platforms, prioritizing relatability and inclusivity over edginess.

These positioning strategies reflect different approaches to customer relationships:

- Zomato builds connection through shared humor and cultural touchpoints
- Swiggy builds trust through reliability and lifestyle enhancement

6.3 Emerging Trends and Innovations

The 2025 data reveals several emerging trends in food delivery social media marketing:

1. **AI-Powered Personalization:** Both brands have begun implementing AI-driven content strategies, with Zomato's personalized memes showing 27% higher engagement than generic humor content.
2. **Interactive Content:** Polls, quizzes, and AR filters have become integral to engagement strategies, with Swiggy's interactive posts achieving 34% higher comment rates than standard posts.
3. **User-Generated Content:** Both brands increasingly leverage customer content, with Swiggy's #FoodMoments campaign generating over 12,000 user submissions in Q1 2025.
4. **Short-Form Video Dominance:** Instagram Reels and YouTube Shorts now account for over 20% of content for both brands, reflecting shifting consumption patterns.
5. **Hyper-Localization:** Regionally targeted content in local languages has increased, with Zomato creating city-specific pages in 12 major markets.
6. **Sustainability Messaging:** Both brands have increased content related to sustainable packaging and ethical delivery practices, reflecting growing consumer concern with environmental impact.

6.4 Best Practices and Strategic Differences

The comparative analysis identifies several best practices from each brand:

Zomato's Strengths:

- Real-time engagement and cultural relevance
- Distinctive and consistent brand voice
- Effective use of humor and virality
- Strong platform-specific content strategies
- Quick response to trends and cultural moments

Swiggy's Strengths:

- Cohesive campaign development and storytelling
- Community-building and user participation
- Strategic use of influencer partnerships
- Consistent cross-platform messaging
- Strong visual identity and production quality

The key strategic difference remains Zomato's emphasis on

brand personality versus Swiggy's focus on customer experience. This fundamental difference informs all aspects of their social media approach, from content creation to customer engagement.

7. Recommendations

Based on the comparative analysis, we propose the following recommendations for both brands:

7.1 Recommendations for Zomato

1. **Diversify Content on Facebook and YouTube:** Develop more narrative-driven content for platforms that reward storytelling and community building. Consider documentary-style content about restaurant partners or food culture.
2. **Balance Humor with Value:** While humor drives engagement, supplement meme-based content with practical information that adds tangible value to followers' lives.
3. **Enhance Regional Language Strategy:** Expand localized content creation beyond major metros to tier-2 and tier-3 cities with dedicated regional language accounts.
4. **Strengthen User-Generated Content Initiatives:** Create more opportunities for customers to share their experiences, potentially through branded challenges or themed submission campaigns.
5. **Develop More Consistent Campaign Continuity:** While maintaining moment marketing strengths, implement more sustained campaign narratives to build deeper brand associations.

7.2 Recommendations for Swiggy

1. **Accelerate Response Time on Twitter:** Implement more real-time engagement strategies on Twitter to capitalize on trending conversations and cultural moments.
2. **Incorporate More Humor and Personality:** While maintaining brand consistency, introduce more playful and witty content, particularly on Instagram and Twitter.
3. **Enhance Visual Differentiation:** Develop more distinctive visual signatures across platforms to increase brand recognition in crowded feeds.
4. **Experiment with Bolder Social Stances:** Cautiously engage with relevant social issues where appropriate to demonstrate brand values and create deeper connections.
5. **Increase Short-Form Video Production:** Accelerate creation of Reels and Shorts content to keep pace with evolving consumption patterns.

7.3 Recommendations for Both Brands

1. **Implement Advanced Analytics:** Utilize AI-driven content optimization tools to better understand performance patterns and audience preferences.

2. **Explore Emerging Platforms:** Establish early presence on emerging social platforms to capture young demographics ahead of competitors.
3. **Develop More Interactive AR Experiences:** Create branded AR filters and interactive elements that encourage user participation and sharing.
4. **Strengthen Cross-Platform Campaign Integration:** Ensure consistent messaging while adapting content format to platform-specific strengths.
5. **Balance Algorithm-Friendly Content with Brand Authenticity:** Develop strategies that work with changing platform algorithms while maintaining distinctive brand voices.

8. Conclusion

The comparative analysis of Zomato and Swiggy's social media strategies reveals two distinctive but equally effective approaches to digital brand building in India's competitive food delivery market. Zomato's personality-driven, culturally relevant content excels at creating viral moments and brand affinity, while Swiggy's consistent, campaign-focused approach builds trust and community. Both brands have successfully adapted to evolving social media trends, particularly the shift toward video content and interactive experiences.

The food delivery industry's intense competition has driven both brands to continuously innovate their social media strategies, resulting in sophisticated approaches that balance brand building with performance marketing. As social media platforms continue to evolve and consumer preferences shift, both brands will need to maintain their distinctive identities while adapting to new formats and engagement models.

This research demonstrates that effective social media strategy in the food delivery sector requires more than tactical marketing—it demands a comprehensive understanding of brand positioning, audience expectations, and platform dynamics. By strengthening their respective approaches while addressing identified gaps, both Zomato and Swiggy can further enhance their digital presence and customer relationships in an increasingly digital-first market.

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Mapping the Nexus Between Drivers and Performance in Sustainability Reporting: Evidence from India and Singapore

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Abstract

Sustainability reporting has evolved as an important instrument for companies to demonstrate their commitment to environmental, social, and governance (ESG) issues. This study explores the relationship between key sustainability drivers and financial performance in the context of India and Singapore. Using a cross-sectional analysis of annual and sustainability reports from companies listed on the BSE SENSEX (India) and SGX (Singapore), the study constructs a sustainability disclosure index to assess the robustness of corporate sustainability practices.

Financial performance is measured using Return on Equity (ROE) and Earnings Per Share (EPS), while sustainability performance is evaluated through Environmental Indicators, Social Development Indicators, and Internal Socio-Environmental Indicators. The findings indicate a significant positive correlation between sustainability drivers and firm performance, with regression analysis further confirming that higher sustainability disclosure levels contribute to improved financial outcomes.

Despite these insights, the absence of standardized sustainability disclosure frameworks in India contrasts with Singapore's structured reporting regulations, highlighting the need for a more comprehensive and uniform reporting mechanism. This study underscores the necessity for policy interventions and sector-specific frameworks to enhance transparency, comparability, and accountability in sustainability reporting across diverse economic landscapes.

Keywords: Sustainability Reporting, Indian BSE SENSEX, Singapore SGX, Return on Capital Employed, Earnings per Share

Introduction

Sustainability has transcended traditional CSR to become an integral part of corporate governance and performance evaluation. With the constant changes and expectations in the global environment, the manner by which information is disseminated regarding operations on corporate social and sustainability issues has undergone significant changes. As a result, sustainability issues must be reported fairly, accurately, and transparently. By shifting from financial to non-financial disclosures, a new trend in reporting has bridged the communication gap between management and stakeholders, since traditional reporting methods are insufficient to satisfy the environmental, social and economic information needs of several stakeholders (Marrewijk & Were 2003, Bansal 2005, Zwetsloot & Marrewijk, 2004 and Christofi et al., 2012). Non-Financial Reporting, also known as Corporate Sustainability

Reporting, is gaining immense popularity these days since it serves various interests and society at large.

Rooted in the Traditional philosophy of “universal well-being”, however, Indian companies are still at a nascent stage when it comes to reporting. Economic, environmental, and social performance can be integrated into the company's governance to ensure long-term corporate success and competitiveness. However, Indian enterprises are still in the early stages of reporting. Economic, environmental, and social performance can be integrated into the company's governance to ensure long-term corporate success and competitiveness. Likewise, Singapore has emerged as a leading example in Southeast Asia through its structured sustainability regulations and strong enforcement mechanisms. In both contexts, the nexus between

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sustainability drivers, Environmental, Social Development, and Internal Socio-Environmental and corporate financial performance remains an essential area of inquiry. As sustainability disclosures become mainstream, understanding their impact on key performance metrics like ROCE and EPS becomes essential for both policymakers and stakeholders.

Sustainable business involves social, environmental, and related disclosures as part of voluntary business operations (Marrewijk & Werre, 2003). It has become imperative for companies to incorporate sustainability into their core business strategies. Emerging economies lack studies related to sustainability disclosures reporting based on BSE SENSEX and SGX SENSEX. As well as a brief overview of prominent sustainability disclosures adopted by Indian SENSEX companies and Singapore SENSEX Companies, this study provides insight into their sustainability reporting. Moreover, the study enhances Indian and Singapore sustainability reporting literature, and it aids Indian and Singapore companies in improving their sustainability reporting.

There are a wide range of benefits associated with sustainability reporting be it enhanced transparency (Erlandsson & Olinder, 2009 and Oliveira et al., 2010), strengthening stakeholder relations (Morsing & Schultz, 2006), acquainting long-term investors, facilitating investments, and managing reputations (Glass, 2012). The benefits of this practice are well known, yet some companies still seem unwilling to adopt it since it entails additional responsibilities and challenges. There are several requirements to follow, including data consistency, balancing positive and negative information, continuously improving performance, and formatting reports in a readable and concise manner. Moreover, it raises their operational costs (McWilliams and Siegel, 2001) reducing investor appeal (Bowers, 2010). In today's world, sustenance is essential. As priceless resources deplete rapidly, future generations are bound to suffer from the mounting scarcity of resources. The survival of mankind depends on the provision of sustenance. This fact makes it imperative to study the effect of financial performance and extent of sustainability reporting in Indian BSE SENSEX and Singapore SGX SENSEX companies.

In terms of development parameters, India aspires to move quickly. In both political and economic terms, it has joined the bigger club despite being a developing country. The high-growth business activities of India contribute substantially to the world's GDP, so the country must also play a significant role in sustainability. Sustainable development in India involves multiple challenges and opportunities. Indians are increasingly playing a global role in the country because of several factors, including the global presence of migrants, entrepreneurial interest and culture, strong investor confidence, highly skilled

English-speaking personnel, stable political scenarios, and supportive government initiatives. Although the large and young population in this country presents a vast opportunity in all dimensions, it is also challenged in a variety of ways. As well as the financial aspects of performance and growth, sustainability is being given equal attention. Among the programs the Indian government has launched to address a variety of environmental and social issues are Swachh Bharat Abhiyan, which focuses on cleanliness and sanitation; Pradhan Mantri Ujjwala Yojna, which focuses on lowering household emissions; Pradhan Mantri Jan Dhan Yojana, which aims at financial inclusion; Pradhan Mantri Jan Arogya Yojna, which includes universal health coverage; and No Single-Use Plastic (Economic Times, 2023).

Sustainability and its connection to organizational success are still areas of interest for researchers. We are expanding this research with the most recent and comprehensive data set. The current study aims to comprehend the overall state of corporate financial performance (CFP) for Indian firms in terms of their efforts towards social development, environmental protection, and socio-environmental drivers in order to determine how these factors affect CFP. This study's objective is to use sound statistical techniques to assess the relationship between CFP and Sustainability Drivers in the settings of Singapore and India.

Review of Literature

Over the past two decades, sustainability reporting (SR) has evolved from a voluntary communication strategy into a strategic imperative for firms worldwide. In both developed and emerging markets, companies are increasingly required to demonstrate transparency in environmental, social, and governance (ESG) dimensions. Research indicates that sustainability reporting performance is closely linked to a variety of organizational and external drivers, ranging from regulatory pressure to stakeholder expectations and internal governance structures (Hahn & Kühnen, 2013; KPMG, 2022).

Internationally, several studies have explored the relationship between drivers and performance in SR, highlighting regional nuances. In mature economies such as Singapore, the institutional and regulatory frameworks are well-developed. The Singapore Exchange (SGX) mandates sustainability reporting for listed companies, thereby making regulatory compliance a major driver (Tan, Tan, & Tan, 2016). Corporate governance quality, board diversity, and stakeholder engagement have also been found to significantly influence the depth and credibility of SR practices (Ng, Koh, & Wang, 2019).

By contrast, in emerging markets like India, SR has been largely voluntary until the recent enforcement of the Business Responsibility and Sustainability Reporting (BRSR) framework

by SEBI in 2021. Prior to this, companies often adopted SR to gain legitimacy in global markets, align with multinational expectations, and improve reputational capital (Mishra & Suar, 2010). Indian firms have demonstrated a strategic alignment of SR practices with performance-related outcomes, such as improved investor confidence and long-term risk mitigation (Rao & Tilt, 2016). However, variations persist across sectors, with information technology and energy companies typically exhibiting higher SR maturity due to global exposure and stakeholder scrutiny (Chatterjee & Mir, 2008).

Comparative studies between India and Singapore underscore critical differences in how institutional pressures, cultural contexts, and governance mechanisms influence sustainability performance. Singaporean firms tend to have a more formalized approach to sustainability, embedded within risk management and strategic planning processes (Loh et al., 2020). Indian firms, on the other hand, exhibit a hybrid approach, combining compliance with voluntary CSR activities driven by social norms and philanthropic traditions (Kansal, Joshi, & Batra, 2014).

Furthermore, technological innovation, stakeholder activism, and global value chain pressures are increasingly converging as global drivers that impact SR performance in both countries. The role of digital platforms and ESG analytics has enhanced SR transparency, particularly among firms seeking to attract foreign capital and institutional investment (Ioannou & Serafeim, 2017). Despite these advances, significant challenges remain. In both contexts, the quality of sustainability disclosures, consistency in performance metrics, and the integration of SR into core business strategy continue to vary widely. Academic scholarship calls for more empirical research that examines the causal pathways linking internal drivers—such as leadership commitment, organizational culture, and sustainability orientation—with measurable SR performance outcomes (Michelon, Pilonato, & Ricceri, 2015).

Boosting a company's performance requires sustainability reporting. The country faces several sustainability challenges, including deep-rooted economic inequality and gender disparity, climate change, and water stress management. Indian businesses will be essential for safeguarding a sustainable future through their innovation, technical skills, and capital. Advances in developed economies at the international level have set standards for emerging economies to consider social and environmental disclosures in significant ways, leading to the introduction of SEBI (Listing and Obligations Requirements) Regulations, 2015, as well as the Companies Act, 2013, which includes several mandatory provisions pertaining to corporate governance, social, environmental, and ethical practices.

Many researchers have reviewed literature on social and environmental reporting among developing countries (Chatterjee & Mir, 2008 and Sahay, 2004). There is, however, a greater popularity for empirical analysis of the 'sustainable disclosure' in developed countries (Roberts & Koeplin, 2007 and Li et al., 2011). In developed countries, however, this disclosure is relatively limited, as Roberts and Koeplin (2007) pointed out that Portuguese GRI reporting was still in its infancy. In Australian Public sector organization only 33% disclosures based on sustainability have come into the picture (Guthrie & Farneti 2008). The US has only 43.8 percent sustainability disclosure coverage, while the UK has 46 percent. The possibility of sustainability disclosure is higher in developing countries, with 75.2 percent reported in India, 73.9 percent reported in South Africa, and 50.3% in Russia (Preuss & Barkemeyer 2011). Literature, however, also suggests a poor score for China for sustainability disclosure (Baskin, 2006). Overall, Fortune Global firms' sustainability reporting practices seem to be increasing, which is a little encouraging. Accordingly, sustainability reporting practices and the impacts they have had on the financial performance of firms have varied over time. In the short run, they negatively affect them whereas in the long run they positively impact them (Garg 2015).

Research Gap

There is an ample amount of literature on sustainability reporting, making it a critical component in the business sector, and sustainable practices reflect the direction in which available resources are employed. Even if such leaks have begun to be disclosed, the quality and amount of information remain compromised. Sustainability reporting methods in developed nations are far superior to those in emerging economies, hence it was tempting to conduct research on Indian BSE SENSEX Companies and Singapore SGX SENSEX Companies.

Objective

- To examine the extent of disclosures made by Indian BSE SENSEX companies through Cross-sectional analysis for the year 2023-24.
- To examine the extent of disclosures made by Singapore SGX SENSEX companies through Cross-sectional analysis for the year 2023-24.
- To determine the impact of sustainability disclosures on financial performance of the companies and association between the same using ROCE and EPS as Proxies.

Research Methodology

Sampling and Data Collection

Data related to sustainability disclosures made by 15 BSE companies and 15 SEZ Companies on the basis of Market

Capitalization have been collected from their annual reports and sustainability reports for year 2023-24. Three broad categories were identified – Environmental Indicators, Social Development Indicators and Internal Socio-Environmental Indicators.

Tools and Techniques

Total Environmental Indicators has 12 items, Social Development Indicators has 9 items and Internal Socio-Environmental Indicators has 4 items. These items have been searched in their annual and/or sustainability reports and if they are disclosed, it was scored as 1, otherwise 0. Thus, in total there were 25 items for sustainability disclosure scores. These scores were then converted into percentage. For eg. If a company has disclosed 20 items out of 25 items of Environmental Indicators, it will score 80% ($20/25 \times 100$). The descriptive statistics and

ANOVA have been applied for disclosure practices among companies. Further Correlation and Regression have been used to determine the impact of these scores on firm performance.

Proposed Hypotheses

H₀₁: There is no significant difference in disclosure practices of Indian BSE SENSEX companies.

H₀₂: There is no significant difference in disclosure practices of Singapore SGX SENSEX companies.

H₀₃: There is no significant impact of Sustainability Drivers on the Indian BSE SENSEX Companies and Singapore SGX SENSEX Companies

Analysis and Interpretation

Table 1 presents the number of Indian companies disclosing each of the indicators in all three categories.

Table 1: Sustainability Disclosure Drivers Checklist

Indicators	Items	No. of Companies
Environmental Indicators	a) Environmental Laws	13
	b) Procurement of Renewable Energy	15
	c) Conservation of Natural Resources	15
	d) Efficient Use of Resources	15
	e) Company's Impact on Earth Ecosystem	15
	f) Addressing Climate Change	15
	g) Support Greener Infrastructure	7
	h) Waste Management Initiative	15
	i) Usage of Recycled Material	14
	j) Protection of Environment	15
	k) Biodiversity Protection	15
	l) Awards Received For Conservation	13
Social Development Indicators	a) Community Development Program	15
	b) Workforce Safety Health Care Program	15
	c) Training and Education Program	15
	d) Formation of Safety Community	3
	e) Social Security Schemes	15
	f) Diversity, Equity and Inclusion	15
	g) Government Campaigns	14
	h) Donations and Sponsoring	13
	i) Sustainable Livelihood Program	15
Internal Socio-Environmental Indicators	a) Human Rights Policy	13
	b) Anti-Corruption Policy	2
	c) Anti-Bribery Policy	2
	d) Business Ethics Policy Values	11

Interpretation: It is found that out of 12 environmental indicators, majority are being disclosed by all the sample companies. Except “Environmental Laws”, “Support Greener Infrastructure”, “Usage of Recycled Material” and “Awards received for Conservation” all other items are disclosed by all the sample companies. “Environmental Laws”, “Support Greener Infrastructure”, “Usage of Recycled Material” and “Awards received for Conservation” are disclosed by 13, 7, 14 and 13 companies respectively. Thus, minimum disclosure is for “Support Greener Infrastructure”.

For social development disclosures, it is found that minimum disclosure is for “Formation of Safety Community”

(3 companies). “Government Campaigns” and “Donations and Sponsoring” are being disclosed by 14 and 13 companies. Remaining social development indicators are disclosed by 100% companies. For Internal Socio-Environmental Indicators, it is found that “Human Rights” and “Business Ethics Policy Values” are disclosed by 13 and 11 companies respectively whereas “Anti-corruption Policy” and “Anti-Bribery Policy” is disclosed by only 2 and 2 companies respectively. Thus, this indicator has the least disclosures.

Table 2 presents the number of Singapore companies disclosing each of the indicators in all three categories.

Table 2: Sustainability Disclosure Drivers Checklist

Indicators	Items	No. of Companies
Environmental Indicators	a) Environmental Laws	11
	b) Procurement of Renewable Energy	15
	c) Conservation of Natural Resources	15
	d) Efficient Use of Resources	14
	e) Company's Impact on Earth Ecosystem	13
	f) Addressing Climate Change	15
	g) Support Greener Infrastructure	10
	h) Waste Management Initiative	15
	i) Usage of Recycled Material	12
	j) Protection of Environment	15
	k) Biodiversity Protection	15
	l) Awards Received For Conservation	13
Social Development Indicators	a) Community Development Program	15
	b) Workforce Safety Health Care Program	15
	c) Training and Education Program	14
	d) Formation of Safety Community	8
	e) Social Security Schemes	14
	f) Diversity, Equity and Inclusion	15
	g) Government Campaigns	12
	h) Donations and Sponsoring	11
	i) Sustainable Livelihood Program	13
Internal Socio-Environmental Indicators	a) Human Rights Policy	14
	b) Anti-Corruption Policy	7
	c) Anti-Bribery Policy	9
	d) Business Ethics Policy Values	14

Interpretation: It is found that out of 12 environmental indicators, majority are being disclosed by all the sample companies. Except “Environmental Laws”, “Support Greener Infrastructure”, “Usage of Recycled Material”, “ Company's Impact on Earth Ecosystem” and “Awards received for Conservation” all other items are disclosed by all the sample companies. “Environmental Laws”, “Support Greener Infrastructure”, “Usage of Recycled Material”, “ Company's Impact on Earth Ecosystem” and “Awards received for Conservation” are disclosed by 11, 10, 12, 13 and 13 companies respectively. Thus, minimum disclosure is for “Support Greener Infrastructure”, “Usage of Recycled Material”.

For social development disclosures, it is found that minimum disclosure is for “Formation of Safety Community” (8

companies). “Government Campaigns” and “Donations and Sponsoring” are being disclosed by 12 and 11 companies. “Social Security Schemes” and “ Training and Education Program” are disclosed by 14 companies. Remaining social development indicators are disclosed by 100% companies. For Internal Socio-Environmental Indicators, it is found that “Human Rights” and “Business Ethics Policy Values” are disclosed by 14 and 14 companies respectively whereas “Anti-corruption Policy” and “Anti-Bribery Policy” is disclosed by only 7 and 9 companies respectively. Thus, this indicator has the least disclosures.

Table 3 presents the descriptive statistics and results of ANOVA for disclosure practices among Indian and Singapore companies.

Table 3: Descriptive Statistics and Results of ANOVA for Disclosure Scores

Descriptive Statistics					
Variables	N	Mean	Std. Dev.	Minimum	Maximum
Environment Score	30	0.925	0.0632	0.83	1
Social Development Score	30	0.889	0.0652	0.67	1
Internal Socio-Environment Score	30	0.45	0.2216	0	1
Total Score	30	0.836	0.0633	0.72	0.96
Results of ANOVA					
	Sum of Squares	df	Mean Square	F	P Value
Between Groups	4.345	3	1.448	94.335	0
Within Groups	1.781		116	0.015	
Total	6.125		119		
Post-Hoc Analysis					
Comparison	Mean Diff.			p Value	
Environmental and Internal Socio-Env	0.475			0	
Environmental and Total Score	0.089			0.038	
Social and Internal Socio-Env	0.438			0	
Total Score and Internal Socio-Env	0.386			0	

Interpretation: Descriptive statistics show that Environmental Disclosure are disclosed by sample companies in abundance as is evident by its minimum value 0.83 which is the highest among other scores. All the three drivers have maximum value of 1 indicating that some of the companies are disclosing all items within them. Minimum value of Total Score is 0.72 whereas maximum is 0.96. This shows that companies are sufficiently disclosing about sustainability drivers. Mean value of

environment score is 0.925 with a standard deviation of 0.0632, indicating that companies are disclosing 92.5% of the items in this score. Mean score for Social Development Indicators is 0.889 which is lesser than Environmental Indicators. Internal Socio-Environmental Indicators have mean score of 0.45 which indicates that companies are not disclosing this driver properly. It has minimum value of 0 and maximum as 1. This shows that there are some companies which are disclosing all of the items

in the scale whereas some companies are not disclosing any of the items. Due to this poor indicator, Total Score has mean value of 0.836.

Second part of Table 2 shows the results of ANOVA for finding out whether the difference in disclosure of all three sustainability drivers is significant, and if yes, then which drivers have this difference. It is found that the calculated value of F is 94.335 with a p value of 0.00. Thus at 5% level of significance null hypothesis (H1) is rejected and it can be concluded that there is significant difference among disclosure of various drivers. For finding out among which drivers these differences exist, Post-

Hoc analysis has been shown in third part of Table 2. It is found that differences between Environmental and Internal Socio-Environmental; Environmental and Total Score; Social and Internal Socio-Environmental; Total Score and Internal Socio-Environmental are significant as is evident from their p values. Thus, disclosure of Internal Socio-Environmental Indicators are significantly different from disclosure of other drivers.

Correlation Matrix

Table 4 presents correlation matrix among variables under study.

Table 02: Analysis of Investment preferences across different age groups

Variables	ENV	SOC	SOC-ENV	Total Score	ROCE	EPS
ENV	1					
SOC	0.31	1				
SOC_ENV	0.338	0.066	1			
Total Score	.783**	.556**	.747**	1		
ROCE	-0.052	-0.011	-0.147	-0.111	1	
EPS	-0.262	0.219	-0.284	-0.203	0.23	1

**shows significance at 1% level of significance.

Interpretation: It is found that all the sustainability drivers vis-à-vis Environmental Indicators, Social Development Indicators and Internal Socio-Environmental Indicators are significantly and positively correlated with Total score because of the obvious reason that total score is sum total of these three scores. Remaining correlation coefficients are insignificant. All the sustainability drivers show negative, low degree and

insignificant correlation with firm performance. For further testing impact of these scores on firm performance, regression model was estimated using following linear equations.

$$\text{Firm Performance}_i = \alpha_1 + \text{Sustainability Drivers}_i \beta_1$$

$$EPS_i = \alpha_1 + ENV_i \beta_1 + SOC_i \beta_2 + SOC_ENV_i \beta_3 + Total_Score_i \beta_4 \quad \text{Equation 1}$$

$$ROCE_i = \alpha_1 + ENV_i \beta_1 + SOC_i \beta_2 + SOC_ENV_i \beta_3 + Total_Score_i \beta_4 \quad \text{Equation 2}$$

Estimation results of above equations have been presented in Table 4.

Variables	EPS				ROCE			
	Coefficients	St. Error	t	Sig.	Coefficients	St. Error	t	Sig.
(Constant)	55.177	150.837	0.366	0.717	19.736	41.736	0.473	0.64
SOC_ENV	-45.433	40.864	-1.112	0.276	-7.985	11.307	-0.706	0.486
ENV	-224.961	150.311	-1.497	0.147	-0.501	41.59	-0.012	0.99
SOC	241.475	137.399	1.757	0.091	-0.15	38.017	-0.004	0.997
F	2.248				0.191			
F (Sig.)	0.106				0.902			
R-Square	0.206				0.022			
Adj R-Square	0.114				-0.091			

Interpretation: Results of estimation of Equation 1 (dependent variable: EPS) shows that the calculated value of F is 2.248 with a p value of 0.106. Thus the regression model is not a good fit in explaining variance in EPS. Further, adjusted R-Square is mere 0.114 which indicates that only 11.4% variance in EPS is explained by all the sustainability drivers included in the model. When individual coefficients are observed, it is found that all sustainability drivers except Social Development Indicators are having negative sign confirming negative correlation with EPS. But all the coefficients are not significant at 5% level of significance as is confirmed from p values. Thus it can be concluded that null hypothesis (H3) is accepted at 5% level of significance confirming that all the sustainability drivers are not having any significant impact on firm performance proxied by EPS.

Estimation results of Equation 2 (dependent variable: ROCE) give similar results. Both the model and coefficients are not significant in explaining ROCE. The calculated value of F is 0.191 with a p value of 0.902. Thus, this model also is not a good fit. Adjusted R-Square is negative i.e. -0.091 which confirms very low value of R-square (0.022). Individual coefficients are also not significant for any of the sustainability drivers. Thus, null hypothesis (H3) is accepted at 5% level of significance and it can be concluded that sustainability drivers are not having any significant impact on ROCE.

Conclusion

The sustainability reporting has paved the way for Indian companies to report environmental, social and governance issues and it will reinforce the growth of Indian Economy and this has become possible through transformation in reporting by aligning the sustainable practices with business strategies. There has been a dearth in quantitative disclosures and mainly limited to narrative ones. While Indian companies have made significant strides in sustainability disclosure, internal governance and ethical indicators remain underreported. The absence of statistically significant financial impacts underlines the need for better integration of sustainability with business performance systems. In contrast, Singapore's systematic approach highlights the importance of regulatory oversight and stakeholder alignment. As both economies move toward ESG integration, the road ahead must focus on transparency, comparability, and performance alignment. Formation of Safety Community, Anti-Bribery Policy and Anti-Corruption policy have been observed as least reported items. Sustainability drivers are not having any significant impact on ROCE and EPS though significant difference in disclosure practices of Indian BSE SENSEX and Singapore SGX SENSEX companies has been found. The study would provide mechanism for sustainability disclosures and recommends framing stringent policies and regulations to ensure uniformity, fairness and accountability.

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A Study of Behavioural Biases in Individual's Investment Decision-Making

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Abstract

Investment decisions are traditionally regarded as rational and objective processes, underpinned by rigorous financial analysis and supported by established models such as the Capital Asset Pricing Model (CAPM), Efficient Market Hypothesis (EMH), and Modern Portfolio Theory (MPT). These frameworks assume that investors act logically and in accordance with available financial data. However, the domain of behavioral finance presents a contrasting perspective, positing that individual investors are frequently influenced by psychological and emotional biases. Such biases can result in sub-optimal investment choices, adversely affecting portfolio performance and the attainment of long-term financial objectives. This study seeks to examine the influence of behavioral biases on individual investment decision-making, with a specific focus on cognitive and emotional tendencies such as overconfidence, herd behavior, and the disposition effect. Primary data has been collected through a structured questionnaire administered to a sample of 100 individual investors within the Jalandhar district.

The research aims to analyze the extent to which these biases impact investors' risk perception, asset allocation, and long-term financial planning. By identifying and evaluating deviations from traditional financial theories, the study endeavors to bridge the gap between theoretical models and actual investor behaviour, thereby underscoring the necessity for behavioural interventions in financial decision-making.

The insights derived from this research will contribute meaningfully to the evolving field of behavioural finance and will offer practical recommendations to help individual investors make more rational, informed, and goal-aligned financial decisions.

Keywords: Behavioural Finance, Traditional finance, Cognitive and Emotional biases, Investor Decision, Risk Perception, Asset Allocation.

Introduction

Traditional finance theories have long dominated the study of investment, emphasizing the rationality and logical consistency of investors. Models such as the Capital Asset Pricing Model (CAPM), Efficient Market Hypothesis (EMH), and Modern Portfolio Theory (MPT) form the cornerstone for classical financial thought. These theories assume that individuals act in their own best financial interest, using available information to make rational and optimized decisions. Fundamental and technical analysis methods have been employed under these frameworks to guide asset selection, risk assessment, and portfolio management. However, real-world observations often challenge these idealistic assumptions. Despite access to financial tools and information, many investors fail to make

rational decisions and exhibit inconsistencies in behaviour that cannot be explained by traditional models. This gap between theory and practice has led to the emergence of behavioural finance, a field that integrates psychology into economic decision-making.

Behavioural finance suggests that investment choices are significantly influenced by cognitive and emotional biases. These include overconfidence bias, where investors overestimate their knowledge or predictive abilities; herd behaviour, where individuals mimic the actions of others; and the disposition effect, where investors irrationally hold on to losing stocks while selling winners too early. These biases affect

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portfolio selection and risk perception, often leading to suboptimal and inconsistent outcomes.

This study seeks to explore the extent to which such behavioural biases impact individual investment decision-making. The specific objectives of this research are:

1. **To study the role of behavioural biases** in shaping an individual's investment decisions.
2. **To analyse the risk perception** of individuals and how it influences their investment decisions.
3. **To examine the impact of behavioural biases** on portfolio selection and Asset allocation, focusing on how these biases lead to suboptimal investment choices.

By comparing traditional financial theories with behavioural insights, the research aims to highlight the divergence between rational expectations and actual investor behaviour, thereby stressing the importance of behavioural interventions in modern portfolio management.

Problem Statement:

Investment decisions are ideally grounded in rational analysis and sound financial principles. However, investors often exhibit cognitive and emotional biases that lead to decisions deviating from rational decisions. These biases, include overconfidence, herd mentality, and herd behaviour, significantly influence individual choices, often resulting in suboptimal portfolio performance and undermining financial stability. While extensive research has been conducted on market efficiency and rational decision-making, the specific impact of behavioural biases on retail investors remains underexplored. This study aims to fill this gap by analysing the presence and impact of these biases on their investment decisions and will focus on identifying the key psychological factors contributing to such biases and examining their implications on portfolio construction, risk appetite, and investment results. This study seeks to provide a comprehensive understanding of how these biases shape retail investors' decision-making processes and affect their overall financial health.

Literature Review

Behavioural biases significantly impact investment decision-making, leading to suboptimal financial outcomes. Abideen, Ahmed, Qiu, and Zhao (2023) examined the role of overconfidence, herding, anchoring, and the disposition effect in the Pakistani equity market. Their findings revealed that psychological factors, rather than rational calculations, often drive investor behaviour, causing market inefficiencies. They emphasized that enhancing financial literacy could mitigate these biases and promote more rational investment choices. Kahneman and Tversky (1979) introduced the concept of systematic biases in decision-making, where individuals rely on heuristics, leading to predictable errors in judgment. This foundational research laid the groundwork for understanding how cognitive biases, such as overconfidence, shape investor behaviour.

Similarly, Barber and Odean (2001) explored overconfidence bias, finding that investors often overestimate their knowledge

and trading abilities, leading to excessive trading. Overconfident investors tend to ignore risks, resulting in higher transaction costs and lower returns. Their study highlights how cognitive distortions can distort market efficiency and increase volatility. Together, these studies underscore the significance of psychological biases in financial decision-making, urging for better awareness and strategies to improve investor outcomes and market stability.

Research Methodology

This study adopts a cause-and-effect research design to explore how behavioural biases affect investment decisions in the Indian equity market. The methodology is based on both theoretical foundations and empirical practices, ensuring a rigorous approach to data collection and analysis. Drawing from previous studies such as that of Abideen, Ahmed, Qiu, and Zhao, this research tailors its methods to suit the Indian context and demographic characteristics. The following methodological steps were undertaken:

1. Research Design

The study follows a cause-and-effect (causal-comparative) research design to understand how specific behavioural biases impact investor decisions.

This approach enables the identification of underlying relationships between psychological traits and financial actions, such as investment timing, risk tolerance, and asset selection.

2. Study Objective

To investigate the influence of behavioural biases—including overconfidence, herd mentality, and the disposition effect—on investor behavior in the Indian equity market.

The goal is to determine how these biases shape risk perception and portfolio construction in a real-world setting.

3. Foundation of the Study

The research draws conceptual guidance from the work of Abideen, Ahmed, Qiu, and Zhao, who conducted a similar behavioural study in Pakistan.

Their findings act as a comparative benchmark to contextualize investor psychology within the framework of an emerging economy.

4. Sampling Technique

The study uses judgmental (purposive) sampling, a non-probability technique suitable for selecting participants with specific characteristics.

This method ensures the inclusion of informed and experienced investors who can provide meaningful responses.

5. Sample Size and Demographics

A total of 100 active investors of Jalandhar district were selected from different age groups, professional backgrounds, and investment experiences.

This diversified sample aims to capture a wide range of behavioural patterns and financial perspectives.

6. Data Collection Method

Data is collected using a structured questionnaire, systematically designed to elicit responses related to behavioural tendencies and investment choices.

The questionnaire includes:

Multiple-choice questions to gather factual and categorical data. Likert scale questions (ranging from Strongly Agree to Strongly Disagree) to measure the intensity of behavioural traits.

7. Data Analysis Technique

The responses are analyzed using descriptive statistical tools (such as mean, standard deviation, frequency, and percentage analysis). This helps to uncover patterns in investor behavior and identify dominant behavioural biases across the sample.

8. Tools Used for Analysis

Data is processed and analyzed using Microsoft Excel, ensuring accuracy in the computation and representation of results.

Data Analysis and Interpretation

The following section focuses on the analysis and interpretation of primary data gathered from respondents, with the objective of understanding patterns, trends, and key observations relevant to the study.

Demographics Profile of Respondents

This section analyzes the demographic profile of investors, using data collected through a questionnaire designed to capture key attributes such as age, gender, marital status, educational background, preferred choice of investment and the primary goal behind investing.

Table 01: Demographics profile of respondents

Variable	Components of Variable	Number of Variables	Percentage count of Variables
Age	More than 18 years	5	4.80%
	19-24 years	71	68.30%
	25-31 years	11	10.60%
	32-40 years	7	6.70%
	More than 40 years	10	9.60%
Gender	Male	47	45.20%
	Female	57	54.80%
	Others	Nil	Nil
Marital Status	Married	82	78.80%
	Unmarried	22	21.20%
Qualification	Higher Secondary	9	8.70%
	Graduation	37	35.60%
	Post-Graduation	53	51%
	PhD.	3	2.90%
	other	2	1.90%
Preferred choice of investment	Fixed and Term Deposits	54	51.90%
	Mutual funds	56	53.80%
	Stocks	43	41.30%
	Real Estate	39	37.50%
	Cryptocurrency	6	5.80%
	Other(s)	11	10.60%
Primary Goal behind investing	Wealth creation	70	67.30%
	Retirement planning	14	13.50%
	Short-term gains	7	6.70%
	Tax-saving	4	3.80%
	Other	9	8.70%

Interpretation:

The demographic profile shows that most respondents (68.3%) are aged between 19–24 years and the majority are female (54.8%). A large portion (78.8%) are married, and over half (51%) hold a postgraduate degree, reflecting a well-educated group. In terms of investment preferences, mutual funds (53.8%) and fixed/term deposits (51.9%) are the most popular choices, followed by stocks and real estate. Cryptocurrency remains the least preferred. The primary goal for investing among respondents is wealth creation (67.3%), with fewer

focusing on retirement planning, tax-saving, or short-term gains. Overall, young, educated individuals are prioritizing long-term financial growth through safer investment options.

Analysis of Investment Preferences across different Age Groups

The below table and chart illustrate the relationship between age and investment preferences, showcasing both absolute number and percentage distributions for better comparative analysis:

Table 02: Analysis of Investment preferences across different age groups

Age Group (in Years)	Fixed and Term Deposit	Mutual Funds	Stocks	Real Estate	Crypto Currency	Others
more than 18	2	3	1	2	0	2
19-24	30	34	29	23	3	7
25-31	6	7	5	7	0	0
32-40	6	7	6	5	3	2
more than 40	10	5	2	2	0	0
Total	54	56	43	39	6	11

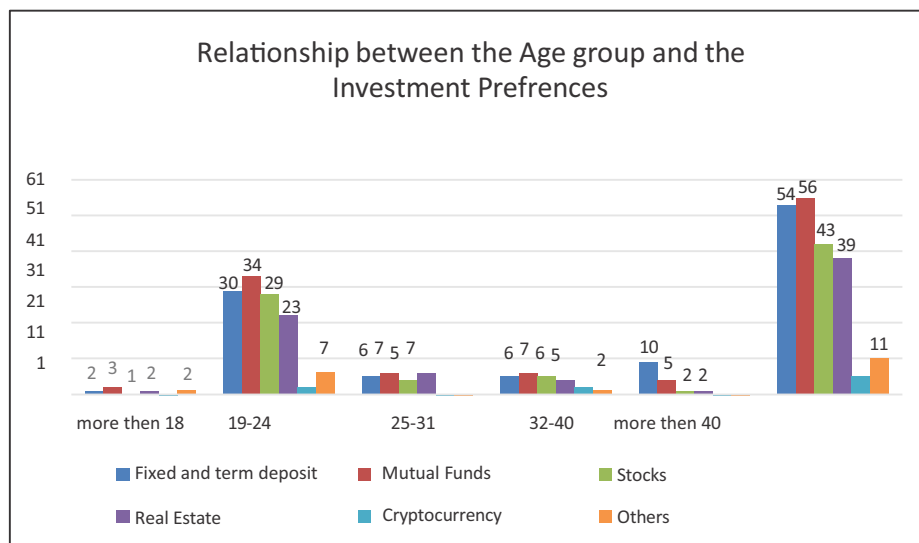


Fig 01: Relationship between the Age group and the investment preferences

Interpretation:

The chart and graph above showcase how different age groups tend to prefer different types of investments—one graph shows the actual numbers, while the other compares the percentages. Both clearly highlight that age plays a key role in shaping investment choices. As people grow older, their responsibilities often increase—be it managing a household, raising children, or planning for the future. Because of these growing obligations, many individuals in the 25–31 and 32–40 age groups lean towards safer investment options like fixed and term deposits, as these provide more security and stability.

On the other hand, younger investors—especially those aged 18 and 19–24—are more drawn to options like mutual funds and stock markets. This is likely because they tend to have a higher risk appetite and are usually still studying or early in their careers, which means they have less income but also fewer financial commitments. Their focus is often on exploring opportunities with potential for growth, even if it involves taking a bit more risk.

Behavioural biases individual investment analysis

This section includes the information regarding the investment analysis and study for the different relationship establishment

for the return earned and satisfaction level among people regarding the earning on their investment.

Table 03: Relation between Rate of return and satisfaction level from rate of return

Likert- Scale representation	percentage distribution of return earned	Satisfaction among people
Strongly -Disagree	3.80%	4.80%
Disagree	9.60%	10.60%
Neutral	51%	55.80%
Strongly -Agree	4.80%	8.70%
Agree	30.80%	20.20%
Total	100.00%	100.10%

Interpretation:

The Likert scale data pertaining to the percentage distribution of returns earned and satisfaction among people reveals insightful patterns regarding public opinion. A significant proportion of respondents indicated a neutral stance, with 51% expressing neutrality towards the returns earned and 55.8% towards their level of satisfaction. This suggests that most individuals neither agreed nor disagreed, potentially indicating a lack of strong opinion, limited knowledge, or mixed experiences with the subject in question.

In terms of positive perception, a combined 35.6% of respondents either agreed or strongly agreed that the returns earned were satisfactory. Comparatively, 28.9% of respondents expressed agreement or strong agreement regarding their overall satisfaction. This disparity highlights that while the financial returns were relatively well-received, general satisfaction lagged slightly behind, possibly due to factors beyond monetary gain, such as service quality, process transparency, or personal expectations.

Conversely, negative responses were relatively limited. Only 13.4% of respondents expressed dissatisfaction with the

returns, while 15.4% reported dissatisfaction in terms of overall satisfaction. This indicates that discontentment was not a predominant sentiment, though it cannot be entirely disregarded. Furthermore, the total for satisfaction marginally exceeded 100%, likely due to rounding adjustments common in percentage-based survey data.

In summary, the data reflects a largely neutral to positive sentiment among respondents. While returns appear to meet expectations for a fair number of participants, there exists a slight gap in overall satisfaction, pointing toward opportunities for qualitative improvements in experience or communication to enhance public perception.

Representation of Behavioural Biases

This section states about how the different biases including Herding behaviour, Disposition effect and the overconfidence will lead to impact the risk appetite and the sub-optimal portfolio choices.

1. Herd behaviour refers to a situation in which investors follow the actions or decisions of a larger group, often ignoring their own analysis or available information.

Table 04: Impact of other investor's portfolio across different age groups

Age group (in years)	Strongly Agree	Agree	Neutral	Strongly Disagree	Disagree
More than 18	0	1	4	0	0
19-24	5	27	31	4	5
25-31	0	5	5	0	1
32-40	0	2	2	2	1
More than 40	0	4	2	1	3
Total	5	39	43	7	10

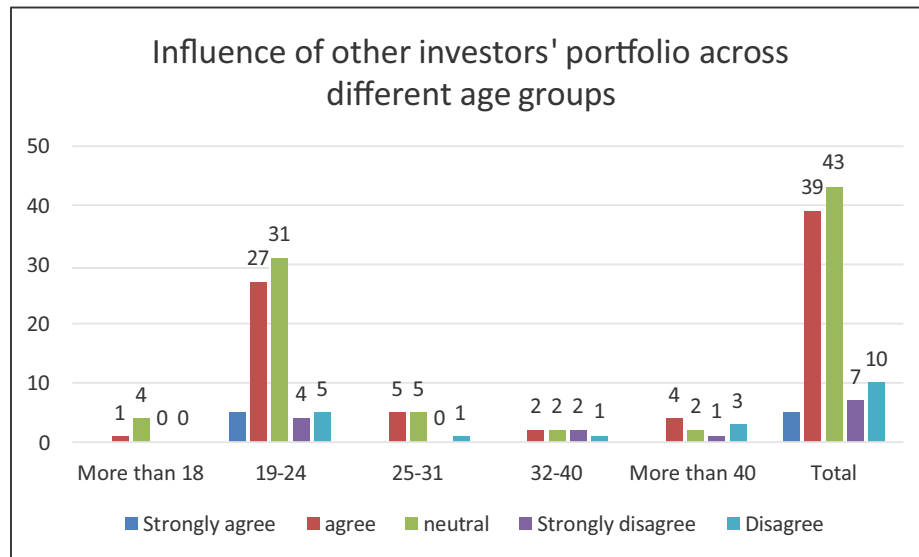


Fig 02: Influence of other investors portfolio across different age group

Interpretation:

The data presented in Table 04 highlights the perceived impact of other investors' portfolios on individuals across different age groups. A significant portion of respondents across all age brackets selected the "Neutral" option (43 respondents), suggesting that many individuals either do not have a firm stance or are unaware of the influence others may have on their investment decisions. This is particularly evident among those aged more than 18, where 4 out of 5 respondents remained neutral. In the 19–24 age group, which comprises most respondents (72), a large number agreed (27) or remained neutral (31), indicating that younger investors are moderately influenced by peer investment behaviour, or they are still in the process of developing their own strategies.

The 25–31 age group showed a balance between agreeing and staying neutral, reflecting a gradual shift towards independent decision-making. In contrast, the 32–40 age group displayed

varied responses, with individuals expressing agreement, neutrality, and disagreement almost equally. This diversity may be attributed to their greater experience in financial matters and exposure to multiple investment environments. Among those aged more than 40, the opinions were mixed, with some agreeing to being influenced while others disagreed, showing that personal judgment and experience may play a stronger role in this demographic.

Overall, while peer influence does play a role—especially among younger investors—the high number of neutral responses indicates a potential lack of awareness or decisive opinion on the matter. This could suggest the need for more financial education or awareness among investors to help them recognize the factors influencing their investment choices.

- The study between impact of other investors decision of selecting a portfolio and their buying and selling decision...

Table 05: The correlation between impact of other investors decision of selecting a portfolio and their buying and selling decision

Likert- Scale representation	Impact of other investors' of selecting a portfolio (%)	Impact of Buying and Selling decision of other investors (%)
Strongly -Disagree	6.70%	8.70%
Disagree	9.60%	14.40%
Neutral	41%	33.70%
Strongly -Agree	4.80%	9.60%
Agree	37.50%	33.70%
Total	99.90%	100.10%
	Correlation Value	0.991889069

Interpretation:

The table presents a Likert-scale-based comparative analysis of how investors perceive the influence of others on two aspects of their investment behaviour: (1) the selection of a portfolio and (2) their buying and selling decisions. Additionally, it provides a correlation value that quantifies the relationship between these two behavioural influences.

The data reveals that a considerable percentage of investors agree (37.5%) or remain neutral (41%) about being influenced by others while selecting their investment portfolio. Similarly, when it comes to buying and selling decisions, a nearly equal percentage of investors either agree (33.7%) or remain neutral (33.7%), indicating a close alignment between both types of investment decisions.

Interestingly, a smaller segment strongly agrees with being influenced by others in portfolio selection (4.8%) and in buying/selling (9.6%). The relatively higher value in buying/selling suggests that market sentiment and peer actions have a stronger psychological impact on short-term decisions

like buying and selling, compared to the longer-term process of portfolio building.

On the other hand, the percentage of respondents who disagree or strongly disagree is also higher for buying and selling decisions (14.4% and 8.7%) than for portfolio selection (9.6% and 6.7%), showing that a slightly larger group of investors believe they make independent transactional decisions.

The correlation coefficient of 0.9919 indicates a very strong positive relationship between the influence of others on portfolio selection and their buying/selling decisions. This suggests that individuals who are influenced by others while choosing their portfolio are highly likely to also be influenced in their trading decisions, and vice versa.

2. Disposition effect is the tendency of investors to sell winning investments too early and hold on to losing one is too long. This calls for 2 major conditions:

- *Explaining the study of selling stock early with small profit...*

Table 06: Correlation between the Investment behaviour of people and the profit objectives

Likert- Scale representation	Selling stocks with small profit (%)	Do your primary goal is never a huge profit (%)
Strongly -Disagree	6.70%	6.70%
Disagree	22.10%	21.20%
Neutral	42%	38.50%
Strongly -Agree	14.40%	16.30%
Agree	14.40%	17.30%
Total	99.90%	100.00%
	Correlation Value	0.990828929

Interpretation:

The data reveals a consistent and cautious investment behavior among respondents. A significant portion maintains a neutral stance on both selling stocks with small profits (42%) and not aiming for huge profits (38.5%), suggesting a balanced or conservative approach. Moreover, around 28.8% of the respondents agree or strongly agree with both statements, indicating a preference for booking small gains rather than holding out for larger, riskier returns. This trend aligns with the Disposition Effect, a behavioral bias where investors tend to sell winning stocks too early to lock in profits, while holding onto

losing stocks in the hope of a turnaround. The high correlation value of 0.9908 reinforces the strong positive relationship between the two attitudes — those who prefer small, quick profits also tend to avoid chasing large gains. This behavior may also be influenced by loss aversion and regret aversion, as individuals aim to minimize the emotional impact of potential losses and avoid future regret. Overall, the data highlights a risk-averse mindset among investors, shaped by psychological biases that affect rational financial decision-making.

- *Tendency to sell stock early at a small percentage of loss...*

Table 07: Age-wise comparison of investors tendency to sell stock early at a small percentage of loss

Age Group (in years)	Strongly disagreed (%)	Disagreed (%)	Neutral (%)	Strongly agreed (%)	Agreed (%)
More than 18 years	0	20	40	0	40
19-24	8.45	22.54	38	15.49	15.49
25-31	9.09	27.27	27.3	9.09	27.3
32-40	14.29	28.6	14.3	14.29	28.6
more than 40 years	10	20	40	10	20
Total	41.83	118.41	159.6	48.87	131.39

Interpretation:

The age-wise distribution of responses reveals noticeable generational trends in attitudes toward the given investment statement. The 19–24 age group, which forms the largest respondent base, shows a dominant neutral stance (38%), along with a moderate level of disagreement and agreement, indicating that young investors are still forming their financial perspectives, often showing hesitation in taking strong positions. The 25–31 group reflects a more even distribution, with a tilt toward disagreement (27.27%) but also notable agreement and neutrality, suggesting a transitioning mindset—possibly balancing risk-taking with practical experience. As we move to the 32–40 age group, responses become more polarized, with 42.89% either agreeing or strongly agreeing, and an equal percentage expressing disagreement, implying that individuals in this range have more firm and confident financial attitudes, shaped by life responsibilities and experience. The 40+ age group displays a strong neutral

preference (40%) alongside balanced agreement and disagreement levels (30% each), suggesting that older investors often rely on experience yet remain cautious, likely due to risk-averse tendencies. Interestingly, the small group of respondents aged just above 18 also leans toward agreement and neutrality, reflecting emerging investor behaviour still under external influence or learning. Overall, most responses across age groups remain neutral (totalling 159.6%), and while agreement (131.39%) slightly surpasses disagreement (118.41%), strongly polarized views are relatively low, suggesting a general preference for moderation, caution, or indecision among investors. This cautious sentiment may relate to behavioural finance concepts such as risk aversion and status quo bias, particularly among younger and older investors.

- *Relationship between market downturn Holding and long-term Investment Preferences...*

Table 08: Correlation between willingness to hold investments during market downturns and reluctance towards long-term investment

Likert-scale Representation	Do not hold for long-term (%)	Hold during downturns (%)
Strongly-disagree	5.80%	3.80%
Disagree	15.40%	5.80%
Neutral	45.20%	38.50%
Agree	21.20%	24%
Strongly-agree	12.50%	27.90%
	Correlation value	0.78567572

Interpretation:

The Likert-scale data reveals key insights into investor behavior regarding long-term holding and market downturn responses. A substantial portion of respondents maintain a neutral stance on both statements — 45.2% for not holding long-term and 38.5% for holding during downturns. This suggests a widespread

presence of indecision or situational dependency, where many investors neither firmly commit to long-term strategies nor clearly define their approach during volatile market phases. Interestingly, the data also shows a growing positive sentiment toward holding during downturns, with 51.9% (agree + strongly agree) expressing resilience compared to only 33.7% (agree +

strongly agree) who admit they do not hold long-term. This gap may indicate that while some investors might hesitate to invest for extended periods in general, they still display patience during temporary market declines, which can be interpreted as context-specific commitment rather than consistent long-term strategy. The correlation value of 0.7857 reflects a strong positive relationship between the two attitudes, meaning individuals who tend to avoid long-term investing are less likely to hold during downturns, and vice versa. This behavior points to underlying behavioral biases such as herd behavior (quick reactions to market changes), loss aversion, and lack of long-term planning. In contrast, those who strongly agree with holding during downturns (27.9%) may exhibit higher risk

tolerance and strategic patience, aligning more with rational investment practices. Overall, the data suggests that while a large share of investors remains non-committal, a growing proportion is beginning to show signs of mature, disciplined investing during market stress, albeit not necessarily aligned with long-term holding philosophies.

3. Overconfidence is a behavioral bias where investors rely solely on their own strategies and judgments, often ignoring external opinions, research, or the strategies of other investors.

- *Priority to the own knowledge of the investors (Respondents)...*

Table 09: Correlation between perceived investment knowledge and decision-making confidence

Likert-Scale representation	Respondent's response when compared to other decisions (%)	Priority given to their own decisions by themselves (%)
Strongly-Disagree	7.70%	3.80%
Disagree	25%	15.40%
Neutral	43.30%	41.30%
Strongly-Agree	9.60%	9.60%
Agree	14.40%	29.80%
	Correlation Value	0.807247648

Interpretation:

The above Likert-scale table highlights investor responses related to overconfidence bias by comparing how they perceive their investment decisions against others and the priority they give to their own decisions. A significant portion of respondents, 43.3% and 41.3% respectively, selected the neutral option for both variables, indicating a balanced or undecided stance regarding confidence in their own strategies. However, a closer look reveals notable behavioral patterns. While only 14.4% of respondents agreed that their decisions were better than others, a much higher 29.8% agreed that they prioritize their own decisions. This gap suggests that many investors, despite not openly claiming superiority, still act on their personal judgments, showcasing implicit overconfidence. Furthermore, the number of respondents who strongly agree on both aspects

is equal (9.6%), pointing toward a consistent group of highly overconfident investors. Most importantly, the calculated correlation value of 0.807 indicates a strong positive relationship between the two variables. This means that as the belief in one's superior decision-making increases, so does the tendency to prioritize one's own choices. This strong correlation confirms the presence of overconfidence bias among the respondents, where individuals tend to overestimate their knowledge or decision-making abilities while disregarding alternative perspectives. Such behavior can lead to risky financial decisions, reduced diversification, and overtrading, which are common pitfalls in individual investment behavior.

- *Study of responses towards other's Knowledge...*

Table 10: Investors response to search for others strategy

Likert-scale	Percentage Distribution	Absolute count
Yes	45.20%	46
No	18.30%	19
May be	36.50%	37
Total	100.00%	104

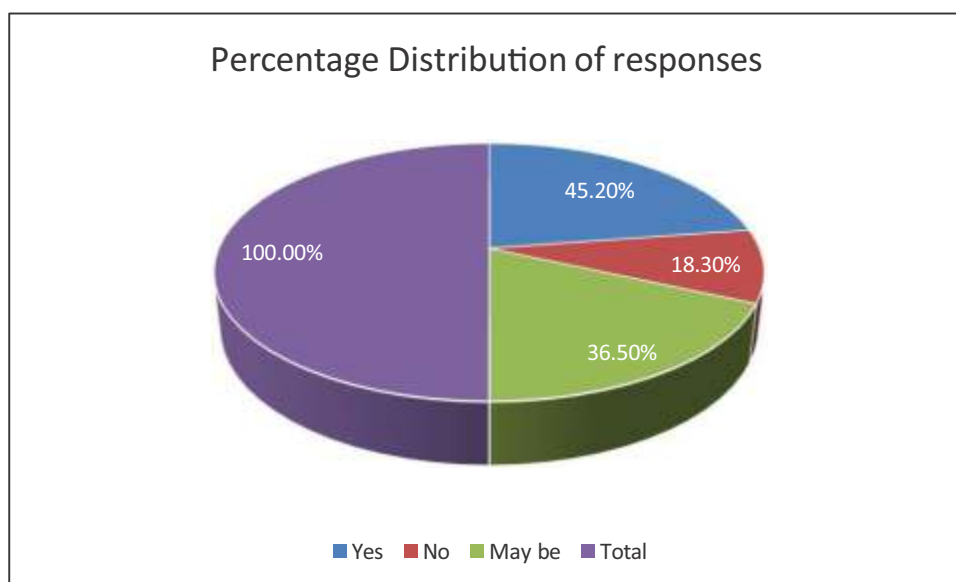


Fig 03: Investors response to search for others strategy

Interpretation:

Table 10 and figure 03 presents investors' responses regarding their inclination to explore the investment strategies of others, which directly relates to their openness to external inputs and the presence or absence of overconfidence bias. Out of 104 respondents, 45.2% (46 individuals) affirmed that they do actively search for others' strategies, indicating a healthy openness to diverse perspectives, analysis, and learning from the investment behaviour of peers. This group may exhibit a more balanced or rational decision-making style, grounded in research and comparison. However, 36.5% of respondents (37 individuals) selected the "Maybe" option, suggesting indecisiveness or occasional behaviour in this regard. This segment possibly reflects situational openness, where investors consider others' views only under specific circumstances or in uncertain market conditions. Notably, 18.3% (19 respondents) clearly indicated that they do not seek or consider others' strategies, a behaviour closely associated with overconfidence bias, where individuals place complete trust in their own

knowledge or intuition. While most of the respondents show at least some willingness to learn from others, the presence of a considerable percentage who never consider external strategies highlights a segment of investors who may be prone to insular decision-making. Overall, this table reflects a mixed behavioural trend among investors—ranging from open and collaborative to self-reliant and potentially overconfident

Study of Risk perception of Individual Investors

The study of risk perception among individual investors reveals that investment behaviour is deeply influenced by personal attitudes toward risk. Factors such as age, income, market knowledge, and past experiences shape how investors perceive and respond to financial uncertainty. While some are highly risk-averse, others display moderate to high risk tolerance. Emotional biases and psychological influences often override rational analysis. Understanding these perceptions is crucial for promoting informed decision-making and enhancing financial literacy among individual investors.

Table 11: Describing the Risk Appetite of the investors

Risk Appetite	Percentage distribution of respondent's response for risk appetite (%)	Absolute count of respondents towards risk appetite (%)
Low	10.60%	11
Moderate	69.20%	71
Moderately high	16.30%	17
High	3.80%	4
Total		104

Interpretation:

The table on risk appetite presents insights into the investment behavior and risk tolerance levels of the 104 respondents. A dominant majority of 69.2% (71 respondents) fall under the moderate risk appetite category, indicating that most investors prefer a balanced approach— seeking reasonable returns while being cautious about the risks involved. This reflects a typical investor profile where safety and steady growth are preferred over aggressive gains. Additionally, 16.3% (17 respondents) identified as having a moderately high-risk appetite, suggesting a small yet significant segment is open to taking calculated risks for potentially higher returns, possibly driven by market knowledge or long-term investment goals. On the other hand, only 3.8% (4 respondents) exhibit a high-risk appetite, representing aggressive investors who are willing to embrace

higher volatility, possibly for short-term gains or based on strong confidence in market predictions. Interestingly, 10.6% (11 respondents) reported a low-risk appetite, implying a conservative approach focused on capital protection rather than wealth accumulation. These individuals may prefer fixed-income instruments, government securities, or low-volatility stocks. Overall, the data shows that while most respondents are moderately risk-tolerant, there exists a varied risk appetite across the sample, reflecting a diverse investor mindset ranging from cautious to ambitious. This distribution is crucial for understanding investment preferences and designing tailored financial advisory strategies.

- *Investors response to a downturn in the market...*

Table 12: Investors response to a downturn in the market

Reactions Given in Questionnaire	Percentage distribution of responses downturn (%)	Absolute count of the respondent's downturn (%)
Stop further investment in such securities	17.30%	18
Adjusted the investment strategy	69.20%	71
Yet not faced any such loss	13.50%	14
Total		104

Interpretation:

The table outlines the behavioural responses of 104 investors when faced with a downturn or loss in their investment portfolio, offering valuable insight into emotional and strategic reactions during market stress. A significant 69.2% (71 respondents) reported that they adjusted their investment strategy in response to downturns. This indicates a proactive and adaptive approach among the majority, suggesting that these investors are willing to learn from past losses, reassess their risk profiles, and make informed decisions to improve future outcomes. Such behaviour reflects a rational and resilient mindset, essential for long-term success in volatile markets. In contrast, 17.3% (18 respondents) admitted that they stopped further investment in such securities after facing a loss. This reaction points toward loss aversion bias—a common

behavioural trait where investors overreact to losses by completely avoiding the asset, potentially missing future recovery, or growth opportunities. Meanwhile, 13.5% (14 respondents) stated they have not yet faced any such loss, which may either indicate new or cautious investors with limited market exposure, or those invested in low-risk instruments. Overall, the data suggests that while most investors demonstrate strategic flexibility and learning behaviour, a notable segment exhibits risk-averse tendencies. These findings underline the importance of investor education and guidance to manage emotional reactions and adopt long-term strategies amidst market fluctuations.

- *Comparative study of risk appetite across different age group...*

Table 13: Comparative study of risk appetite across different age group

Age group (In years)	Low	Moderate	Moderately high	High
More than 18 years	0	4	0	1
19-24	4	48	14	2
25-31	1	6	0	2
32-40	1	3	3	0
More than 40 years	3	7	0	0
Total	9	68	17	5

Interpretation:

The table presents an age-wise breakdown of investors' risk appetite across four categories: Low, Moderate, Moderately High, and High. It reveals that the age group of 19–24 years constitutes most respondents with a moderate risk appetite (48), along with 14 showing a moderately high and 2 with high-risk appetite. This indicates that young investors, particularly in their early adulthood, are generally open to taking calculated risks and are actively participating in investment decisions, possibly influenced by their longer investment horizon and growing interest in financial literacy. The 25–31 years group shows a mixed profile, with 6 in the moderate and 2 in the high-risk category, reflecting a gradual shift towards bolder investment behavior as they gain more financial independence and earning capacity. The 32–40 years age group displays more diversity, with 3 respondents having a moderately high appetite, but a few remaining in the low to moderate range, showing that risk tolerance in this age may vary depending on personal responsibilities and financial goals. Interestingly, in the above 40

years age group, the majority still fall under low to moderate risk categories, suggesting a more conservative approach as investors approach retirement or prioritize capital preservation. The youngest group (more than 18 years), although small, includes 4 with moderate risk appetite and 1 in the high category, indicating early but cautious engagement with investment. Overall, the interpretation confirms that risk appetite tends to be higher in younger age groups, particularly those in the 19–31 age range, and generally declines with age, aligning with the life-cycle theory of investment behavior.

Impact of behavioural biases on Portfolio selection

Behavioural biases significantly impact portfolio selection by influencing how investors perceive risk, evaluate information, and make decisions. Biases such as overconfidence, Disposition effect, and herd mentality can lead to irrational investment choices, misallocation of assets, and suboptimal returns, highlighting the need for awareness and education in behavioural finance.

Table 14: Value of the firm impact the investment decision

Likert -Scale	Percentage Distribution of impact of investment decision (%)	Absolute count of impact of investment decision
Strongly-Disagree	7.70%	8
Disagree	5.80%	6
Neutral	44.20%	45
Strongly -Agree	4.80%	5
Agree	37.50%	38
Total	100.00%	104

Interpretation:

The analysis of the Likert-scale responses regarding the impact of investment decision- making reveals a varied perception among the respondents. Out of 104 participants, the majority (44.20%) remained neutral, indicating a sense of uncertainty or lack of strong opinion about whether external or psychological factors influence their investment choices. A significant portion of respondents, comprising 42.30% (Agree – 37.50% and Strongly Agree – 4.80%), acknowledged that such factors do have an impact on their decisions. This highlights an awareness among a considerable segment of investors about the possible

influence of behavioral aspects on investment behavior. On the other hand, a smaller percentage (13.50%) disagreed or strongly disagreed, suggesting that they believe their investment decisions are unaffected by external or emotional influences. Overall, the findings suggest a need for enhanced financial literacy and awareness programs to help investors better understand the psychological components that may affect their financial choices.

- *Need of Fundamental and Technical analysis and its impact on portfolio...*

Table 15: Correlation between the Need of analysis and Impact on portfolio decision

Likert – Scale Representation	Need of Analysis for Fundamental and Technical analysis (%)	Impact on financial year-end on Portfolio Decision (%)
Yes	71.20%	51.50%
No	10.60%	20.40%
May be	18.30%	27.20%
	Correlation Value	0.995723904

Interpretation:

The Likert-scale data presents insights into respondents' perspectives on the need for fundamental and technical analysis and the impact of the financial year-end on portfolio decisions. A substantial 71.20% of respondents agreed that there is a clear need for conducting both fundamental and technical analysis before making investment decisions, indicating a strong awareness of analytical tools in portfolio management. In comparison, 51.50% of respondents recognized that the financial year-end has an impact on their portfolio decisions, suggesting that periodic financial assessments and reporting timelines do influence investor behavior. Meanwhile, 18.30% and 27.20% of respondents respectively selected "Maybe" for

both variables, reflecting a segment that is uncertain or situational in their investment approach. A small percentage disagreed with the necessity of analysis (10.60%) and the impact of financial year-end decisions (20.40%). Notably, the correlation value of 0.9957 signifies a very strong positive relationship between the perceived need for analysis and the influence of financial year-end on decision-making. This suggests that investors who recognize the importance of fundamental and technical analysis are highly likely to also consider year-end financial factors when making portfolio decisions.

• *Factors Influencing the investment decision the most...*

Table 16: Factors Influencing the investors decision the most

Influencing Factors impacting the portfolio	Percentage distribution by the investors (%)	Absolute count
Past performance of the asset	54.80%	57
Economic news and trends of market	73.10%	76
Relatives and friends' advice	23.10%	24
Expert recommendations and advice	35.60%	37
Social media channel	11.50%	12
Total	198.10%	206

What factors fluence your investment decision the most

104 responses

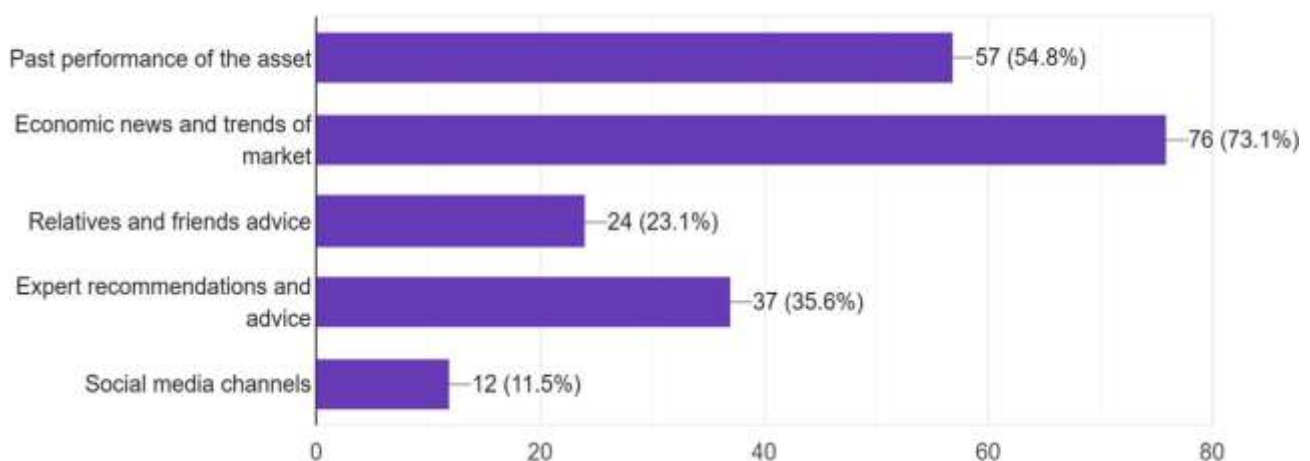


Fig 04: Factors Influencing the investors decision the most

• *Investment decision driven by emotions rather than financial analysis...*

Table 17: Investment Decisions driven by emotions

Likert-scale representation	Percentage Distribution about are investment decisions driven by emotions (%)	Absolute count of emotions
Strongly-disagree	11.50%	12
Disagree	24%	25
Neutral	41.30%	42
Strongly-agree	11.50%	12
Agree	11.50%	12

Interpretation:

The analysis of the Likert-scale data on whether investment decisions are driven by emotions provides valuable insight into the behavioural tendencies of investors. Among the 102 respondents, the highest proportion (41.30%) selected the neutral option, indicating a significant degree of indecision or lack of clarity regarding the role emotions play in their financial decision-making. This neutrality could stem from limited self-awareness, lack of exposure to behavioural finance concepts, or reluctance to admit emotional influence in what is ideally perceived as a rational process. Interestingly, 35.50% of the participants (comprising 24% who disagreed and 11.50% who strongly disagreed) believe their investment decisions are not influenced by emotions, suggesting a perception of objectivity and control. However, such responses could be indicative of overconfidence bias, where individuals assume they are making purely logical decisions while unconsciously being influenced by

factors such as fear, greed, or market sentiment. On the other hand, 23% of respondents (with 11.50% agreeing and 11.50% strongly agreeing) openly acknowledged that emotions do influence their investment decisions. This segment reflects a more self-aware group of investors who recognize that emotions like excitement during a bull market or panic during a downturn can significantly affect their portfolio choices. The overall findings suggest that while a notable portion of investors deny or are unsure about emotional influence, nearly one-fourth admit to it. This reinforces the relevance of behavioural finance education, which can help investors identify emotional triggers and develop strategies to mitigate impulsive decision-making. Bridging the gap between perceived and actual behaviour is essential for promoting more informed and rational investment practices.

- *Influence of high dividend yields on investment decisions...*

Table 18: Influence of high dividend yields on investment decisions

Likert-Scale Representation	Percentage Distribution of high yield dividends	Absolute count of the Respondents
Strongly-Disagree	3.80%	4
Disagree	12.50%	13
Neutral	40.40%	41
Strongly-Agree	16.30%	17
Agree	26.90%	27
Total	99.90%	104

Interpretation:

A significant portion of respondents, accounting for 40.40% (41 individuals), maintained a neutral stance on the topic of high-yield dividends. This neutrality may stem from a lack of sufficient knowledge or a cautious approach toward investment-related matters. On the other hand, a considerable segment expressed a positive outlook, with 26.90% agreeing and 16.30% strongly agreeing—collectively representing 43.2% of the sample. This suggests that nearly half of the respondents view high-yield dividends favorably, possibly recognizing them as attractive or

beneficial investment options. In contrast, a smaller group displayed a negative perspective, with 12.50% disagreeing and 3.80% strongly disagreeing, totaling 16.3%. These respondents may harbor concerns about the risks or long-term sustainability of high-yield dividends. Overall, while a plurality of respondents has yet to form a definitive opinion, the data reflects a generally optimistic sentiment among those who have taken a clear stance, indicating a favorable perception of high-yield dividends.

- *Rate the portfolio based on the return received...*

How much you rate your portfolio choice, based on return received?

104 responses

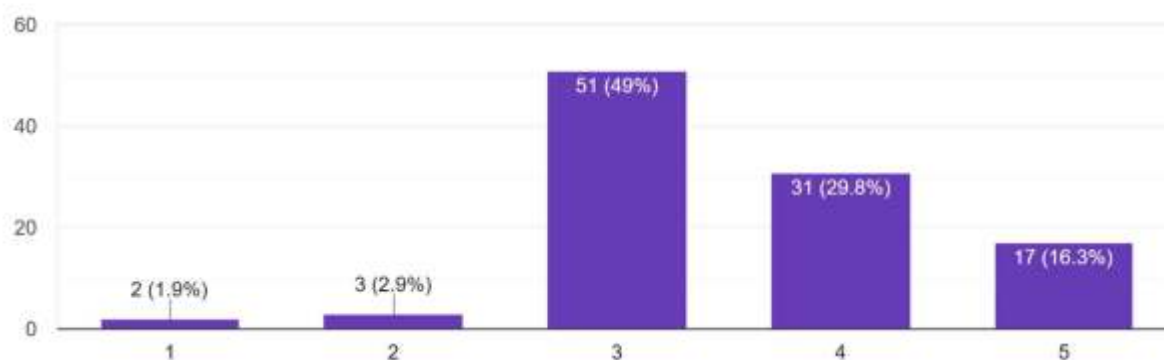


Fig 05: Rate the portfolio based on the return received

Interpretation:

The bar chart provides insights into how 104 respondents rated their portfolio choices based on the returns they received. A considerable portion, 49% (51 respondents), gave a neutral rating of 3, suggesting that nearly half of the participants view their investment returns as moderate—neither overly satisfactory nor disappointing. This neutrality could reflect cautious optimism, limited investment knowledge, or expectations that were met without exceeding them. On the other hand, a significant percentage of respondents showed a positive outlook: 29.8% (31 respondents) rated their returns as 4, and 16.3% (17 respondents) gave the highest rating of 5, indicating strong satisfaction. This combined 46.1% of favourable ratings demonstrates that many investors are confident and content with the outcomes of their portfolio

decisions. In contrast, only a small minority—1.9% (2 respondents) rated it as 1, and 2.9% (3 respondents) as 2—expressed dissatisfaction. These findings suggest that investor sentiment is largely neutral to positive, with very limited dissatisfaction. When related to the broader context of the research paper, which examines perceptions surrounding high-yield dividends, this chart reinforces the conclusion that investors generally perceive their investments, possibly including dividend-based strategies, as stable or rewarding. This overall optimism highlights a tendency toward trust and satisfaction in portfolio decision-making, particularly when the returns align with or exceed expectations.

• *Behavioural biases significantly impact your decision...*

Table 19: Impact of behavioural biases on portfolio

Impact of behavioural biases on portfolio	Percentage distribution	Absolute count
Yes	50%	51
No	26.90%	28
Maybe	23.10%	24
Total	100%	104

Interpretation:

Out of a total of 104 respondents surveyed to assess the impact of behavioural biases on portfolio decisions, a significant proportion—50% (51 respondents)—affirmed that such biases do indeed influence their investment behaviour. This reflects a considerable level of awareness among investors regarding the psychological and emotional factors that can unconsciously drive financial decision-making. Recognizing the presence of behavioural biases such as overconfidence, loss aversion, herd

mentality, and anchoring suggests that these investors are either directly experiencing their effects or have a conceptual understanding of behavioural finance principles. Conversely, 26.90% (28 respondents) expressed the belief that behavioural biases do not impact their portfolio decisions. This segment may either perceive themselves as rational and analytical decision-makers or may lack sufficient exposure to the concept of behavioural finance. It is possible that these investors underestimate the subtle and often unconscious influence of

emotions and cognitive distortions on financial choices. Additionally, 23.10% (24 respondents) indicated uncertainty by selecting "Maybe," reflecting ambiguity in their understanding or awareness of behavioural biases. This group may be in a transitional stage of financial learning, where they are either not fully informed about how such biases manifest in real-world investing or are unable to directly associate their past investment decisions with specific behavioural patterns. Overall, the data highlights a meaningful insight into investor psychology: while half of the respondents are aware of behavioural influences on investment decisions, a combined 50% (those who responded "No" or "Maybe") still reflect either denial or ambiguity. This emphasizes the growing need for comprehensive investor education programs focusing on behavioural finance. Enhancing awareness of these biases can lead to more informed, rational, and goal-oriented investment strategies, ultimately improving portfolio performance and financial well-being.

Findings of the Study

The study has given the following findings:

1. To Study the Role of Behavioural Biases in Individual Investment Decisions

The findings reveal that the age group of 19–24 years is most significantly affected by behavioural biases, particularly herd mentality, which can be attributed to their limited market knowledge, early-stage financial awareness, and lack of real-time investment experience. This group often relies on peer influence, online trends, and social media platforms to guide financial decisions. Their preferences primarily include mutual funds and fixed deposits, indicating a bias towards capital preservation and safety, though some also show interest in real estate and stocks for long-term wealth building. Despite their cautious approach, overconfidence bias was observed as many respondents believed strongly in their own market judgment, often engaging in frequent trading without expert advice. This self-reliant behaviour increased their exposure to risks, particularly during IPOs or market rallies, where investment decisions were influenced more by peers than by personal analysis. The disposition effect was also noted, where investors sold profitable assets too early to realize gains but held onto poorly performing ones in hope of recovery, which adversely affected long-term returns. Other age groups showed varying patterns: respondents below 18 were mostly influenced by trends, parental guidance, and peers, highlighting strong herd behaviour and limited independent analysis. The 25–31 age group showed moderate emotional biases but demonstrated increasing caution and learning from past investment experiences, gradually shifting toward more informed decisions. Participants aged 32–40 and above 40 exhibited the highest levels of investment discipline and emotional control,

likely due to accumulated financial experience and career stability. These investors preferred strategic, long-term plans and were less influenced by market noise or short-term fluctuations.

2. Findings on Risk Perception in Individual Investment Decisions

The study reveals that individuals perceive risk in diverse ways, and their investment decisions are deeply shaped by how they understand and react to financial risks. Younger investors, especially those in the 19–24 age group, often associate risk with fear of loss rather than potential for gain. Due to limited experience and knowledge, they tend to prefer safer investment options like fixed deposits and mutual funds, reflecting a strong desire for capital protection over wealth creation. Their decisions are highly influenced by emotions, peer opinions, and online trends, making them more reactive to short-term market movements. In contrast, individuals in the 25–31 age group begin to develop a more balanced perception of risk. They start understanding that risk is an inherent part of investing and gradually move from impulsive decisions to more thoughtful ones. They still exhibit emotional biases but are more open to moderate risk-taking in pursuit of better returns, often backed by a growing awareness of financial tools and market behaviour. Respondents aged 32 and above show the most mature understanding of risk. With years of experience, stable careers, and long-term financial planning, they tend to assess risk more rationally. These investors are less influenced by temporary market fluctuations and display a higher tolerance for calculated risks. Their investment choices are guided by long-term goals, and they focus on diversification to balance risk and return effectively.

Overall, the findings suggest that risk perception evolves with age, experience, and financial education. While younger investors seek safety and are prone to emotional decision-making, older and more experienced individuals approach risk as a strategic factor in their investment journey, aiming for growth with stability.

3. Findings on the Impact of Behavioural Biases on Portfolio Selection

The study found that behavioural biases have a significant influence on how individuals select and manage their investment portfolios. Many investors do not make decisions purely based on logic or financial analysis—instead, their choices are often guided by emotions, past experiences, social influences, and psychological patterns.

One of the most common biases observed was herd mentality, where individuals tend to follow what others are doing, especially in rising or falling markets. This behaviour leads many

investors to buy popular stocks or mutual funds without fully understanding the risks or fundamentals behind them, which often results in poorly diversified portfolios and higher exposure to market volatility.

Another prominent bias affecting portfolio selection is overconfidence. Many investors believe they can predict market movements or outperform professional advice, leading them to make aggressive investment choices. This often results in excessive trading, concentration in a few stocks, or ignoring warning signs, all of which can weaken portfolio performance over time.

The disposition effect was also evident, where individuals held onto losing investments for too long in the hope of a rebound, while quickly selling profitable ones. This emotional response to

gains and losses creates an imbalance in the portfolio and reduces long-term returns.

Interestingly, more experienced investors—especially those above the age of 32— demonstrated a better ability to manage these biases. Their portfolios were generally more diversified, aligned with long-term goals, and reflected a deeper understanding of balancing risk and return.

In summary, behavioural biases play a powerful role in portfolio selection. While younger and emotionally-driven investors often make reactive or imbalanced choices, those with experience and awareness tend to develop more stable and strategic portfolios. Understanding and managing these biases is essential for building a well-performing and resilient investment plan.

Recommendations to the Study

What suggestive measures can help to reduce the biasness from the portfolio?

37 responses

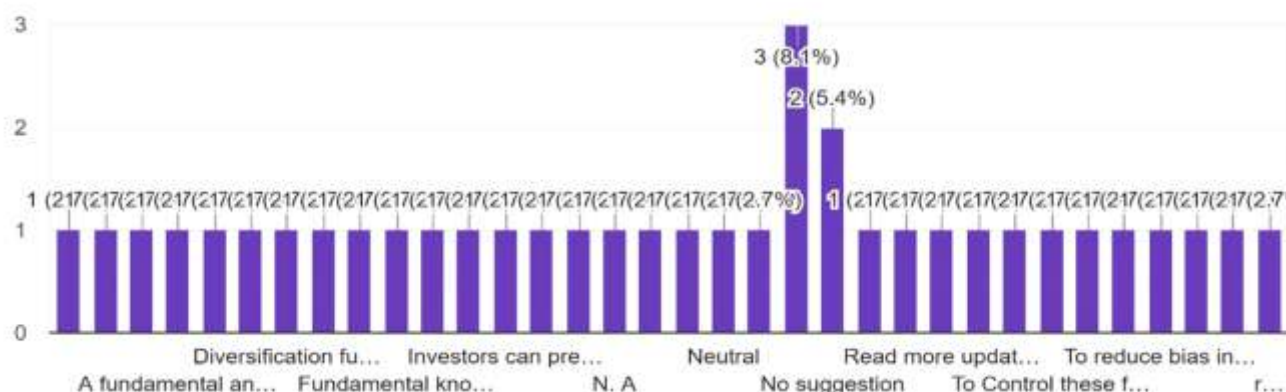


Fig 06: Suggestive measures that can help to reduce the biasness from portfolio as suggest by the respondents

Recommendations and suggestions by the respondents

The study collected valuable insights from 37 respondents on how to minimize behavioural biases in portfolio selection. The suggestions point toward a strong need for awareness, education, and disciplined investment practices:

- Financial Education & Awareness:**

Several respondents emphasized the importance of acquiring fundamental and technical knowledge about the market. Educating investors about market behaviour, financial instruments, and long-term planning can help reduce emotionally driven decisions and prevent common biases like herd mentality and overconfidence.

- Portfolio Diversification:**

Many participants suggested that diversifying investment portfolios across asset classes, sectors, and risk levels can effectively reduce the impact of cognitive biases. A diversified portfolio helps in managing risk and reduces the influence of emotional reactions to short-term market movements.

- Updated & Informed Decision-Making:**

Reading more updated market information, expert analyses, and financial news can help investors make more informed decisions. Respondents believe that staying informed can reduce reliance on hearsay or peer influence.

- **Self-Control & Behavioural Awareness:**
Some respondents highlighted the need for self-control and emotional discipline while investing. Recognizing personal biases and making efforts to control impulsive decisions can support better portfolio outcomes.
- **Professional Guidance:**
A few suggestions also pointed to the benefit of seeking professional advice or using financial planning tools to overcome biases. This can provide a more objective and structured approach to portfolio building.
- **Neutral and Uncertain Responses:**
A small proportion of respondents marked their stance as neutral or gave no suggestions, indicating either uncertainty about the issue or a lack of awareness, further reinforcing the need for financial education among individual investors.

Conclusion of the Study

The study concludes that behavioural biases significantly influence individual investment decisions, especially among younger investors who are more prone to herd mentality, overconfidence, and emotional reasoning. Risk perception varies across age groups, with experienced investors showing better control and strategic planning. These biases also impact portfolio selection, often resulting in poor diversification and short-term thinking. However, as financial awareness increases, investors tend to make more informed and balanced decisions. Respondents suggested measures like financial education, diversification, and emotional control to reduce bias. Overall, understanding and managing behavioural biases is essential for improving investment decisions and achieving long-term financial goals.

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Role of Augmented Reality Technology in Customer Experience: Current Scenario and Future Opportunities

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**Sushil Pande

Abstract

This is fundamentally a technology period characterized by multiple innovations that have occurred, are, and will occur, directly influencing consumer choices, intentions, and desires. Today, every company aims to innovate in addressing client needs related to their products through advertising, novel applications, and product quality. To achieve this, the company will employ new technologies such as augmented reality to create market demand, providing clients with more engaging and beneficial product displays and virtual try-on capabilities at home, enhanced by improved connectivity and interactivity. This study reveals a notable gap in understanding the current and future uses of augmented reality (AR) for consumers, despite a wealth of research. This study's primary objective is to provide a systematic review that provides an overview of the state of the art in augmented reality research for consumer experiences. This article utilizes theme, co-citation, and keyword analyses to assess this domain's publications, keywords, and approaches. Moreover, it offers a forward-looking perspective for academics and institutions in this field.

Keywords: Augmented Reality, Bibliometric Analysis, Customer Experience, thematic mapping

Introduction

Technology constantly changes the perspective of customer thinking, motivating customers to think about and see products in new ways, try products in different manners, and have a better experience and feeling. Several technologies have evolved in this context, Especially Virtual reality and augmented reality. Sutherland (1965) initially initiated the notion of a transparent display attached to the head in "The Ultimate Display," establishing the framework for technologies related to Augmented Reality. Augmented Reality adds digitally produced aspects to the customer's environment and is employed across multiple industries, such as education, amusement, shopping, tourism and healthcare. Companies are pressured to deliver engaging consumer experiences across online and offline channels. Customers now do not finalize their journey solely on one channel (Wolny et al., 2014); They think that companies will integrate offline and online interactions to produce a smooth omnichannel experience (Cummins et al., 2016). The digital transformation in existing technology, such as AR, VR, AI, and useable and wearable devices, changes the customer experience perspective. Smartphones and low-cost internet connection facilities have become inseparable from consumers' daily lives and regularly change the customer experience. One of

the newest Smartphone applications to attract customers is augmented reality (AR), which has been used to create virtual showrooms, changing rooms, makeup apps, and virtual tours.. For example, many shopping apps in India provide a virtual try-on facility for customers when purchasing luxury items, décor items, electronics, paint, etc., creating better connectivity and experience between the customer and the product. The dynamic, real-time merging of digital content—like product information, images, and animations -with the consumer's surroundings is known as augmented reality (Azuma et al., 2001).

Augmented reality's (AR) fascinating array of "smart" technologies is what gives it its potential (Marinova et al., 2017) aimed at improving the online customer experience via an intuitive, context-aware, and socially integrated interface. Thus, augmented reality is defined by integrating digital and physical components. Consequently, augmented reality is evolving into a transformative technology that will revolutionize marketing in the forthcoming years (Tan et al., 2022). PwC (2019) estimates that the benefits will reach \$338.1 billion by 2025 and \$1.0924 trillion by 2030. Recent studies on the function of augmented reality in customer experience include:

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Table 1: Recent Scopus Article details
Source: Author's creation

Authors	Title	Year
Gleim M.R et al.	Examining the customer experience in the metaverse retail revolution	2025
Zeng N. et al.	AR atmospherics and virtual social presence impacts on customer experience and customer engagement behaviours	2024
Issac Sam S.J et al.	Customers metaverse service encounter perceptions: sentiment analysis and topic modeling	2024
Tom Dieck M.C. et al.	Augmented reality marketing in hospitality and tourism: a guide for researchers and managers	2024
Habil S.G.M. et al.	The metaverse era: leveraging augmented reality in the creation of novel customer experience	2024
Sands S. et al.	Immersive Advertising” A Review and Research Agenda Potential Effects of and Considerations for AR, VR, and MR Advertisements	2024
Wieland D.A.C. et al.	Augmented and virtual reality in managing B2B customer experiences	2024
Butt A.H. et al.	Augmented reality is the new digital banking “ AR brand experience impact on brand loyalty	2024
Gleim M. et al.	Metaverse: shifting the reality of services	2024
Chu S.-C et al.	Artificial intelligence, virtual and augmented reality, social media, online reviews, and influencers: a review of how service businesses use promotional devices and future research directions	2024
Poushneh A. and Vasquez-Parraga A.	The effect of semiautonomous augmented reality on customer experience and augmentation experience	2024
Suarsa S.H. et al.	E-Customer Satisfaction And Consumer Attitudes Toward Mobile Augmented Reality Advertisements In The Indonesian Cosmetics Market	2024
Sahli A. and Lichy J.	The role of augmented reality in the customer shopping experience	2024
Buhalis D. et al.	Metaverse as a driver for customer experience and value co-creation: implications for hospitality and tourism management and marketing	2023
Bag S. et al.	Unveiling metaverse potential in supply chain management and overcoming implementation challenges: an empirical study	2023
Attri R.	Wakefit Innovations: overcoming challenges of online sales of furniture & furnishings	2023
Butt A. et al.	Engaging the customer with augmented reality and employee services to enhance equity and loyalty	2023
Fritz W. et al.	From tablet to table: How augmented reality influences food desirability	2023
Vaidyanathan N. and Henningsson S.	Designing augmented reality services for enhanced customer experiences in retail	2023
Gong T. and Park J.	Effects of augmented reality technology characteristics on customer citizenship behavior	2023
Barhorst J.B. et al.	Transcending reality: Introducing mental time travel experiences and their ability to influence brand outcomes	2023
Silva S.C. et al.	How footwear companies can use online CX to WOW customers	2023
Kozinets R.V.	Immersive netnography: a novel method for service experience research in virtual reality, augmented reality and metaverse contexts	2023

Scholarly research on AR's impact on customer experience, responsiveness, and engagement has increased due to its growing use in marketing (Rauschnabel et al., 2022). A review of the current literature is necessary to guide future research due to the growing interest in AR marketing strategies. Nonetheless, the existing literature on the subject is insufficient due to the nascent academic research on augmented reality utilization. In order to develop a comprehensive and coherent picture of the state of AR research today and to pinpoint research needs, we will methodically assess the literature.

This study focuses on the basic features of the literature, such as the year of publication, the goals of the research, and the methodology. It analyzes the industrial sector, setting, type, and conceptual structures of AR marketing. We identify key subjects in each application domain based on outcome data to show the state of scholarly research today. We also provide recommendations for further study.

Research Methodology

This investigation utilized a comprehensive review of the literature. This study systematically assessed, categorized, and visualized extensive bibliometric data through a bibliometric review. This study utilized the esteemed bibliographic database Scopus to guarantee the inclusion of only high-quality research publications. The research incorporated three dimensions performance analysis, science mapping and thematic map gathering utilizing the R- software (Aria et al., 2022). For this

dimension, we will use VOSviewer and Bibliometrix R Package.

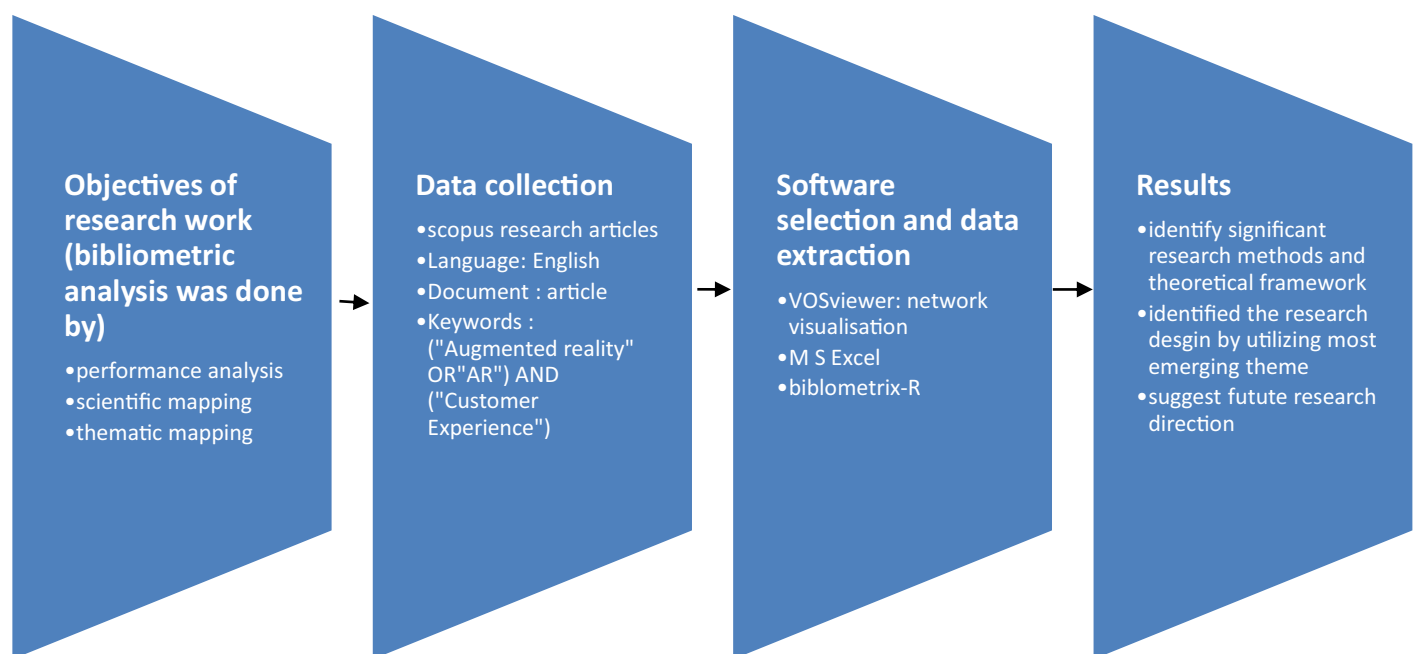
VOSviewer will use citation evaluation in the performance assessment. The articles with the most significant citation counts were thoroughly analyzed to ascertain the conceptual structures and data collection and analysis methods utilized in studying the role of AR in customer experience. For the citation analysis, a minimum criterion of five citations was applied. VOSviewer was used to do co-citation and keyword analysis for science mapping. (Javeed S. et al., 2024).

The minimal requirement for the keyword analysis was three occurrences. Likewise, 80 examples met the citation analysis's minimum criterion of 20 citations. The theme map and evolution in the ARM area were constructed using the Bibliometrix R-package. The data analysis is divided into four parts, representing objectives, data collection, selection of software, and results (Fig1). These phases delineated emerging issues, scholarly publications, and avenues for future AR research.

Finding and result

Performance analysis

The figure depicts the yearly publishing and citation patterns for the final 55 publications chosen after manual filtration and duplication removal.



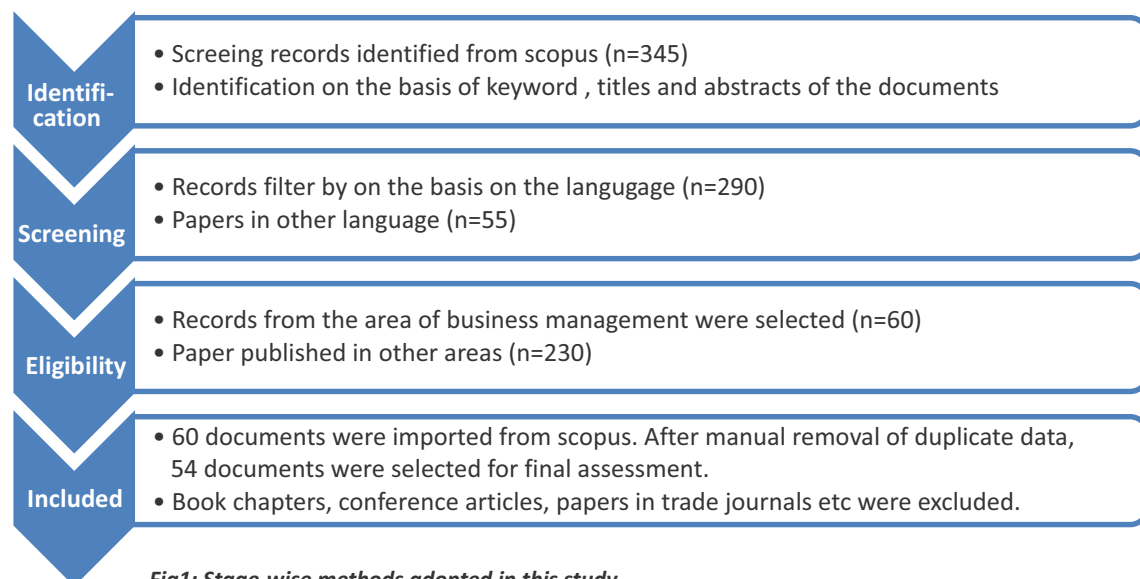


Fig1: Stage-wise methods adopted in this study
Source: Author's creation

Figure 1 illustrates the study process, delineating the fundamental objectives, data collection methods, software utilized for analysis, and the outcomes obtained post-analysis. The following figure delineates the fundamental procedure researchers employ to screen and filter data within the Scopus database.

Since 2013, the application of augmented reality (AR) in customer experience has gained increased attention, as seen in Figure 2. From 2013 to 2025, the average publication count constituted 3% of 54 publications, while 97% were published post-2022. The report delineates the expansion of augmented reality in virtual consumer experiences, with the rise in citations indicating a growing interest among scholars in this domain.

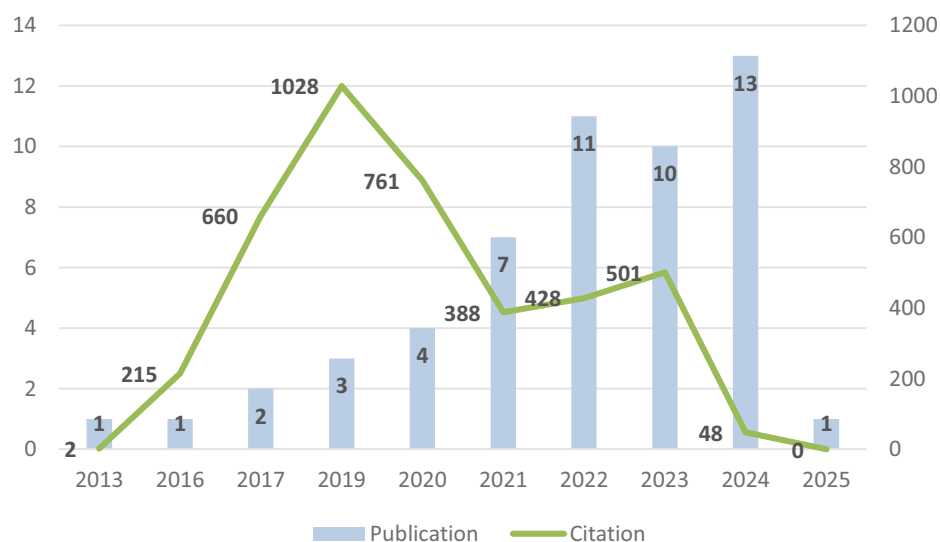


Fig2: Graphical presentation of literature collection
Source: Author's creation

Analysis of citations for 13 highly referenced works in the domain of AR in customer experience

Citation analysis provides a quantitative overview of data concerning research domains, authors, and journals, facilitating

the identification of prior contributions within the relevant field (Ho, 2012) (Table 2)(Fig 2).

Table 2: Category-wise top 13 cited works with Scopus journal details
Source: Author's creation

10	Title of research article	Journal	Citation
Carlos Flavian et al. (2019)	The impact of virtual, augmented and mixed reality technologies on the customer experience	Journal of Business Research	787
Hoyer W.D. et al.(2020)	Transforming the Customer Experience Through New Technologies	Journal of Interactive Marketing	481
Dacko S.G. (2017)	Enabling smart retail settings via mobile augmented reality shopping apps	Technological Forecasting and Social Change	354
Poushneh A. et al.(2017)	Discernible impact of augmented reality on retail customer's experience, satisfaction and willingness to buy	Journal of Retailing and Consumer Services	306
Buhalis D. et al.(2017)	Metaverse as a driver for customer experience and value co-creation: implications for hospitality and tourism management and marketing	International Journal of Contemporary Hospitality Management	246
Parise S. et al. (2023)	Solving the crisis of immediacy: How digital technology can transform the customer experience	Business Horizons	215
Heller J. and Chylinski M. et al. (2019)	Let Me Imagine That for You: Transforming the Retail Frontline Through Augmenting Customer Mental Imagery Ability	Journal of Retailing	183
Kozinets R.V. (2023)	Immersive netnography: a novel method for service experience research in virtual reality, augmented reality and metaverse contexts	Journal of Service Management	165
Jessen A. and Hilken T. et al.(2020)	The playground effect: How augmented reality drives creative customer engagement	Journal of Business Research	147
Chylinski M. et al.(2020)	Augmented reality marketing: A technology-enabled approach to situated customer experience	Australasian Marketing Journal	132
Golf-Papez M. et al(2022)	Embracing falsity through the metaverse: The case of synthetic customer experiences	Business Horizons	119
Carlos Orús et al.(2021)	Enhancing the customer experience with virtual and augmented reality: The impact of content and device type	International Journal of Hospitality Management	103
Batat W. (2021)	How augmented reality (AR) is transforming the restaurant sector: Investigating the impact of Le Petit Chef on customers dining experiences	Technological Forecasting and Social Change	97

Thematic analysis (Thematic map and evolution)

Thematic analysis is mainly utilized for the analysis of qualitative data. A qualitative technique for examining categories and elucidating themes pertinent to the data is thematic analysis (M.I. Alhojailan, 2012). The term "thematic analysis" refers to a pattern detection technique that involves carefully analyzing and rereading the content in order to identify underlying themes, or "theories" or "approaches." Like other social science approaches like ethnography, phenomenology, and content analysis, thematic analysis finds, refines, documents, and/or evaluates recurrent themes to extract meaning from data (M. Javadi & K. Zarea, 2016).

Thematic maps, grounded in density and centrality, delineate four thematic categories derived from interconnected clusters of the Author's keywords. Figure 4 presents 151 author keywords, divided into four categories: The upper right category (motor theme) encompasses sophisticated and pertinent themes such as "e-commerce," "AR enjoyment," "AR satisfaction," "artificial intelligence," "technology and services," and "retail user satisfaction." The upper left category (Niche topic) encompasses developed yet less significant subjects such

as "advertising," "experiential value," "mobile augmented reality," "business management accounting," and "digital marketing." The lower left category (developing or decreasing theme) encompasses underdeveloped and minor topics such as "Repurchase intention." The lower right category (fundamental theme) encompasses "augmented reality," "customer satisfaction," "virtual reality," "metaverse," "customer engagement," "interactivity," "customer journey," and similar topics that require further research focus. Topics such as "online shopping," "customer value," and "perceived usefulness" are situated in the centre of the upper right and left categories, reflecting significant themes for investigation. Customer satisfaction is reflected in the lower centre category, indicating the necessity for increased focus in this domain.

AR distinguishes itself by functioning as both a catalyst and a core concept. Using augmented reality as a central topic is a pioneering strategy that enhances customer engagement and expands the limits of experiential marketing, illustrating how AR could fundamentally transform traditional marketing paradigms. Moreover, its role as a core topic underscores the pivotal position that AR occupies in contemporary marketing strategies, reflecting its ubiquity and essential significance (Javornik, 2016).

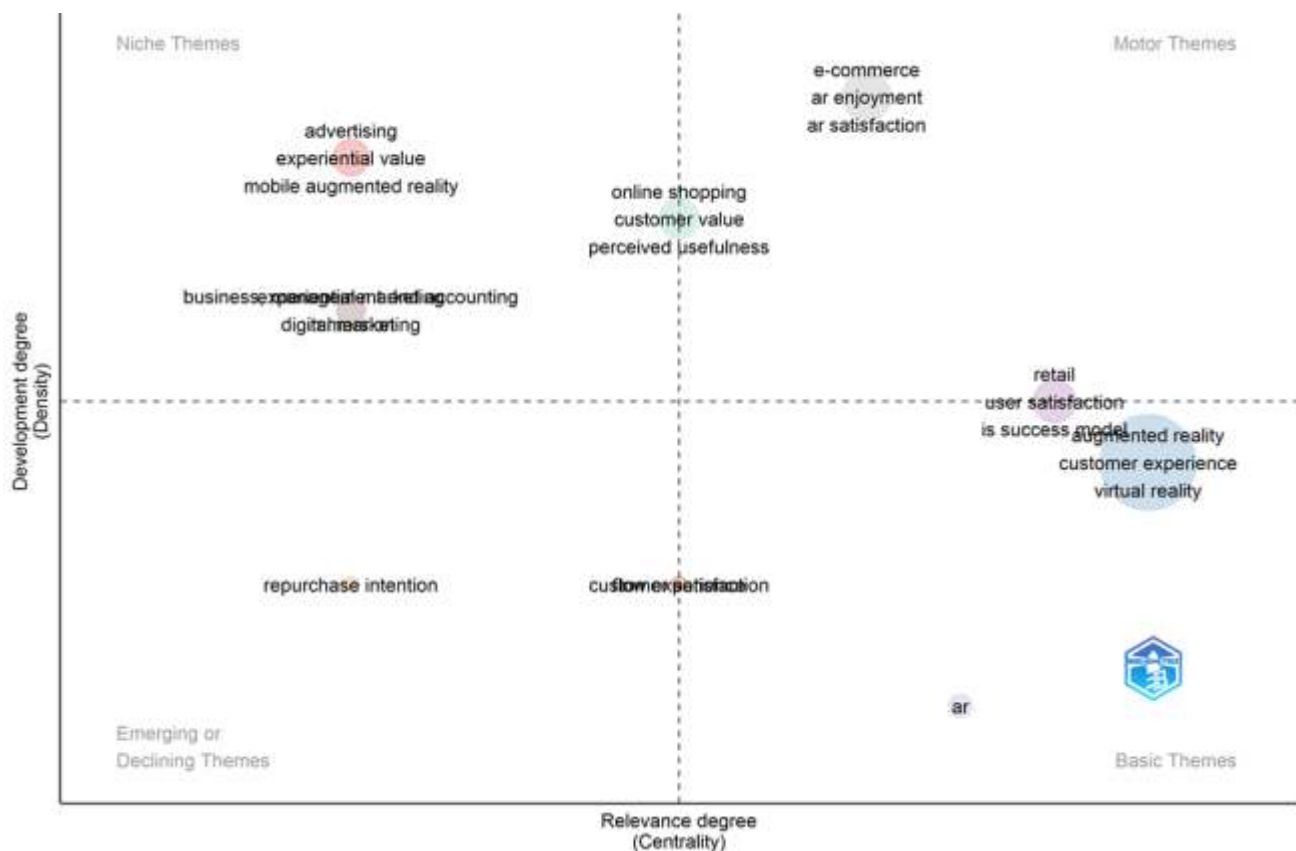


Fig 4: Thematic mapping of the Author's keyword
Source: Author's creation

The theme evolution map illustrates a change in the dynamics of AR and VR convergence from 2013 to January 2025 (Fig 5). From 2013 to 2023, the domain of AR, customer experience, customer satisfaction, and engagement expanded significantly, integrating these elements with broader aspects of customer

experience and augmented reality. Augmented reality underscores its significance in enhancing consumer experience, contentment, and engagement, demonstrating a profound influence on the future of technology-integrated marketing.

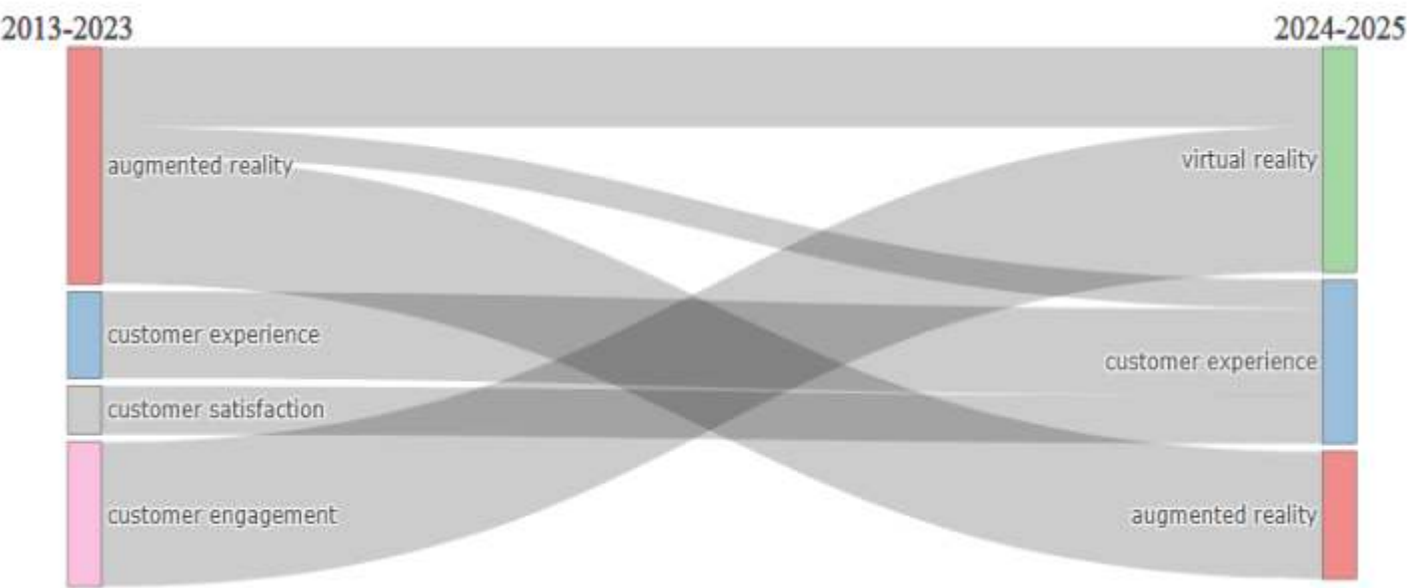


Fig 5: Thematic evolution based on the Author's keyword
Source: Author's creation

The science mapping method

The proposed study mostly concentrated on keyword and co-citation analysis. Science mapping, sometimes referred to as bibliometric mapping, analyzes the importance and strength of correlations among different article aspects by presenting the co-occurrence weight of keywords and the total connection strength (Javeed S. et al., 2024).

Keyword analysis

Author keywords are primarily used in keyword co-occurrence analysis. Terms are taken from full texts, abstracts, and titles when unavailable. Each keyword's occurrences about other keywords, link strength, and total number of links are computed using VOSviewer. Links indicate co-occurrences, whereas occurrences show the presence of keywords in papers. Link

strength shows the total number of references between two items.

Fig 6 shows the AR keyword network. Each of the presentation's five visually distinct clusters Red is the first cluster, followed by green, blue, yellow, and purple by the fourth and fifth clusters, respectively-is represented by a different color. While distance and lines show associations, the position of the text and circles indicates the strength of co-occurrence.

This analysis focuses on customer experience and examines augmented reality's relationships, themes, and trends. Keyword analysis provides a thematic viewpoint and insights into current, past, and future theme links (Javeed S. et al., 2024). Table 3 shows the five clusters from the investigation and the keyword cluster delineation.

Table 3: Cluster-wise co-occurrence of keywords with minimum number of 3 occurrences

	Total link	Total Occurrence	Total link strength
Cluster 1 (Consumer behavior and Application)			
Consumer behavior	9	3	13
Mobile Augmented reality	8	3	10
Mobile phone	7	3	9
Retailing	10	5	16
Sales	11	4	17
User satisfaction	8	4	13
Cluster 2 (AR and Fields)			
AR	7	3	8
Hospitality	5	3	7
Marketing	8	5	12
Metaverse	5	8	18
Virtual reality	10	14	31
Cluster 3 (Customer Experience in ecommerce)			
customer experience	17	28	32
E-commerce	3	3	4
Online shopping	4	3	4
Perceived usefulness	3	3	4
Cluster 4 (AR in Retailing)			
Augmented reality	20	46	80
customer journey	4	3	7
Retail	6	3	8
Retail Technology	4	4	9
Cluster 5 (AR use in Customer engagement and interactivity)			
Customer engagement	3	4	6
Interactivity	6	5	10

The five clusters elucidate distinct facets of AR and customer experience. Cluster 1 examines mobile augmented reality and its impact on consumer behaviour concerning retailing, sales, and user satisfaction. Cluster 2 examines the application of augmented reality across various domains, including hospitality, marketing, the metaverse, and virtual reality. This application also enhances the customer experience. Cluster 3 examines

customer experience in online shopping, e-commerce, and the perceived usefulness of augmented reality. Cluster 4 examines the customer journey, retailing, and advancements in retail technology, specifically regarding augmented reality. Cluster 5 examines the application of AR in improving customer engagement and interactivity.

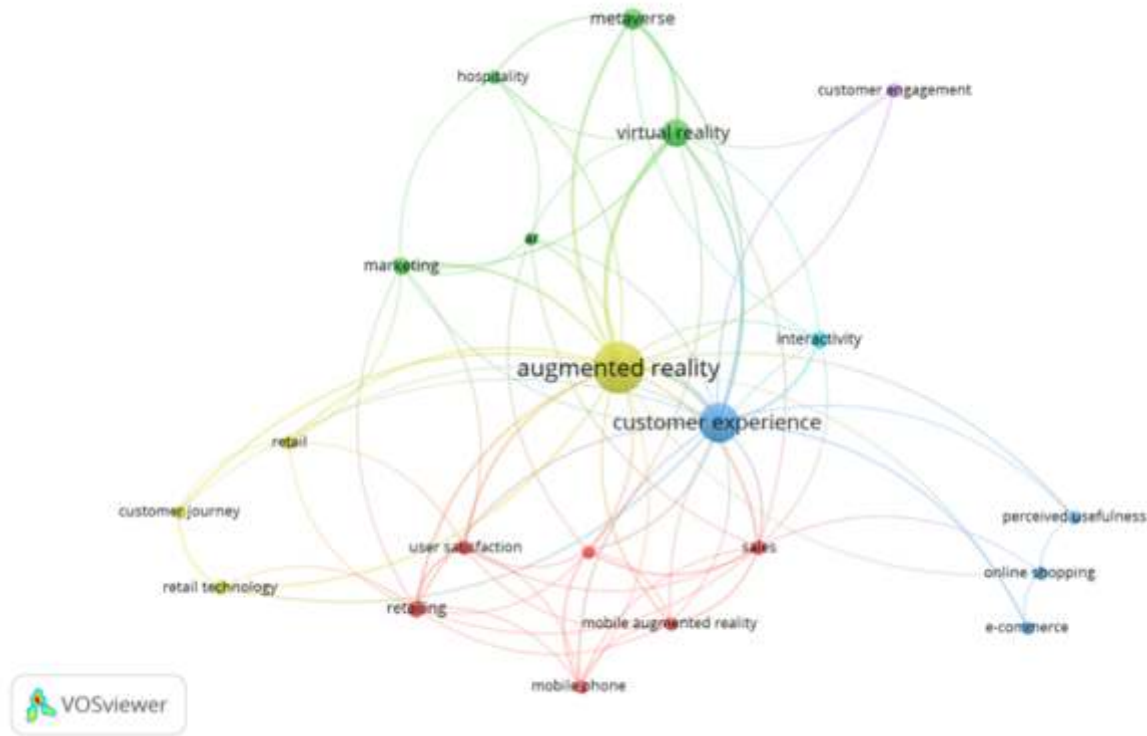


Fig 6: AR keywords base Network visualization.

Table 3: Co-occurrence of keywords in clusters with at least three occurrences

Source: Author's creation

Co-citation analysis

This scientific modelling method posits that publications cited together indicate thematic relationships. It aids researchers in identifying thematic clusters of significant publications.

The initial sample of 48 papers for co-citation analysis was refined to include only those with 20 or more citations, yielding 64 papers that met the established threshold. Four primary

clusters emerged from the analysis of these 64 papers: the first cluster comprised 21 papers, the second cluster included 18 papers, the 3rd cluster contained seven papers, and the fourth cluster consisted of 3 papers. Table 4 lists the four most-cited publications from each cluster, and Figure 7 shows the co-citation network of authors who work on Augmented reality technology and customer experience.

Table 4: Most cited papers in each cluster

Cluster1		
Chu S.-C. et al.(2024)	International Journal of Advertising (Taylor and Francis Ltd.)	Artificial intelligence, virtual and augmented reality, social media, online reviews, and influencers: a review of how service businesses use promotional devices and future research directions
Huang T. et al.(2019)	Journal of Services Marketing (Emerald Group Holdings Ltd.)	Enhancing online rapport experience via augmented reality
Poushneh A. and Vasquez-Parraga A. (2024)	European Journal of Marketing	The effect of semiautonomous augmented reality on customer experience and augmentation experience
Zeng N. et al. (2024)	International Journal of Retail and Distribution Management (Emerald Publishing)	AR atmospherics and virtual social presence impacts on customer experience and customer engagement behaviours

Cluster2		
Buhalis D.et al. (2023)	International Journal of Contemporary Hospitality Management (Emerald Publishing)	Metaverse as a driver for customer experience and value co-creation: implications for hospitality and tourism management and marketing
Flavian C.et al. (2019)	Journal of Business Research (Elsevier Inc.)	The impact of virtual, augmented and mixed reality technologies on the customer experience
Kumar, Harish (2022)	International Journal of Retail and Distribution Management (Emerald Group Holdings Ltd.)	Augmented reality in online retailing: a systematic review and research agenda
Tom Dieck M.C. et al.(2024)	International Journal of Contemporary Hospitality Management (Emerald Publishing)	Augmented reality marketing in hospitality and tourism: a guide for researchers and managers
Cluster 3		
Chylinski M. et al. (2020)	Australasian Marketing Journal (Elsevier Australia)	Augmented reality marketing: A technology-enabled approach to situated customer experience
Heller J. et al.(2019)	Journal of Retailing (Elsevier Ltd)	Let Me Imagine That for You: Transforming the Retail Frontline Through Augmenting Customer Mental Imagery Ability
Hilken T. et al.(2022)	Business Horizons(Elsevier Ltd)	Embracing falsity through the metaverse: The case of synthetic customer experiences
Cluster 4		
Ahmad H. et al.(2023)	International Journal of Retail and Distribution Management (Emerald Publishing)	Engaging the customer with a augmented reality and employee services to enhance equity and loyalty
Wang W.et al.(2023)	Information Technology and People(Emerald Publishing)	Understanding customer satisfaction of augmented reality in a retail: a human value orientation and consumption value perspective

First Cluster: In recent years, reality technologies have enhanced customer experience and augmented experiences in various ways (Chu S.C. et al., 2024). This cluster focuses on the shaping of customer experience. The Author indicated that using AR in advertising, promotion, and virtual try-ons affects the customer experience.

Second cluster: This cluster defines the primary fields within the business sector where augmented reality is predominantly utilized, including tourism, education, and retailing (Buhalis D. et al., 2023). This cluster examines the role of AR in improving competitive advantage within the sectors of tourism, hospitality, and retail. AR technology enhances customer-oriented approaches across various fields, increasing readiness, attractiveness, and effectiveness.

Third Cluster: Leading companies in the retail sector in India, such as Flipkart and Amazon, utilize augmented reality to enhance customer experience (Heller J. et al., 2019). This cluster examines the role of augmented reality in influencing customer interactions. It focuses on other technologies related to AR that enhance real-time customer experiences through advertising and virtual try-on facilities.

The fourth cluster encompasses two papers addressing customer engagement and satisfaction (Ahmad H. et al., 2023). This cluster examines how AR technologies create improved programs to enhance customer engagement, directly impacting customer satisfaction.

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Predictive Study on Bankers' Adoption of FinTech Apps : Role of In-branch Efforts and Challenge Areas

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Abstract

The last quarter century has ushered in the era of digital banking kiosks for consumer feasibility all over the nation. However, this shift to newer banking technologies also requires a plethora of in-branch efforts by banking employees in order to bridge the migration gap for the customers. This study aims to analyse the challenges faced by bankers in the adoption of digital banking channels through PLS-SEM assessment. Some of the challenge areas to be used as factors of analysis are sufficiency of training, concerns regarding security breaches and data privacy, human resistance to change, understanding technical jargon in absence of clear instructions, etc. A pilot study with 20 top and middle level banking employees will be used as an insight to create a structured questionnaire. The population for this study will consist of both private and public sector banks with the sample size being that of 402 participants. The responses will then be assessed and analysed via a statistical model which will show the extent of impact of aforementioned variables on bankers' perception towards latest Fintech Apps. The outcome of this study will assist in the identification of key areas which need refinement and strategic intervention. The study will also serve as a guide for banks to facilitate and promote such policies which can help the banking employees in the adoption of digital banking apps and their integration into the existing framework effectively.

Keywords: Digital Banking, FinTech, Mixed Methods, PLS-SEM, UTAUT

1. Introduction

A profound integration of advanced financial technology has taken place in the world, heralding a new era. The combination of artificial intelligence, blockchain, cloud computing, and bigdata in FinServ and FinTech has transformed the view of the global financial markets (Gomber, 2017). Murinde, 2022). FinTech refers to all major technologies used by banks and other financial firms, as well as new financial ideas and services that emerge from those technologies (Xudong Zhang, Zhihui Li, 2025). FinTech uses diversely innovative avant-garde ideas in services, applications as well as the various processes in Finance. As a specialized financial technology, it expands, automates, enhances and scales the delivery of financial services and products. With technology as a driving force and globalisation as catalyst, Fintech has revolutionised the financial activities by rendering innovative and cost-effective solutions. This integration has broadened the reach and created new opportunities (Haichuan hu, Zhenting jia, Siyao Yang, 2025).

The substantial growth in demand for multiple smart/digital financial services has motivated old-school financial service

providers to migrate towards fintech; thus leveraging enhancement of financial activities via Fintech developments (Karim & Lucey, 2024; Pollari, 2016; Zeng , 2024). The advantages drawn from adopting fintech in banking operations are unprecedented. It has vastly affected profitability and branch reach (Wang, 2023). A bank where technology is embedded in the systems, enhances customer experience and reduces expenses pertaining to the upkeep of the physical branch. This may render a competitive edge, resulting in increased revenues (Haichuan hu, Zhenting jia, Siyao Yang, 2025). It also puts negative effect on monopolies and enhance inclusion (Aleemi, 2023). Moreover, the instituting FinTech in banking system creates advantages which are outside the frontiers of an organisation. At one instance small and medium-sized enterprises get benefits from speedier and more tailor-made financing options (Guo, 2023; Zhang, 2023), which can provide impetus to employment and support domestic economies. At the second instance, it can reshape the entire banking industry resulting in enhanced quantity of credit to the population.

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(Haichuan hu, Zhenting jia, Siyao Yang, 2025). Other than financial benefits, the application of fintech in the banking industry have non- financial advantages, too. Fintech adoption helps in enhancing ESG (environmental, social, and governance) performance of the bank. FinTech can greatly enhance a company's ESG results at each stage of its development, although the improvements vary. (Haichuan hu, and Siyao Yang, 2025).

Fintech has now become a significant contributor to the economic advancements in our country; thereby paving the way for relevant financial inclusion, absolute resilience, and the growth of the real Indian economy (Gao, H., & Zhang, Q. 2019). There weren't many FinTech companies in India before to 2016 and the nation's economy was majorly dependent on cash transactions. The real thrust for the development of FinTech in India was given by 2016 demonetization (Gupta and Agrawal, 2021). Initially, the majority of customers were reluctant in making transition to digital payment methods and other types of online shopping (Mehta and Kumari, 2021) but the pandemic somehow forced to accept it. The COVID-19 pandemic has posed significant economic challenges for traditional brick-and-mortar businesses leading to uncover fresh avenues for growth with digitalisation (Sreenu Nenevath, 2025). "Lending, Online KYC, Digital Insurance, Digital Microfinance, Buy-Now-Pay-Later, and Banks without Physical Branches are just a few of the new fintech services that have emerged in less than five years. It has been predicted that by the current year, the Indian fintech market will have grown triple fold from its 2021 valuation of 50 billion to 150 billion dollars in 2025" (Sengupta, 2023).

Currently, we are experiencing amazing progress in modern technology because of AI, as many industries have become very interested (Sætra, 2023). Lately, organizations are using artificial intelligence tools to assist with providing customer service. The goal of delivering great customer support by responding promptly and being always accessible has resulted in a rise in AI chatbot use. Along with assisting in the critical areas of round the clock customer services, it also enhances the company's sales performance (Hildebrand and Bergner, 2019). A previous year detailed report submitted by Mordor Intelligence believed that the chatbot's market all over the world is of approximately 7 billion dollars in value (2024). The report also predicted that the market size will continue to increase at a CAGR of 24.32 % in between the years 2024 and 2029 (Mordor Intelligence, 2024). Various studies and estimations have shown that the United States, India, Brazil, the United Kingdom, as well as Germany are few of the leader in AI chatbot adoption and usage. Consistent avid interest in chatbots has surged fivefold in the last five years within these countries; and subsequent market predictions are suggesting a future valuation of 1.3B dollars by the end of 2025 (AIMultiple, 2023).

The extensive global implementation of artificial intelligence (AI) and digital technologies has given way to rapidly expanding use of financial technology (fintech) as well as AI thereby increasing the quantum of investments in both the aforementioned stocks (Abakah, 2023a; Ren, Ma, & Wang, 2024). Data, Information, and communication are absolutely paramount in a rapidly changing financial market. AI Chatbots are slowly revolutionizing and transforming the global financial market, which also includes sales and marketing, customer service support and systems for information retrieval as well as virtual assistants. It has done so by providing creative solutions to the biggest problems and challenges of any financial market which are - practically streamlining all the aspects of the trading life cycle (starting from the first level of price discovery to the final stage of trade reconciliation), improving efficiency and productivity in the field, as well as automating multiple tasks (Ali and Aysan, 2023). Today, it is obvious that an early integration of AI Chatbots in their existing framework will most likely result in a substantial competitive advantage over other competitors just because technology is becoming more and more prevalent in all financial institutions and organization. Using technology to radically alter how banking services are offered, with the aim of improving customer service and following the rules, is something the sector has often done. The nexus of newer technologies (AI Chatbots etc.) with the banking industry has ushered a yet another chapter.

With open AI coming into existence, research and investigations on chatbots have risen. Alin's (2023) systematic review found that a lot of published works addressed and examined how chatbots influence education and academic activities. charting the impact of introducing chatbots to the workings of the global economy had been done by very few researchers. It becomes obvious as most of the extant studies about Chatbots are on education in academics (Gao et al., 2023, Zhai, 2023), life teachings (Terblanche & Kidd, 2022), legal cases (Perlman, 2023), healthcare, medical sciences & biological studies (Mann, 2023). In contrast, up to the present day, only a limited number of skilled researchers focus on developing a fitting testing method for using Chatbots in banking and financial areas (Abu Bakkar et al., 2023).

While economies like China, India, Indonesia, Vietnam, etc., as part of the Asian Pacific market have experienced exponential growth in adoption of artificial intelligence and Chatbots; the consumer trust in chatbots is inconsistent in these areas. Two-fifths of customers said they steer away from using AI or chatbots when they cannot understand the answer given by the system. The majority of respondents considered chatbots simple to get in touch with. Only 30% said that chatbots could support them, and only 10% thought AI could understand them just like another person could (Userlike, 2022).

According to Rogers (1983), the process of dissemination of technology is absolutely integral for comprehending potential users' readiness towards the positive embracement of new innovations and for ensuring that they have been practically adopted. A considerable amount of data collected through various studies validates the growing potential of new technologies like chatbots in enhancing all organizational processes, especially in relation to an organization's communication capabilities. However, a substantial gap exists in understanding the technological processes especially the drivers and bottlenecks. Previously substantiated studies have proved the growing importance of newer technology adoption and integration models in describing and reasoning with the diverse behavioral aspects of adjusting with latest technologies at both an individual and organizational level. Some distinguished theories and frameworks are - the TAM (Davis, 1987), the UTAUT (Venkatesh et al., 2003), the TPB (Ajzen, 1985), as well as the TRA (Fishbein and Ajzen, 1977). The aforementioned models provide various insightful analyses into the positive (drivers) and negative (barriers) factors affecting newer technology acceptance; identifying both the contextual and technological aspects. In view of these propounded ideas, the UTAUT can be properly expanded upon. As per Dwivedi et al. (2019), the aforementioned Venkatesh et al. model facilitates managers with a very useful solution to analyse and ascertain the chances of a successful venture for the latest technology and also helps them in understanding what drives the positive acceptance of new innovations. This ultimately allows managers to proactively formulate interventions (training, selling, marketing, etc.) targeting that portion of the population of customers that may otherwise be less predisposed towards accepting new technology.

Since bank employees are the bridge between their customers and the banking services offered; hence the responsibility to make sure that the customers embrace the new technologies is largely shouldered by them. In response to the above idea, the study explored how bankers view Chatbots by using the UTAUT model in its research.

Therefore, this research makes an attempt to ascertain the challenges and barriers in the path of the integration of artificial intelligence and virtual chatbots into the existing traditional framework of the banking sector and to finally establish the factors that are impetus providers to bankers regarding the adjustments needed to adopt AI and Chatbots in their regular working environment.

2. Theoretical Framework

When it comes to structural and operational change in the organisation, resistance is imperative. With the revolution in the name of AI and Chatbot, acceptance varies at different levels.

The end-user manifest different degrees of interests and resistances. So, it is important to draw a framework so as to understand different perspectives of problems and challenges in the adoption of new technology.

The model propounded by Venkatesh in the name of UTAUT, so far, has proved to be 70% apt in explaining variance in the consumer behaviour while adopting new technology. The previous theories were unable to diagnose predictive behaviour. This limitation was sufficient to propose a comprehensive approach and easily understandable framework (Venkatesh, 2003). "According to UTAUT, factors that determine how likely a behavior will happen are performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC)." This model highlights that EE makes the task effortless, whereas PE helps improve the results for the business. Along with the original framework, to bring novelty, support of Central Bank was added as a moderator. This, eventually, creates an all-inclusive framework to explain the behaviour of bankers while accepting newer technologies (Chatbots and AI).

3. Research Methodology

Many disciplines such as social sciences along with education, the health sciences, and the business research use the mixed-methods technique frequently. The main objective of mixed method research is to benefit from both qualitative and quantitative approaches, by minimizing their shortcomings (Creswell & Creswell, 2018). A more comprehensive and reliable research of the topic can be made by the researchers if they combine the qualitative as well as quantitative data to get deeper insights, validate, and triangulate their conclusions (Creswell & Creswell, 2018; Sekaran & Bougie, 2019). Thus, the exploratory sequential mixed-methods methodology is applied in this work to explore the way the bankers apply chatbots. To get a good understanding of the subject, the study began with a literature review of relevant material. There were two successive steps in the empirical investigation. Phase 1 which is based on the data resulted after the semi structured interviews, the researchers deduced the empirical coding that are expected to apply as foundation for the study. This resulted in the development of the primary factors which increased the setting of the study. Based on the empirical codes, research model was then constructed by developing a hypothesis out of each of these codes. Phase 2: To extend empirical evidence for support of the theoretical scope, quantitative cross-sectional survey using a larger sample to test all the offered hypotheses followed. The following is a more details explanation of research process.

3.1 Qualitative Study

A qualitative preliminary survey was conducted with bank employees belonging to different commercial banks and they

were involved in open ended, semi structured interviews to determine the factors that affect their perceptions regarding chatbots. Focus groups were the major data collection method that was used for this investigation. Purposive sampling was applied in this case on the relevant informants who are authorities of what they are researching about as opined by various researchers (Yin 2017; Sekaran & Bougie 2019; Creswell & Poth (2018)). The majority of modern qualitative researchers feel that at the saturation point, the number of interviews that will be required will depend on the subjective assessment made by the researchers. When it reaches saturation or when new themes are no longer coming and there is no relevance to the data then the researcher may choose to stop. Twenty informants were involved in this semi structured interviews and this is adequate in taking this particular study to saturation.

3.2 Quantitative Study

Utilizing the information from semi structured interviews to find out several possible influences on the use of chatbots among

bankers. Some theories were utilized to come up with the final model that was recommended. After that, a quantitative cross sectional study with a larger sample of bank staff from various commercial banks was done to evaluate the hypotheses. In order to validate the results, PLS-SEM was used in SmartPLS3 (Ringle et al 2022). PLSSEM is thought to be “a variance-based methodology” comprising least-square functions that attempt to maximise the explained variance on the dependent variables (Hair et al, 2021). In order to understand more about the influencers affecting bankers' adoption of chatbots, the study came up with a survey. Standardized measurement scales implemented in previously conducted studies were adapted to the study setting with a view of validating the instruments in the study setting. For measuring each concept, the Likert scale of seven points has been used, 1 identified “strongly disagree” and 7 indicated as “strongly agree”. The Table1 below indicates the constructs, number of items and their origin. Satisfactory results were obtained during a pilot test when 45 survey respondents took part in it.

Table 1: List of constructs

Constructs	Description of constructs	No of Items	Source
“Behavioural Intention” (BI)	Intention to make use of new technologies.	4	“(Venkatesh et al., 2003)”
“Performance Expectancy” (PE)	The system improves task performance and is beneficial.	4	“(Venkatesh et al., 2003)”
“Effort Expectancy” (EE)	System usefulness and convenience.	4	“(Venkatesh et al., 2003)”
“Social Influence” (SI)	The choices that a person makes in his or her system usage are based on the opinions of particular parties.	3	“(Venkatesh et al., 2003)”
“Facilitating Conditions ” (FC)	Resources availability of that will make a given technology easier to implement.	3	“(Venkatesh et al., 2003)”
“Central Bank Support ” (BS)	The role of bank in propagating and advancement of use of technology.	3	“(Amin et al., 2011)”

4. Constructs and Hypothesis Development

“The four principal components of the UTAUT are Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI) and Facilitating Conditions (FC) were analyzed.” In addition, the Central Bank Support (BS) act as moderator on Behavioural Intention (BI) to adopt financial technology, especially chatbots, is tested. The subsequent paragraphs contains a detailed description of the constructs, as well as the model understudy and hypothesis.(fig 1).

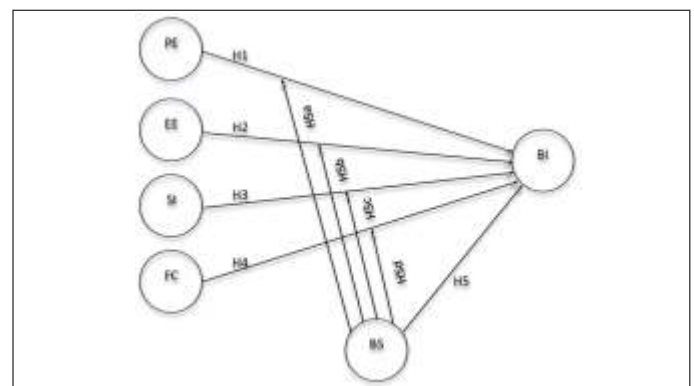


Fig 1: Conceptual Framework (Source: Authors Creation)

4.1 Performance Expectancy (PE)

The performance expectancy or the prediction of users' perceptions on improved performance as outcome of technology implementation has been widely researched. Performance expectancy is viewed as the central measure of behavioural intention by UTAUT (Venkatesh and Morris, 2003), and its extension, UTAUT2 (Venkatesh, Thong and et al., 2012). The significance of this construct in explaining the increased use of information systems was noted in several research (Bouteraa et al, 2023; Bouteraa, Hisham and et al., 2022 a; Osei, Kwateng and et al., 2022). Most companies adopted chatbots as a mechanism to answer routine questions or to serve as the first contact (Jee 2016). Literature supports the significance of performance expectancy in shaping users behaviour when using chatbots in multiple industries, such as life teachings (Terblanche and Kidd, 2022), healthcare (Sitthipon, 2022) and travel and tourism. The aspect of its function in the banking business however has received less attention. Based on the literature, bankers might incline to use chatbots if they believe that they will dramatically enhance their performance of the tasks and present a range of benefits such as efficiency and usefulness of the banking operations as well as easy and fast transactions. The hypothesized statement would be

H1: *PE significantly affects the BI to adopt chatbots on Fintech Apps.*

4.2 Effort Expectancy (EE)

EE is an important predictor of people's tendency of using technology. It is about an individual's opinion about a given technology being easy to perform, thus not demanding both mental and physical efforts (Venkatesh et al., 2003). In other words, chances are that individuals adopt technology that has been viewed as easy to follow (Venkatesh et al., 2012). A significant component that influence behavioural intention has been identified as effort expectancy (Bin-Nashwan, 2022; Yeh et al., 2022 and Rahim et al., 2022). In other words, people's effort expectations would be central to the question of whether they would use chatbots. To the degree that chatbots were perceived to require no extra time involvement or learning strategy, the widespread purpose of using the stage would be greater (Sitthipon, 2022). Therefore, the bankers' inclination to implement chatbots may be increased with their convenience and usability. The hypothesized statement would be

H2: *EE significantly affects the BI to adopt chatbots on Fintech Apps.*

4.3 Social influence (SI)

Social psychology theories corroborate a belief about social factors which influence conduct. According to the conflict elaboration theories of social effect, group interactions change when an idea is accepted or rejected (Mugny et al., 1995). The most fundamental types of influence are identification,

internalisation, and compliance (Kelman, 1974). Social influence, as one of the models of technology adoption and usage describe, is the impact of, how other people perceptions affect the usage of technology (Venkatesh, Morris and et al, 2003). These are forms of user behavior according to research on technology which are highly based on expectations, preferences and inducements of others (Al-Saedi, Al-Emran and et al., 2020; Bin-Nashwan, S.A., 2022). Other studies have however reflects disagreement (Abbasi, Tiew and et al., 2021; Al-Hattami H.M. et al, 2023; Bouteraa, Raja Hisham and et al., 2022a; b; Bouteraa, Chekima and et al., 2023). The relative context analysis in the present work was driven by conflicting findings that revealed the situation dependence of peer impact. The idea that bankers' use of chatbots is encouraged by their colleagues is supported by the perception that chatbots are contemporary and modern. The hypothesized statement would be

H3: *SI significantly affects the BI to adopt chatbots on Fintech Apps.*

4.4 Facilitating Conditions (FC)

This variable is related to existence of the supporting infrastructure essential for the dissemination of a particular technology (Venkatesh, Thong & et al., 2012). Facilitating conditions are a prerequisite in the embracing the numerous technologies, which has come into view in the literature (Bouteraa, Raja and et al., 2022a; b; Chekima, Chekima and et al. 2020; Palau-Saumell, Forgas-Coll and et al. 2019). If chatbots are to be utilised effectively, users must be enabled with technical assistance, convenient user interface and valuable information (Sitthipon, 2022). This means that bankers would enjoy positive feelings and seamless platform experience if enough enablers were provided like technological know-how, internet connectivity and smart devices, professional advice and support, etc. The hypothesized statement would be

H4: *FC significantly affects the BI to adopt chatbots on Fintech Apps.*

4.5 Central Bank Support (BS)

As Torres et al. (2021) state, government support is financial and administrative support to which the introduction and adoption of new information technology are facilitated. Advertising technological applications of financial revolutions and infrastructure investment, the government can make a particular service more legitimate and reliable. A feeling of security is created by presence of assistance from government (Hu et al, 2019). By findings from empirical research, government support and technological adoption are highly correlated (Hu, Ding and et al., 2019; Kreydenko, Bogdanova and et al., 2020; Stone, Ashmore & et al., 2020). In the banking sphere, the AI application is a vogue topic. But support from the central bank is also needed for this arms race in technology, as

an institution attached to the government, which makes it simpler and more secure amongst users to adopt instrument. In the functional concept, chatbots employment in banks is a double-edged sword, so central bank support is needed. Governments can facilitate the development of standards for both AI and system interoperability, which alone has the potential to become a significant barrier in its own right, by minimising or obstructing the interplay. The central bank in its capacity as a relevant authority can help smooth integration of AI technology into existing financial systems as well as promote interoperability of different AI models or platforms; in this regard, standardisation of interfaces and protocols is to promote. Since they can easily combine chatbots with what they already have, the financial organisations might be more likely to use them. In the light of the foregoing, it is essential to analyze the role of central bank assistance as the moderating factor in the banking industry to use of the chatbots in view of offering informative data. Little research has studied the role of the function of government support as a moderator in the context of using the chatbots, though its viability as one of the moderating constructs was established (Haleem, Khan and et al., 2019; Li, Pak and et al. 2020; Yoon, Vonortas and et al., 2020). The hypothesized statement would be

H5: *BS significantly affects the BI to adopt chatbots on Fintech Apps.*

H5a: *BS significantly moderates the connection between PE and BI to adopt chatbots on Fintech Apps*

H5b: *BS significantly moderates the connection between EE and BI to adopt chatbots on Fintech Apps*

H5c: *BS significantly moderates the connection between SI and BI to adopt chatbots on Fintech Apps*

H5d: *BS significantly moderates the connection between FC and BI to adopt chatbots on Fintech Apps*

5. Data Analysis and Result

Smart PLS3 has inbuilt capabilities to demonstrate the descriptive statistics, the indicators demonstrate that after cleaning the data, there is no missing values, however performing the Mahala-Nobis test for each member of dataset 8 out of 410 were identified as multivariate outliers, after excluding (Tabachnick and Fidell, 2013) all the 8 multivariate cases, the valid cases for performing the model test were 402 cases.

By the demographic characterization of the respondents presented in table 2, a predominant number of males respondents (58.71%) were identified against the females (41.29%). The highest groups represented are between 35 and 45 years (29.85%), 25–35 years (24.63%) and less than 25 years (20.65%). As for education, most respondents possess a postgraduate (61.69%), a bit smaller number of bachelor degree holders (31.09%) and other elementary forms of education. In terms of job positions, cashiers and clerks make the biggest group (25.87%, 23.88%), followed by managers/officers, customer care, auditors, and others. About, half of respondents have up to both 5 years of work experience (48,76%); between 5 and 15 years figure out 31.84%.

Table 2: Demographic Profile

Variables	Category	Frequency	Percentage
Gender	Male	236	58.71%
	Female	166	41.29%
Age	Below 25	83	20.65%
	25-35	99	24.63%
	35-45	120	29.85%
	45-55	74	18.41%
	Above 55	26	6.47%
Education Level	Bachelor's Degree	125	31.09%
	Post Graduate Degree	248	61.69%
	Doctorate	3	0.75%
	Professional Degree	26	6.47%
Position at Job	Clerks	96	23.88%
	Cashier	104	25.87%
	Customer Support	39	9.70%
	Manager /Officer	52	12.94%
	Auditors	24	5.97%
	Other	87	21.64%
Experience	Upto 5 Years	196	48.76%
	Between 5 Years and 15 Years	128	31.84%
	Between 15 Years and 25 Years	40	9.95%
	Above 25 Years	38	9.45%

5.1 Measurement Model

This includes evaluation of discriminant validity of the measurement model HTMT (Heterotrait- Monotrait) in Table 5, convergent validity in terms of factor loadings and average variance extracted-AVE, and reliability in the form of composite reliability-CR (Hair et al., 2019). “The results for the retained item loadings for evaluating the model are exhibited on Table 3 and Table 4. they are concluded to be generally accepted since

the items have achieved the threshold levels for CR (≤ 0.7), AVE (≤ 0.5), and factor loading (≤ 0.5). One item BI1 had poor loading less than 0.5; it was therefore eliminated (Hair et al, 2019). All in all, the findings serve the validity of this measurement model. HTMT ratio (Kline, 2016) were used to determine discriminant validity.” There were no discriminant validity problems as Table 4 shows the HTMT value for each construct is 0.85 or below (Henseler et al., 2015) except the four.

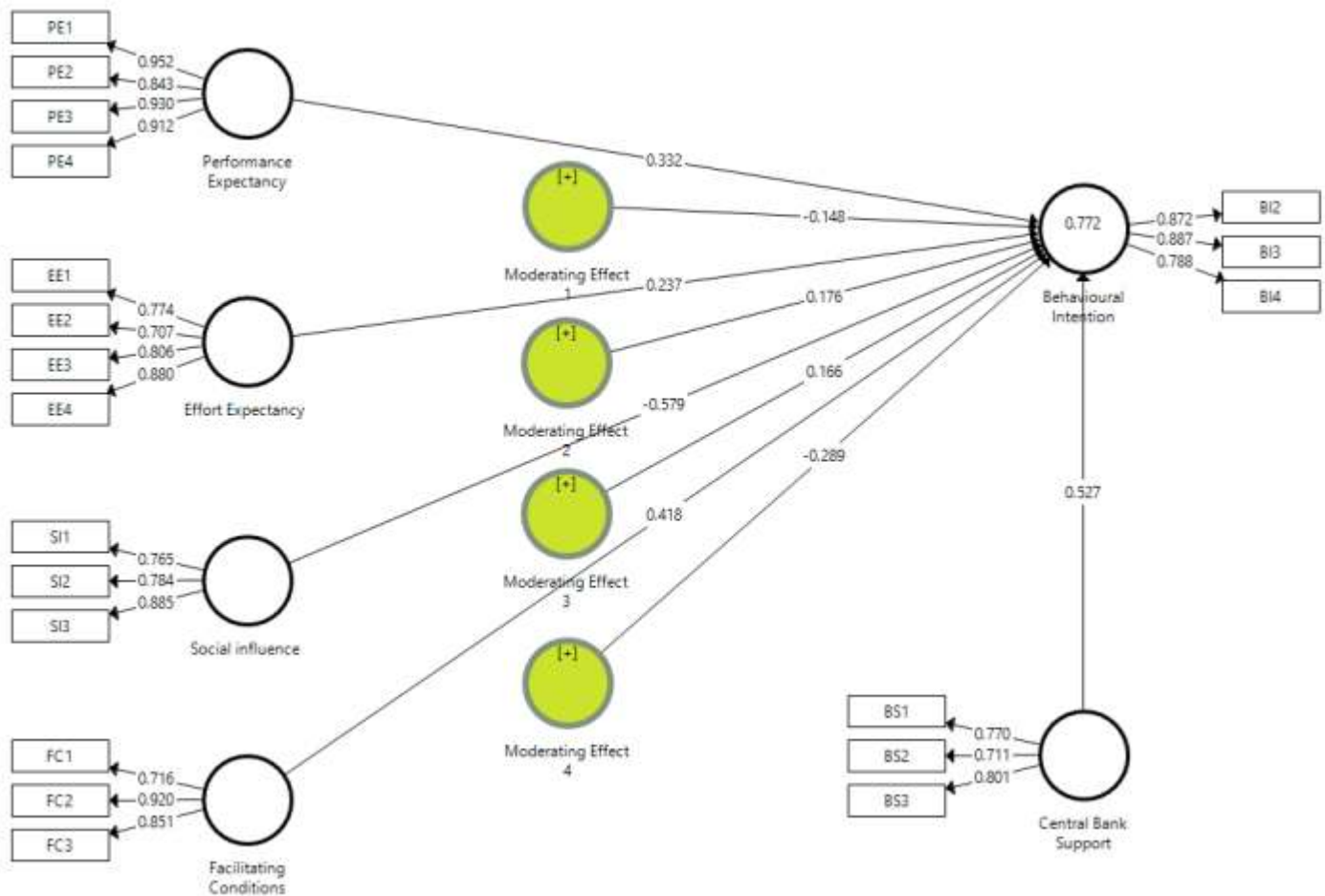


Figure 2: Measurement Model (Source: Authors' Work)

Table 3: Summary Result of Reliability (Source: Authors' Work)

Construct	Composite Reliability CR	Average Variance Extracted (AVE)
BI	0.886	0.723
BS	0.805	0.58
EE	0.872	0.631
FC	0.871	0.695
PE	0.951	0.829
SI	0.854	0.661

Table 4: Item Cross Loading (Source: Authors' Work)

Constructs	Indicators	Loadings
BI	BI2	0.872
	BI3	0.887
	BI4	0.788
BS	BS1	0.77
	BS2	0.711
	BS3	0.801
EE	EE1	0.774
	EE2	0.707
	EE3	0.806
	EE4	0.88
FC	FC1	0.716
	FC2	0.92
	FC3	0.851
PE	PE1	0.952
	PE2	0.843
	PE3	0.93
	PE4	0.912
SI	SI1	0.765
	SI2	0.784
	SI3	0.885

Note: Item BI1 excluded due to poor loading.

Table 5: HTMT (Heterotrait- Monotrait) (Source: Authors' Work)

	BI	BS	EE	FC	PE	SI
BI						
BS	0.994					
EE	0.757	0.801				
FC	0.812	0.954	0.58			
PE	0.73	0.548	0.625	0.452		
SI	0.685	0.931	0.717	0.956	0.496	

Table 6: Collinearity Statistics VIF (Source: Authors' Work)

Variables	VIF
BI2	2.171
BI3	2.276
BI4	1.439
BS1	1.179
BS2	1.376
BS3	1.341
EE1	2.431
EE2	2.044
EE3	1.695
EE4	2.048
FC1	1.525
FC2	2.851
FC3	2.136
PE1	5.713
PE2	2.306
PE3	4.849
PE4	3.823
SI1	1.248
SI2	1.971
SI3	2.168

5.2 Structural Model

After attaining adequate reliability and validity of the constructs in the measurement model, the predictive power and the significance of the path coefficient of the structural model were computed. VIF or variance inflation factor was used to check the collinearity in the exogenous variables. The most of the studies (Hair et al. 2021); A VIF should not be equal to 5 or greater, (Craney and Surles 2002) The VIF values for all the items except PE1 are less than 5 as indicated in Table 5, therefore there is no multicollinearity problems between the variables.

All hypotheses were tested with the help of the structural model analysis. To this piece of work, 5000 iterations of bootstrapping at 5% level of significance have been utilized which is in accordance with (Hair et al., 2021; Ringle et al., 2022). Table 7 indicates the outputs of the directly and moderated hypothesis tests. The value of R² and adjusted R² is found as 77.2% and 76.7% respectively.

5.3 Hypothesis Testing

Table 7: Hypothesis Testing (Source: Authors' Work)

Hypothesis	Relationship	Standard Deviation (STDEV)	t Statistics	p Values	Remark
H1	PE à BI	0.045	7.291	0	Supported
H2	EE à BI	0.063	3.792	0	Supported
H3	SI à BI	0.078	7.459	0	Supported
H4	FC à BI	0.072	5.84	0	Supported
H5	BS à BI	0.064	8.279	0	Supported
H5a	BS * PE à BI	0.049	3.012	0.003	Supported
H5b	BS * EE à BI	0.06	2.916	0.004	Supported
H5c	BS * SI à BI	0.064	2.57	0.01	Supported
H5d	BS * FC à BI	0.049	5.877	0	Supported

The direct paths are significant according to the path analysis thus confirming the hypotheses (H1 to H5). PE increases the BI to Fintech adoption positively ($\beta = 0.332, p < 0.000$). Also EE and BI are related to the use of Fintech ($\beta = 0.237, p < 0.000$). Besides, Social Influence (SI) has a strong negative relationship with BI in Fintech adoption ($\beta = -0.597, p < 0.000$). Moreover, (FC) has a high correlation with BI ($\beta = 0.418, p < 0.000$) and the same is true for Central Bank Support ($\beta = 0.527, p < 0.000$) and its relationship with intention to adopt fintech. These findings are an indication that EE, PE, TRUST, SI, FC and FL are however crucial in motivating the intention to adopt fintech platforms (fig 2).

5.4 Role of Moderators

Bank Support is identified to be the strong positive moderator for the relation between Effort Expectancy and Behavioural Intention ($\beta = 0.176, p < 0.004$), Social Influence and Behavioural Intention ($\beta = 0.166, p < 0.01$). The moderator analysis is carried out on Smart PLS; bank support system exist as a moderator between PE and BI and likewise other relations (EE and BI), (FC and BI), (SI and BI). Negative moderation significance has been detected between PE and BI as well as, in the case of FC, with regards to BI (fig 2).

6.1 Theoretical implications

A number of theoretical contributions can be attributed to this study, most importantly towards the development of the banking sector.

First and foremost, by using the UTAUT model, the study reaffirms its credibility and applicability in predicting the behavioural aspect of adjusting to change. It comprehensively shows how the factors of “performance expectancy, effort expectancy, social influence and facilitating conditions” affect the users' (banking employees in this case) behavioural intention to adopt new technologies like chatbots and Artificial intelligence tools readily.

Secondly, the study not only uses the standard aforementioned determinants and the Behavioural Intention of users provides the study substantial depth. It also adds significantly to existing literature since little to no research has been published taking into consideration the role of the Central Bank's support in the adoption of AI tools like Chatbots in the commercial banking sector.

In addition to this, by integrating numerical data (quantitative) with detailed contextual information (qualitative) by using a mixed methods approach, the study has accumulated a more holistic and nuanced understanding of the research problem. Through this, the study has proven that in this approach each method compensates the weaknesses of the other - While quantitative data may lack context and qualitative data may lack generalisability; together they make a balanced approach.

Therefore, this study has extended upon the existing literature in a meaningful manner by strengthening the knowledge of policy makers and researchers about the various factors that negatively affect or provide impetus to the adoption of AI tools and Chatbots in the banking sector.

6.2 Practical Implications

This study on the adoption of new technologies by banks offers invaluable insights into the factors that influence implementation, user acceptance and long-term strategic positioning. These findings are critical not just for academic understanding but for practical decision-making and policy formulation within financial institutions. This study will greatly enhance the knowledge of key decision makers, bankers, managers, institution heads, legislators and Central Bank executives; helping them in ascertaining and mitigating negative influencers and risks in new technology adoption.

Through the use of the UTAUT model the study has provided key areas which practically need strategic refinement. As per the study, performance or task efficiency, in the context of banking, translates to how effectively chatbots assist users in conducting transactions, retrieving account information, or resolving common issues. For banks, this means ensuring that chatbots are reliable, fast, and capable of providing accurate and helpful information. Marketing campaigns and customer education should highlight these benefits to reinforce the perceived usefulness of the chatbot. Some other factors highlighted by the study namely effort expectancy and facilitating conditions, refer to the ease of use associated with the technology. Banks should create a clear and responsive design so that the users would find the chatbot interface intuitive and user-friendly and are more likely to adopt it. Bankers should be provided with readily available human as well as technical support to ensure a seamless integration of new technology across all platforms such as bank websites, servers, applications, etc. Policy makers can infer from the study that the user's perception regarding the supportive organisational and technical infrastructure greatly impacts their readiness to adopt unfamiliar innovations. Banks should also capitalize on the impact of social influence on the user's behavioural intention to adopt Chatbots by promoting its usage through testimonials, endorsements, and encouraging front-line employees to recommend chatbot services during customer interactions. Creating a sense of community endorsement can positively shape user attitudes and increase adoption rates. The study by including the moderating construct has highlighted the practical implications of regulations set by government powered authorities such as the Central Bank. Thus, this study can help those key policy makers in formulating a supportive regulatory network for monitoring the adoption and implementation of AI tools such as Chatbots in banks.

7. Limitations

Although the study provides an extensive insightful analysis of the research problem, it has its limitations too. The study is industry specific i.e. focused on the banking sector and therefore it is possible that the results may not be applicable for other fields of work. Also, the population sample taken is entirely comprised of Indian users and thus the study lacks knowledge about differing results in other countries due to cultural and geographical disparities. The study also uses a single moderator but in actuality, there are various other moderating factors which affect the behavioural intention of the users which have not been taken into consideration at all. Lastly, the study primarily addresses initial adoption rather than continued use, satisfaction, or abandonment, which are increasingly important in digital technology studies.

8. Conclusion

The research has endeavoured to explore the factors responsible for the adoption of newer technologies in the banking set-up. This industry has a twin objective to enhance reach as well as the profitability. The previous studies focussed on the bank customers. But, this study aimed to study the perspectives of a banker as they are the in-house customers. The efficacy of any change lies in satisfying the internal customer so that it can be extended to the ultimate customers. The UTAUT model along with the central bank support as a moderator was used to explore the inherent reasons in the adoption or abdication of newer technologies. Where there is positive relation between performance expectancy, social influence and facilitating condition for behavioural intention to adopt newer technologies, effort expectancy is negatively correlated. The central bank support helps in building the trust towards the adoption.

It can be definitively said that this study has significant practical as well as theoretical implications and suggestions for every financial institution that is looking to integrate the use of artificial intelligence in its existing framework with as minimal friction as is possible. This will directly help bankers and subsequently lead to better customer satisfaction and enhanced demand fulfilment as well as increased profitability.

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Does ESG Infra-investment Act as a Catalyst for Corporate Climate Action and Net-Zero strategies? A Systematic Literature Review

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Abstract

As sustainability gains momentum in current infrastructural development, the necessity of ESG as a force to reach the ambitious goals becomes a priority. The targets laid out by countries, institutions and businesses aren't randomly chosen but scientifically formulated to assist in achieving sustainability and business sustainability. ESG reports serve as disclosures and assist in enhancing company performance, effectiveness, and dedication towards a solidarity drive towards sustainability. As firms proceed with such disclosures and growing frameworks, complexity also gets amplified. Furthermore, as complexity intensifies, so does the need to greenwash and green shift. It is thus critical to examine whether such frameworks effectively assist organisations in reaching the devised Corporate Climate Initiatives.

This research will seek to realize ESG infra-investment and its effectiveness in assisting organizations attain certain corporate climate agendas, culminating in an effort to complement the country's agenda towards the green and sustainable economy. Systematic Literature Review (SLR) will facilitate the identification of challenges in using ESG approaches and frameworks within business plans. The SLR will further analyze the relationship between ESG investments and their relation to Corporate Climate Action and Net-Zero goals. This research will be aiming to identify gaps in ESG infra-investment, thereby offering direction towards further research. We will determine major opportunities, risks having the potential to affect resource deployment and goal-setting through the SLR. The results will assist stakeholders such as academicians, investors, policymakers, entrepreneurs, and value chain partners in making ESG compliance both effective and sustainable.

Keywords: ESG infra-investments, Corporate Climate Action, Net-Zero targets, Climate finance, emissions reduction, ESG compliance, Target-setting, GHG accounting, Systematic Literature Review

Introduction

The growing global climate emergency has put corporations in the central position to drive the change toward a low-carbon economy. As countries and sectors sign up for net-zero ambitions, aligning Environmental, Social, and Governance (ESG) principles with investment choices, especially in infrastructure, has become a key driver of sustainable change. ESG infrastructure investment, including green energy, sustainable mobility, climate-resilient urban planning, and climate-adaptive technologies, is increasingly valued not just for its environmental worth but also for its strategic importance in aligning business operations with long-term climate objectives.

ESG infrastructure investment finances new developments and R&D in waste management, recycling, circular business models,

and emission reduction (Scope 1, 2, and 3). It also involves the creation of substitute carbon-heavy materials, sustainable supply chains, climate finance, and GHG accounting, fueling economic growth and environmental care. With increasing businesses, increasing urbanization, and the necessity to achieve ESG compliance to encompass the triple bottom line, it is imperative to gauge ESG infra-investments' success at their early stage. Given the transformational impact of ESG-aligned infrastructure investment, it is crucial to understand its role in the effective design of policies, influence over investor behavior, and facilitating corporates to achieve quantifiable decarbonization progress. As much as corporate sustainability rhetoric is now dominated by ESG disclosures and carbon-neutral pledges, the following outstanding issue remains under-

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researched: "Does ESG infra-investment function as a true spur to corporate climate action and net-zero plans, or are reputational and compliance imperatives the dominant drivers?".

In response to this question, the research utilizes a Systematic Literature review methodology. Global ESG assets valued over \$30 trillion in 2022 are expected to reach over \$40 trillion by 2030, according to Bloomberg Intelligence (BI). This would represent more than 35% of the estimated \$140 trillion of assets under management and reflects unequivocally the shift towards responsible and sustainable investing (Bloomberg Intelligence, 2024). Supporters urge that ESG infrastructure investments, like green bonds for wind farms or hydrogen-ready steel mills, can reduce emissions while generating financial returns (Rahman et al., 2023). Opponents argue that most companies practice "greenwashing"—making ESG disclosures to promote reputation without meaningful climate effect (Berg et al., 2022). The Intergovernmental Panel on Climate Change (IPCC) urges that reducing the global rise in temperature to 1.5°C will mean cutting emissions in half by 2030 (IPCC, 2023).

Businesses, accountable for nearly 70% of worldwide CO₂ emissions (CDP, 2023), are under increasing pressure to bring investments into line with SBTi (science-based targets). However, research indicates that just 20% of the Fortune 500 companies have legitimate net-zero strategies (SBTi, 2023). This sets the stage for the study to learn, grasp, and close the gap that exists in realizing net-zero objectives through effective ESG compliance monitors and frameworks. Companies such as Ørsted and NextEra Energy employed ESG-tied capital or ESG Infra-investment (as we discuss and argue in this paper) to shift from traditional sources of power to renewable energy, proving that sustainable finance may be the catalyst for systemic transformation (IEA, 2023). On the other hand, most companies view ESG as a tick-box exercise, focusing on short-term regulatory compliance at the expense of long-term decarbonization (Eccles et al., 2020).

By closing the gap between the theory of ESG investment and business climate practice, this research hopes to add to the dynamic debate on sustainable finance and provide the working guidance for companies looking to convert ESG promises into effective environmental actions. In a nutshell, the long-term objective of this LR is to embrace a forward-looking mindset instead of the defensive approach.

Most of the time, a common wisdom has revealed the redundancy of frameworks, insufficient structured and consistent frameworks, and the greatest challenge of all are endless policy reforms. This renders strategizing and standardizing not only a problem but an impediment to the organisations. Rolling out ESG, Corporate Climate strategies, or

Net-zero technologies entails resources, time, and human capital.

Under SEBI (Securities and Exchange Board of India), a strict document citing the norms and regulations of ESG has indeed been declared, and its advantages to the resource management of the companies, waste management, and environmental management are surely guaranteed. However, its efficacy and its real benefits are still doubtful in the market.

As per the Paris Agreement, it was unanimously agreed to curb the global temperatures way below 2 degrees Celsius and ideally restrict it to 1.5 degrees Celsius above pre-industrial levels.

Countries around the world have been working towards the same and restoring their individual Net-Zero targets. Of them, India aims for Net-Zero by 2070, and such loud targets can be met only when every sector of the country is involved in active target setting. Likewise, organizations, MSMEs, SME's and MNCs need to set realistic and, more importantly, science-based targets that are not only feasible, but attainable and achievable. ESG being a tool, it assists an organization to accomplish just that, and this research is concerned about comprehending its efficacy quotient and comprehend if ESG by itself can assist enterprises in achieving their as well as assist the nation in becoming Net-Zero as well as initiating steps to de-escalate the effects of Climate change and become resilient or much better proactive towards improvement.

Primarily, the research approaches employed are a combination of qualitative and quantitative research; from country-level databases, projection models, baseline studies, Ordinary Least Squares, Empirical analysis, moderation analysis, climate vulnerability index, etc. This research examines various such models and approaches cautiously to evaluate the advantages as well as the drawbacks of each study. A cautious analysis also concludes on various other variables influencing the effectiveness of ESG application for corporate climate action and climate change mitigation strategies which the gap analysis exhaustively addresses.

Finally, for improved efficiency, there must be a globally approved entity with nationalized standards and an abiding agency. A sustainable and progressive model must be developed with measurable and quantifiable criteria that provides incentives or reward to the organisations more than charity alone, and scaled up towards equal access to resources and sustainability in business.

Literature Review

The most glaring criticism against ESG frameworks has been their failure to deliver quantifiable financial and non-financial

advantages from the point of view of investors and organisations, and is a nobler cause than one that is profitable and sustainable. Nevertheless, early results of the research indicate that there is a positive correlation between funding green bonds in renewable ventures such as solar/wind/geothermal and contributes to a dramatic 15 % reduction in emissions that its competitors or peers (Tang & Zhang, 2020). Additionally, the cement and steel industries significantly overestimate their ESG infra-investments, and their actual decarbonization is virtually as close to zero. (Cregan et al., 2024) Financial institutional investors have increasingly exhibited a preference for ESG-compliant companies and punish poorly performing companies in their ESG infrastructure expenditure (Dyck et al., 2019). This information, however, is extremely country and region-specific.

ESG parameters include a broad range of sustainability-related or key material risks and issues that go beyond traditional financial metrics. Institutions' ESG performance is becoming a growing focal point in financial markets, where investors decide and manage their investments also based on ESG criteria (Riedl and Smeets, 2017; Amel-Zadeh and Serafeim, 2018; Aureli et al., 2020).

ESG ratings more and more emerge as the only authenticity standard for ESG-compliant companies and form the necessity of informed investor choices. (Brooks and Oikonomou, 2018) The redundancy and incomparability, however, result from sophisticated frameworks, materiality assessments that are incomplete, and absence of ESG performance analysis (Madison and Schiehl, 2021).

(Changyi Zhu et al., 2025; David L. Deephouse et al., 2013) addresses the connection between the strategic value of incorporating ESG factors in family business financial planning and deviations from non-family businesses. It elaborates at length on how family control positively affects financial performance in Chinese family businesses and how their socioemotional wealth shapes ESG participation. Utilizing regression models and mediation analysis through control variables of firm size, leverage, age of firm, fixed asset ratio, growth rate, and rate of turnover. The research posits that policy makers and regulating agencies need to provide incentives as well as calibrate disclosure norms in order to induce the usage of ESG by family businesses. 1,181 Chinese family businesses were examined and determined that ESG engagement has a huge positive impact on financial performance and serves as a mediator of family control to profitability. This dynamic is explained by the socioemotional wealth (SEW) framework, as families are intent on protecting their heritage and reputation through sustainable means. Supporting this result, Sitompul et

al. examine Indonesian food and beverage firms' sustainability reports and find a positive correlation between carbon management initiatives and profitability and sales growth. In their analysis, they find six strategic pillars—carbon governance, reduction, removal, compensation, competitiveness, and legitimacy—that together drive enhanced business results. Both papers highlight how ESG, when deployed strategically in alignment with firm values and sector realities, drives competitive advantage. Yet, their application is restricted to narrow geographies and industries, possibly limiting the applicability of outcomes across more extensive corporate domains.

(Cleiton Hluszko et al., Sustainability in practice, 2024) proposes the same results on the Latin American organisations and emphasizes, as well as assesses, the connection between ESG matters and measures adopted for sustainable development in the Latin American Companies. 79 firms from Peru, Brazil, Mexico, Chile, Colombia, and Argentina, and their sustainability reports are analyzed according to their respective material issues and ESG infra-investments towards adoption of renewable energy, training of stakeholders, sustainable selection of suppliers, management of risks, environmental impact studies, and social initiatives for local communities. The research emphasized strengthening indicators, speeding up the sustainable transition, and making ESG topics mainstream in supplier selection and occupational safety.

(The Link Between ESG Performance and Earnings Quality, Valentina Tohang et al., 2024) investigates the correlation of that with Earnings Quality in the digital industry in Asia and discovered that ESG performance is positively correlated with discretionary accruals and negatively with inherent earnings quality. Fixed effect panel data of 79 listed telecommunication services companies in Asia are utilized for conducting quantitative research, and ESG performances and ratings are captured by EQ with control variables such as firm size, leverage ratio, return on assets, and other financial metrics. The research seeks to examine the determinants of EQ, such as the inherent operating environment and risk of the industry business process (innate factors) and management reporting decision (manager's discretion). In essence, it implies that "greenwashing" activities employed as symbolic ESG practices can have a negative impact on the Earnings Quality (EQ) when considered from the operations and uncertainty risks of an organization. It also explained the way CSR (Corporate Social Responsibility) and other social elements of ESG contribute constructively towards both intrinsic and discretionary profits, and this constructive relationship also assists in affixing quantifiable parametric evidence to comprehending benefits to society and various stakeholders involved in the impact radius of any organization.

In another research (Jinchi Dong et al., 2023) emphasis is intentionally on comprehending decarbonisation policies or Net-Zero policies and CBA (cost-benefit analysis) for energy-intensive industries of China to achieve national Climate Targets. This research is of vital importance and offers a direct parameter to comprehend, measure as well and compare target setting with performances through CBA. The research employs the MESSAGEix-CAEP model and China Carbon Neutrization Technology Database (CNTD) to analyze various abatement scenarios and consequences. It provides insight into the marginal cost of abating climate change via carbon neutrality and analyzes sectorally the most lucrative plus valuable abatement option. One of the most important findings of this research discusses the increased CO2 emissions by 2029 under the stable carbon neutrality baseline study, and the use of coal will reduce, and then iron and steel usage will increase. Even though there appears to be the lowest marginal abatement costs with the power sector, on the other hand, electrification process would mean a huge power demand increase.

One of the biggest criticisms, however, has been that emissions scores are not transparent in representing the reality of the environmental performance of an organization (Charlie Cregan et al., 2024). The study examines data for 75 steel producers that account for 65% of world production, and data are collected from company reports and third-party sources. Some of the key variables are GHG emissions, emissions intensity, investment in low-carbon operations, and green steel initiatives, which were analyzed using the Ordinary Least Squares (OLS) regression models to evaluate the scores and emissions/investment data relationship. There is a worrying dearth in methodological disclosure by ratings providers of firm-level carbon emissions and investment in low-carbon production or ESG infra-investments. Lacking significant evidence, that investments or emissions scores or absolute scores.

Net-zero by 2050 for heavy industries (iron & steel, clinker & cement, chemicals, and pulp & paper) in the overall global net-zero carbon scenario is highly improbable because residual emissions appear unavoidable (Mariësse A.E. van Sluisveld et al., 2021). The model is applied to model the interactions between society, the biosphere, and the climate system. The model contains projections of the iron & steel, clinker & cement, chemicals, and pulp & paper industries. The researchers experiment with four alternative decarbonisation stories: Technology Replacement, Process Efficiency, Demand Management, and Circular Economy. They examine the reactions of the model to the different stories in various regions. For 6 various world regions with the IMAGE integrated assessment model, the decarbonisation policies are tried, and asserted that only when net-negative emissions are realized in the power and energy sectors by 2040, the indirect emission

removal will be able to offset remaining emissions in the heavy industrial sectors. (Maria Jose de Villafranca Casas et al., 2024) On the same subject, 60 major steel manufacturers were analyzed and their GHG reduction targets were analyzed to determine the target settings' robustness, status, and likely influence as regards CO2 emission reduction in particular in the steel sector.

The evaluation targeted the 60 largest steel producers in volume, accounting for more than 60% of the world's total steel production. The study examined the target-setting, target ambition, and implementation plans of the 60 firms. Emission reduction pathways were projected under various scenarios, ranging from a baseline scenario to a target scenario. Just 30 out of 60 had reduction targets, and steel firms are behind in implementing transparent emission cutback plans by putting in place reachable and detailed goals for their company, with some even trailing a planned or agenda. Most trending infra-investments among the emission reduction plans are hydrogen-based DRI, increased deployment of renewable power, and Carbon Capture Utilization and Storage (CCU/S) for blast furnaces. (F. Berg et al., 2022) Examine divergence of SG ratings from 6 major agencies and determine whether the methods are effective.

The research design is to break down rating divergence into scope, measurement, and weight contributions based on a shared taxonomy. A sample of traits consisted of 924 companies and six rating agencies in 2014. Data collection consists of indicators from six rating agencies translated into sixty-four categories. Applying methods such as non-negative least squares regression to make estimations of weights for aggregation, it concluded that measurement divergence is the primary source of rating divergence (56%), followed by scope divergence (38%) and weight divergence (6%). Statistical analyses indicate a very large rater effect or bias affecting measurement divergence. Strong ESG practices are broadly linked to better financial performance like Return on Equity (ROE), Return on Assets (ROA), and sales growth.

For example, De Lucia, Pazienza, and Bartlett (2021) discovered that ESG drivers such as environmental innovation, staff productivity, and governance by the board had a positive impact on financial performance in European state-owned enterprises. In a similar way, Sitompul et al. (2022) illustrated that carbon reduction and governance practices in Indonesian food and beverage companies resulted in enhanced profitability and revenue. Also, Chen, Mussalli, and Mahdavi (2021) pointed out that ESG investing, if grounded on material and sector-specific considerations, might improve financial returns (alpha), particularly when combined with sophisticated data methods such as NLP and portfolio optimization.

A perennial issue in ESG studies is greenwashing—when companies achieve high ESG ratings without concomitant environmental outcomes. Treepongkaruna et al. (2021) studied U.S. companies and determined that there was no significant correlation between ESG rankings and lower carbon emissions, supporting the greenwashing hypothesis. Foley et al. (2022) blamed this phenomenon on ethical missteps and lack of transparency in business ESG conduct. Additionally, Plastun et al. (2022) observed that there are inconsistencies between ESG rating methodologies that further lead to misrepresentation and misinterpretation of ESG performance, which further erodes credibility.

Döttling and Kim (2021) uncovered how retail ESG investment is susceptible to financial pressure, such as during the COVID-19 crisis, when retail investors quickly withdrew from ESG funds. Institutional investors, on the other hand, stuck with them, employing ESG as a long-term risk-reduction strategy. The research highlights the dual drivers—financial and ethical—behind ESG investing, but indicates that retail

preference can act like a luxury product, pricing in to declines and crises.

Several studies underscore the critical importance of world ESG standardization. Plastun et al. (2022) analyzed over 650 ESG rating products and 300 or more investment products and discovered high levels of heterogeneity in definitions of ESG, scoring frameworks, and regulation requirements. This fragmentation constrains comparability and hampers global integration of ESG. Foley et al. (2022) and Chen et al. (2021) further emphasized that without harmonized standards and transparent benchmarks, investors and businesses are not able to effectively implement effective ESG strategies and measure actual sustainability performance.

To better understand the key findings and relationships between ESG, Corporate Climate Action and Net-Zero strategies, a TCCM (Theory, Context, Characteristics and Methodology) framework is used to gauge the baseline for the same (Table 1).

Table 1 : TCCM Framework for existing Literature Review

Dimension	Description	Supporting Studies
T – Theory		
Legitimacy Theory	Firms use ESG disclosures to align with societal norms and expectations, sometimes superficially (greenwashing). ESG is sometimes used symbolically (greenwashing), improving external perception while masking poor internal EQ	Treepongkaruna et al. (Greenwashing, Carbon Emission, and ESG) Tohang et al. (ESG & Earnings Quality), Cregan et al. (Steel Industry Ratings)
Stakeholder Theory	Emphasizes the role of firms in addressing the interests of all stakeholders, not just shareholders.	Sitompul et al., Foley et al., Plastun et al. Zhu et al. (Family Firms & ESG), Hluszko et al. (Latin American ESG Practices)
Institutional Theory	Institutional quality and governance structures influence ESG implementation and impact.	Alam et al., Plastun et al. González-Pozo et al. (ESG Methodology Reform), Dong et al. (China's Decarbonization)
Socioemotional Wealth Theory	Emotional goals of family firms (e.g., identity, reputation) drive ESG engagement and financial outcomes.	Zhu et al. David L. Deephouse et al., 2013
Just Transition Ethics	Ethical framework guiding equitable transition to sustainable economies.	Foley et al.
Risk Management Theory	ESG investing serves as a hedge against systemic and reputational risks.	Döttling & Kim, Alam et al. van Sluisveld et al. (Heavy Industry Decarbonization), Cregan et al. (Steel Industry)

Resource-Based View (RBV)	ESG capabilities as intangible resources that enhance firm performance.	De Lucia et al., Chen et al. Zhu et al. (Family Firms & ESG), Tohang et al. (ESG & Earnings Quality)
Cost-Benefit Analysis Framework	Used to assess the financial and social trade-offs of climate strategies.	Dong et al.
Sustainability Paradigm	Aligning corporate strategies with long term ecological and social sustainability goals.	Sitompul et al., Chen et al., Plastun et al. Hluszko et al. (Latin America), Dong et al. (China's Carbon Neutrality)
C – Context		
Geographic Context	Studies span across global, regional (EU, US), and country-specific (Indonesia) levels, China, Latin America, EU, Asia	Alam et al., Döttling & Kim, Sitompul et al., De Lucia et al., Plastun et al.
Industry Context	Financial services, food and beverage, public enterprises, investment funds, and ESG rating agencies. Family firms, telecom, utilities, heavy industry (steel, cement, chemicals), ESG rating agencies.	Multiple
Temporal Scope	Data spans 1995–2025; COVID-19 serves as a stress test in investor behavior studies.	Döttling & Kim, Alam et al. Zhu et al. (2016–2020), Villafranca et al. (2022), Dong et al. (2020–2060 projections)
C – Characteristics		
ESG Practices & Readiness	Measurement and assessment of ESG scores and national/corporate ESG preparedness.	Alam et al., De Lucia et al., Chen et al. Hluszko et al. (Latin America), González-Pozo et al. (Methodology Reform)
Financial Performance	ROA, ROE, profitability, and sales growth are analyzed as outcomes of ESG actions.	De Lucia et al., Sitompul et al. Zhu et al. (Family Firms), Tohang et al. (Earnings Quality)
Greenwashing	Explored as a misrepresentation of ESG effectiveness in emissions.	Treepongkaruna et al. Cregan et al. (Steel Ratings), Tohang et al. (Symbolic ESG Practices)
Carbon Strategies	Investigated carbon governance, reduction, removal, and legitimacy.	Sitompul et al. Dong et al. (China), van Sluisveld et al. (Heavy Industry)
Investor Behavior	Institutional vs. retail investment patterns in ESG, especially during crises.	Döttling & Kim González-Pozo et al. (Investor Preferences), Zhu et al. (Family Firm Investments)
Standardization & Regulation	Classification and analysis of ESG benchmarks and investment standards.	Plastun et al. Villafranca et al. (Steel Targets), Dong et al. (China's Policy)

Ethics & Governance	Role of just transition ethics, board tenure, and policy transparency in ESG success.	Foley et al., De Lucia et al.
Emissions & Climate Strategy	Direct and indirect emissions, decarbonization roadmaps, and technology adoption.	Dong et al., Casas et al., Cregan et al., van Sluisveld et al.
ESG Ratings & Methodology Critique	Gaps between ESG scores and actual firm performance call for rating reform.	Cregan et al., González-Pozo et al.
Net-Zero and Carbon Neutrality	Feasibility, ambition, and gaps in heavy industry net-zero trajectories.	Casas et al., van Sluisveld et al.
Investment in Decarbonization	Relationship between climate ratings and actual investment in low-carbon solutions.	Cregan et al.
ESG as Strategic Resource	ESG leveraged for long-term positioning and stakeholder legitimacy.	Zhu et al., González-Pozo et al.
M – Methodology		
Quantitative Analysis	Regression (logistic, ordered), Granger causality, PSM, empirical tests.	Alam et al., Treepongkaruna et al., De Lucia et al. Zhu et al. (Family Firms), Tohang et al. (Earnings Quality), Cregan et al. (OLS)
Machine Learning (ML)	Random Forest, SVM, k-NN, Ridge, ANN for ESG-finance modeling.	De Lucia et al.
Scenario Modeling	IMAGE, MESSAGEix-CAEP for decarbonization pathways.	van Sluisveld et al. (Heavy Industry), Dong et al. (China)
Natural Language Processing (NLP)	Corporate sentiment analysis for ESG insights.	Chen et al.
Content Analysis	Analysis of corporate sustainability and carbon strategy reports.	Sitompul et al. Hluszko et al. (Latin America), Villafranca et al. (Steel Targets)
Behavioral Analysis	Mutual fund flows, retail vs. institutional behavior, Google search trends during COVID-19.	Döttling & Kim
Conceptual & Normative	Ethical framework development through literature synthesis.	Foley et al., Plastun et al. González-Pozo et al. (ESG Methodology), Foley et al. (Just Transition)
Data Sources	ESG scores (Refinitiv, Morningstar, ASSET4), carbon emissions, firm-level data, and policy databases.	Multiple
Regression Analysis	Used to explore mediating/moderating effects between ESG and performance variables.	Zhu et al., Cregan et al.
Integrated Assessment Models (IAMs)	Long-term decarbonization modeling under various narratives.	van Sluisveld et al.
Multi-Criteria Decision-Making (MCDM)	Extended Best-Worst Method (BWM) for ESG ratings construction.	González-Pozo et al.

Gap Analysis

The essential omission throughout the literature is the low generalizability of results. Research is extremely region-specific or sector-specific. Likewise, Casas et al. restrict their examination to the 60 largest international steel corporations. Though these specialized settings provide richness, they heavily limit the expendability of results to geographies other than, sectors other than, and organizations other than.

There appears to be comparability unavailability for cross-sectoral/ country data to examine ESG performance relationships thus there is a necessity of using larger samples.

Vague treatment of ESG constructs and measurement inconsistency, as a number of studies, like those by Cregan et al. and González-Pozo et al., indicate that ESG ratings tend not to be methodologically transparent and do not necessarily capture firms' actual environmental or social impacts. Tohang et al. show that strong ESG scores may coexist with low earnings quality (or EQ) because of symbolic or cosmetic ESG practices. Concerns about greenwashing therefore increase and mislead stakeholders. There should be a standardized agency between rating companies that is strong, transparent, and inclusive of all metrics.

The lack of longitudinal and dynamic analyses is a further restriction. Although the majority of research employs panel data or cross-sectional designs, few monitor the development of ESG strategies and climate performance over extensive time horizons. Since the integration of ESG often involves a progression influenced by changing regulations, stakeholder demands, and internal cultural transformation, short-term studies may overlook the complete strategic and financial effects of ESG integration.

A giant void in depth in probing internal organizational dynamics like governance models, family generational changes, or board compositions, variables that might have a direct impact on ESG adoption and validity. Similarly, hardly any studies examine how internal organizational incentives, manager cognition, or ethical leadership come into play in the effective implementation and genuineness of ESG practices, which would be crucial in separating symbolism from real sustainability change.

Another limitation is the poor inclusion of Scope 3 emissions and end-to-end value-chain effects in climate-focused ESG analysis. For example, although Casas et al. evaluate carbon targets across steel firms, they exclude Scope 3 emissions as well as wider supply-chain factors. Studies that factor in upstream and downstream emissions data, supply chain ESG practices, and lifecycle assessment would present a better understanding of corporate net-zero progress.

Lastly, there is a significant absence of research into the policy and institutional drivers of ESG success, even though there are evident signs that institutional and regulatory quality have an impact on ESG performance. Although some authors recognize this, as González-Pozo et al. in their demand for better rating methodologies and policy standards, the relationship between public policy, corporate conduct, and ESG performance is under-theorized and under-researched. It is important to understand how governments, multilateral institutions, and financial regulators might encourage more effective incentive for substantial ESG integration, particularly in industries such as heavy industry that are behind their own decarbonization trajectories.

Conclusion/Way Forward

The Literature review gave us an understanding of the gaps that currently exist when it comes to successfully achieving Corporate Climate Strategies and accomplishing Net-Zero actions using ESG strategies. We tried to answer questions on how or whether they are actually effective, how they can be improved, what the parameters defining these evaluations and many more. We also identified the constraints of scope, depth, transparency, bias, and standardization that currently exist in ESG disclosures and climate action target setting.

Further research should focus on improving the current matrices and metrics, making them more inclusive, developing better models to study both quantitative as well qualitative ESG performances and focusing on the later when it comes to evaluating or monitoring corrective actions towards Net-Zero goals as well as enhance the reporting framework by working cumulatively on policy integration and global quantification of impact and abatement measures.

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Behavioural Biometrics in India: Overcoming Adoption Challenges and Opportunities

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Abstract

Being a sophisticated tool, Behavioural biometrics is widening its range more efficiently in Indian financial sector, increasing cyber threats. The cyber threats have been growing majorly in conventional authentication ways like passwords and fingerprints etc. It emphasis more on dynamic user interaction movements such like typing speed and touchscreen pressure to have a secured transactions. AI and machine learning integration enhances adaptability and accuracy remarkably in such complex systems nowadays quite effectively. Behavioural biometrics faces myriad adoption hurdles in India such as gnarled legacy system integration issues and steep costs and thorny data privacy concerns. Behavioural biometrics in India undergoes systematic analysis focusing on drivers, challenges and future directions within a regulatory landscape and assorted case studies. It culminates in rather detailed suggestions for facilitating sustainable growth and wider implementation by banks policy makers, tech firms and various researchers.

Keywords: Behavioural Biometrics, Financial Sector, Cybersecurity, Fraud Detection, India, Digital Transformation, Artificial Intelligence, Regulatory Frameworks

Introduction

The global financial landscape has undergone a drastic shift over the past decade, with transactions rapidly supplanting traditional banking norms. India has swiftly adopted digital payment technologies, largely due to initiatives such as Digital India and the Unified Payments Interface, amidst widespread smartphone penetration and affordable internet. The National Payments Corporation of India (NPCI) announced that UPI processed over 10 billion transactions in 2023, remarkably in just one month, showcasing a significant shift towards a cashless economy. However, digital financial crimes have surged markedly amidst this rapid shift towards a digital landscape. India reported over 9,100 cases of bank fraud in 2022 alone, which led to losses exceeding 604 billion Indian rupees (Statista, 2023). Such cases encompass a myriad of dodgy schemes, ranging from phishing and sophisticated social engineering tactics to highly advanced identity theft tactics leveraging Generative AI. Traditional security controls, such as passwords and one-time passwords, are no longer strong enough against

highly sophisticated cyber threats. Behavioural biometrics presents an intriguing solution amidst such challenges. Behavioural biometrics scrutinizes users' habitual interactions with devices, verifying identity in real-time, unlike static indicators such as fingerprints or iris scans. Typing patterns, mouse movements, and touch screen usage create unique behavioural signatures that are extremely hard for scammers to replicate accurately. The rising sophistication of cyberattacks, combined with the size of India digital economy, requires more intelligent, stronger, and more flexible security measures. Traditional authentication techniques based on static credentials are not well-placed to address the fast-evolving fraud tactics, ranging from phishing, account takeovers, and spoofing attacks fuelled by AI. Though behavioural biometrics is full of promise, it has come slowly in vogue, primarily because of high costs, integration complexities, privacy risks, and general consumer illiteracy.

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If more sophisticated authentication methods are not universally applied, then the financial institutions, risk increased by fraud losses, reputational damage, and even regulatory penalties. It is essential to study the efficacy of behavioural biometrics, the barriers to its implementation, and ways to promote its greater adoption in India's unique economic, social, and technological context.

This paper studies the advantages of behavioural biometrics in Indian financial institutions and banking sectors. It reviews the technology itself, examines the world and Indian adoption patterns, scrutinizes the driving factors, and evaluates the prime challenges. The paper also investigates case studies of successful deployments, examines regulatory developments, forecasts market growth, and concludes with bespoke strategic suggestions for different stakeholders.

Though the initial focus is on financial services, the learning thus obtained could be applicable to ancillary domains like e-commerce, healthcare, insurance, and public services that are increasingly relying on secure electronic transactions.

Literature Review

The fields of biometric security and human-computer interface (HCI) are the foundation of behavioural biometrics. In contrast to physiological biometrics, which depend on quantifiable physical traits (such as fingerprints or facial features), behavioural biometrics relies on changing behavioural patterns that develop over time yet remain distinctly recognizable.

Recent research shows that human behaviour patterns—such as typing method, language, rhythm, mouse movements, or mobile device actions—could play a significant role in inimitability and act as effective validating indicators. We could use statistical methods and machine language to study the patterns of human behavior.

Ahmed and Elhoseny (2020) showed that implementing behavioural biometric systems resulted in a 30% reduction in fraud incidents within North African banks. They highlighted the system's potential to facilitate passive authentication for financial institutions. Kumar, Gupta, and Sharma (2022) found a 25% reduction in unauthorized banking activities following the integration of behavioural biometrics. They emphasized that this advancement boosted customer satisfaction through more fluid authentication processes. Ravi, Singh, and Rathi (2018) examined the challenges of implementing behavioural biometrics in traditional banking environments, specifically with respect to legacy IT infrastructures.

Singh and Rathi (2021) solved the ethical issues related to the harvesting of behavioural data. They emphasized the importance of minimization of data, consent with knowledge, and educating users. Verma (2022) explored cost considerations

for Indian banks and found that although a large return on investment is presented by behavioural biometrics, modular pricing models must be implemented in order to enable large-scale uptake.

BioCatch (2024) published that more than \$1 billion in possible fraud was prevented via real-time behavioural analysis, confirming the necessity for continuous risk assessment. Singh and Gupta (2021) assessed the financial benefits against the cost of introducing behavioural biometric systems in Indian fintech firms, concluding that long-term benefits exceed initial costs.

Mordor Intelligence (2023) predicted a 27% compound annual growth rate (CAGR) for the global market for behavioural biometrics, driven by innovation in the banking and fintech sectors. Mastercard (2024) identified a 60% drop in mobile fraud cases due to the application of behavioural patterns within a mobile authentication analysis. Statista (2023) provided statistical information on the Indian digital fraud ecosystem, highlighting behavioural biometrics as a top upcoming technology for fraud prevention.

Wang et al. (2019) contrasted physical biometric systems with behavioural biometrics and determined that the latter is better suited for real-time fraud identification. Biometrics Institute (2023) revealed that 65% of banks globally are now testing or implementing behavioural biometrics. Chowdhury and Ahmed (2021) examined the application of behavioural biometrics in mobile banking in Bangladesh and India and found that user interface design has a strong impact on data accuracy.

Ali and Rahman (2020) assessed the feasibility of behavioural biometrics in low-connectivity environments and suggested hybrid solutions for implementation in rural areas. Grant Thornton Bharat (2024) highlighted the compatibility of behavioural biometrics with the Reserve Bank of India's guidelines on strong customer authentication (SCA). NASSCOM-AI Taskforce (2022) proposed ethical standards for AI-based biometric technologies, recommending a privacy-oriented approach in the use of behavioural biometrics.

The FIDO Alliance (2023) emphasized behavioural biometrics as a crucial element in their promotion of password-less authentication methods. Chandra and Arora (2021) designed a deep learning-based behavioural profiling model that recorded an impressive 92% accuracy within Indian banking environments. RBI Cybersecurity Framework (2020) encouraged banks to implement AI-driven adaptive authentication solutions, which implicitly advocated the utilization of behavioural analytics. Jain et al. (2021) designed a hybrid behavioural biometric system using keystroke and mouse dynamics that recorded high precision in Indian academic login systems.

Biometrics Institute (2023) survey discovered that 65% of global financial institutions were either fully implementing behavioural biometrics or were testing it somehow. The deployment of behavioural biometrics and other types of SCA has been encouraged in Europe by regulatory models like PSD2 (Payment Services Directive).

Major American Banks like Wells Fargo and Bank of America has employed behavioural analytics to detect fraud. Countries like Singapore and Australia have used behavioural biometrics, along with traditional verification methods, to form a robust multi-layered security system for transactions.

The effectiveness of behavioural biometrics in reducing fraud has been well researched, although there are not enough studies to confirm the challenges they face while implementing these practices in developing countries like India, China, etc. Furthermore, there is a lack of research on consumer perceptions regarding behavioural biometrics.

Overview of Behavioural Biometrics: Description and Mechanism

The field of identifying and verifying individuals through their unique patterns of behaviour in contrast to physical traits such as fingerprints or face shape is called behavioural biometrics. Through the use of gadgets, behavioural characteristics are dynamic and ever-changing, providing real-time possibilities for verification.

Some of the significant behavioural features utilized include:

- *Keystroke Dynamics*: Typing speed, rhythm, and pressure.
- *Mouse Movement*: Patterns of mouse movement, velocity, and direction.
- *Touchscreen Interaction*: Touch typing on touchscreen devices, pressure, and swipe patterns.
- *Device handling*: How an individual holds, tilts, or handles a tablet or smartphone.
- *Voice Dynamics*: Speech cadence, intonation, and speech patterns.

Following initial enrolment, users are not required to actively engage in the authentication process since behavioural biometrics is non-intrusive.

Behavioural Biometrics Mechanism

Four steps are typically needed for behavioural biometrics to work:

1. *Information Gathering*: User activity data, including typing, swiping, and speech, is gathered passively. Users do not need to enter data on purpose.
2. *Feature Extraction*: Key behavioural characteristics are extracted, such as swipe direction, frequency of hand tremors, and typing rate.

3. *Model Training*:
 - o *Machine Learning (ML)*: Algorithms employ extracted behaviour features to build user profiles.
 - o *Continuous learning*: As user behaviors change over time, the model learns to adjust accordingly.
4. *Authentication and Decision Making*: Real-time comparison with the stored behavioural model occurs when a user uses a device. When the deviation is within a tolerable limit, access is provided. Large deviations initiate secondary authentication or block access.

Integration of Deep Learning, ML, and AI boosted the accuracy and reliability of the behavioural biometrics. Given below are the enhanced features of:

- *Artificial Intelligence (AI)*: Recognizes complex, subtle patterns of behavior.
- *Machine Learning (ML)*: Adapt to genuine behavioural changes over time, e.g., increased speed of typing.
- *Deep Learning (DL)*: Analyzes vast behavioural data sets to identify subtle patterns that traditional algorithms overlooked.

AI-driven behavioural biometrics can distinguish between suspect activity (e.g., bot-like activity or theft of devices leading to misuse) and actual human behavioural changes (e.g., transitioning from using a laptop for typing to a mobile device).

Use cases and applications:

These are applied in various sectors of. Businesses like:

- *Finance and Banking*: Taking users of internet banking online. Authorizing high-value transactions. Averting takeovers.
- *E-commerce*: Secure online transactions and digital wallets.
- *Healthcare*: Protection of electronic health records (EHRs).
- *Government Services*: Enhancing e-governance portal citizen authentication.
- *Enterprise Security*: Employing continuous authentication to support zero-trust security models.

Advantages of Biometric Behaviour:

- *Ongoing Authentication*: Security doesn't stop with initial login.
- *Extremely Hard to Duplicate*: As compared to physical traits, behaviour is highly distinctive and hard to replicate.
- *Convenience for Users*: The user experience is not seriously disrupted.
- *Anomaly Detection*: Capable of detecting impostors, spammers, and bots in real-time.

Current Adoption Rates and Statistics

A. Global Adoption Landscape

A market for behavioural biometrics is arising worldwide. Among the 2023 Biometrics Institute survey, 45% of significant

banks worldwide have adopted some form of behavioural biometric authentication (Biometrics Institute, 2023). The Global Business Research Company's report (2023) put the value of the behavioural biometrics market at USD 1.66 billion in 2023 and estimated it would reach USD 14 billion by 2032 with a growth rate of 26.77% CAGR (Grand View Research, 2024).

- *USA and Europe:* Wells Fargo, Barclays, and HSBC utilize behavioural biometrics to enhance online banking security. EU banks employ it to meet the PSD2 Strong Customer Authentication SCA requirement.

- *Asia Pacific:* The Bank of Melbourne and other Australia's NAB bank and Singapore-based fintech are leaders in the Asia Pacific region. Recognized as an emerging market, India has several pilot projects underway.

B. Adoption in India

While India does not have published, comprehensive statistics relating to behavioural biometrics, robust indicators reveal significant growth (Biometrics India Market Report, 2023).

Biometric Technology	Adoption Rate in Banking (2023)
Fingerprint Authentication	76%
Facial Recognition	54%
Voice Biometrics	32%
Behavioural Biometrics	27%
Iris Scanning	12%

C. The Causes of Speeding Adoption

Reasons in Favor of speeding adoption:

- *RBI Regulatory Boost:* Need for safer modes of authentication in banking (RBI, 2020).
- *Fraud Risk:* Over 85% of bank-level frauds reported in India are linked to digital channels (Statista, 2024).
- *Digital India Movement:* Having 1.3 billion individuals with an active digital presence is an opportunity, as well as a security challenge.
- *Customer Expectation:* Up to 70% of Indian consumers prefer unobtrusive, adaptive invisibility of security systems over OTP-based ones (Grant Thornton Bharat, 2024).

recognition. Both banks adopted voice biometric authentication in 2022 using their mobile applications to allow their customers to authenticate based on their unique voice characteristics like pitch, tone, and cadence of their voice.

Results:

- Indian Bank indicated that fraud cases in mobile banking decreased by 15% within the first year after implementation.
- City Union Bank mentioned the customers commended the simplicity in using the system without memorizing complex passwords.

D. Market Outlook for India

The behavioural biometrics market in India is expected to develop at a CAGR of 27.55% during 2024-2032. (Mordor Intelligence, 2023).

- *Market Size Projections:*
 - o For the year 2023 it is expected to be around USD 150 million.
 - o For the year 2033 the estimate is approximately USD 1.25 billion.
- *Key Sectors of Growth:* Banking, Financial Technology, E-commerce, and Government Services.

Challenges Faced:

- Issues with poorly logged user commands in noisy conditions.
 - Ongoing requirement of adaptation with clients who have changed their voice (disease).
- Behavioural biometrics offers both opportunity and practical challenges implementing it in Indian scenario as attested by banks' experiences.

Case Studies of Behavioural Biometrics Implementation

A. Indian Bank and City Union Bank:

Indian Bank and City Union Bank were among the first to venture into the possibilities of behavioural biometrics, specifically voice

B. Strategic Deployment at State Bank of India (SBI)

A Request for Interest (RFI) for a corporate-wide behaviour biometric solution for its online banking channels was published by State Bank of India (SBI) in July 2024.

Scope of SBI's initiative:

- The bank executed the behaviour biometrics system in all the YONO application, mobile banking, and online banking.

- Place special emphasis on fraud detection in real-time through analysing users' behaviour throughout the login and transaction process.
- Emphasis on privacy protection and regulatory compliance.

Potential Impact:

- Reaching over 45 crore users.
- Developing one of Asia's largest behavioural biometric ecosystems in SBI.

C. HSBC: A Global Leader in Biometric Behaviour

In its mobile banking apps, HSBC introduced behavioural biometric identification as early as 2016. This was mostly done in Europe. In just two years, account takeover fraud has decreased by 40%, false positives and needless blocks have been significantly reduced, and over 50 million customers are protected by passive behavioural authentication.

Relevance to India: Indian banks in the hope to successfully scale behavioural biometrics solution can take advantage of HSBC's success journey.

D. Advanced Solutions by BioCatch

The Israeli-American firm BioCatch was a pioneer in developing behavioural biometrics systems, which are today in common usage in India.

Importance:

- Identifies all types of fraud, including account takeover, social engineering scams, and mule account activities; processes over 3,000 behavioural signs, including swipe patterns, device tilts, hand tremors, and typing anomalies.

As per a 2024 study conducted by BioCatch, behavioural analytics helped detect over 50% of fraud cases involving Indian clients early on, often before any funds were lost (BioCatch, 2024).

Adoption Drivers

A. Increasing Cyberthreats and Online Fraud

Online fraud cases are rapidly increasing in India. Based on RBI figures, the instances of internet fraud rose by 35% year on year during 2020-2024 (RBI, 2020). Further, Social Engineering Scams, Account Takeover fraud and data Identity stealing are rapidly increasing in India. A proactive, real-time detection method that can detect suspicious behaviour before financial losses occur is offered by behavioural biometrics.

B. RBI Regulatory Thrust

To persuade Indian banks to employ advanced, non-OTP-based authentication methods, RBI has played a crucial role.

Key regulations facilitating adoption:

- Digital Payment Security Controls 2021: Dynamic, risk-based authentication needs to be employed (RBI, 2020).
- 2024 Draft Framework: Suggested behavioural biometrics for mobile banking and high-value transactions.

Adaptive authentication methods, such as behavioural biometrics, are becoming more and more necessary for banks looking to maintain compliance.

C. Expectations of the Customer

The need is for secure and seamless experiences. Consumers of today demand seamless, extremely secure digital interactions. Nearly 65% of Indian consumers prefer frictionless login options to those based on passwords or OTPs, as per a 2023 users' acceptance survey (Grant Thornton Bharat, 2024). If behavioural biometrics made the system more secure without extra effort, 50% agreed that they would be able to use them. 50% said they would be comfortable using behavioural biometrics if it made the system more secure without extra effort.

D. Technological Developments: Cloud Infrastructure, AI, and ML

Behavioural biometrics is increasingly accessible and affordably priced due to new technologies:

- Enhanced pattern recognition is enabled by artificial intelligence (AI).
- Machine Learning (ML) enhances the system's capacity to adapt to evolving user behaviour.
- Cloud deployment, by reducing infrastructure costs, makes behavioural biometrics solutions via SaaS (Software as a Service) models affordable even for mid-sized banks.

The cost-benefit ratio is improving fast, which makes adoption more appealing (Singh & Gupta, 2021).

E. How Banks and Fintech can stand out from the Competition?

In a very competitive market, banks and fintech companies that implement latest security mechanisms stand out.

Advantages:

- Enhanced brand reputation for security consciousness.
 - The ability to meet international standards, allowing global partnerships.
 - The capability to attract and retain tech-aware clients.
- Early adopters enjoy first-mover advantages that can be turned into genuine business advantages

Obstacles and Challenges to Adoption

A. Costly prices and financial barriers

The high upfront cost required is one of the largest barriers to the use of behavioural biometrics in India. Acquiring software

licenses, procuring robust computer hardware, interfacing with legacy systems, and training internal security teams are all required to deploy an advanced behavior-based biometric system. Mid-size banks report that behavioural biometric solution investments amount to approximately INR 50–70 lakh one-time, while annual maintenance costs range from INR 10–20 lakh, based on size (Verma, 2022).

Cost-Specific Difficulties:

- These investments are not within the means of small and co-operative banks, which dominate rural and semi-urban India.
- Even with their technological advancement, fintech companies often enjoy thin profit margins and might find it difficult to prioritize behavioural biometrics over customer acquisition campaigns.

B. Environmental Variability and Technological Constraints

The following are the factors influencing behavioural biometrics:

- *Device variability:* Users on desktop and mobile platforms can have different behaviors.
- *Environmental factors:* While typing under stressful conditions compared to relaxed ones, a user could type differently.
- *Medical conditions:* A user's behaviour can temporarily shift due to illness or injury, potentially leading to false positives.

Highly advanced AI models capable of distinguishing between suspicious behaviour and innocuous behavioural shifts are one of the system requirements. Behaviour models are constantly retrained to include real user changes over time (Chowdhury & Ahmed, 2021).

C. Low Resistance and Consumer Awareness

In India, consumers remain poorly aware of behavioural biometrics, even though there has been a rise in instances of cybercrime. In a survey carried out in 2023, only 30% of Indian bank consumers knew what behavioural authentication meant (Grant Thornton Bharat, 2024). Certain consumers are resistant to adoption due to fear of constant monitoring or lack of understanding of how the technology works.

Psychological Barriers:

- Privacy invasion concerns.
- The sense of being "watched" constantly.
- A lack of faith in banks' management of biometric data.

Massive educational programs, user-oriented communication strategies, and guarantee on ethical use are required to overcome these hurdles (Singh & Rathi, 2021).

D. Legal, Ethical, and Data Privacy Issues

In behavioural biometrics, user activity data is tracked and processed continuously. Serious privacy concerns are raised by this, such as:

- The concern that companies may collect too much or misuse private behavioural data.
- Surveillance creep likelihood, whereby information that has been obtained for identification purposes may end up being employed in profiling or for marketing.
- Difficulties with the regime: The Indian Personal Data Protection Bill (PDPB) needs consent prior to handling sensitive personal information, for instance, biometric data.

Financial institutions need to develop behavioural biometric systems within the parameters of the IT Act of 2000, Aadhaar Act, and PDPB. Full transparency, easy opt-outs, and little data retention regulation are required to ensure ethical rollout (NASSCOM-AI Taskforce, 2022).

E. Risk of Advanced Fraud and Spoofing

Cyber threats evolve in proportion to security solutions:

- Speech or video biometrics can be spoofed with deepfake methods.
- Globally, there's a surge in synthetic identity fraud, where it merges genuine and false information.
- AI-powered bots will attempt to impersonate user patterns of behavior.

Deep contextual understanding in behavioural biometric systems should look beyond the surface behavioural pattern (e.g., sequence navigation, hesitation frequency, micro-gesture timing) (BioCatch, 2024).

Regulatory Guidelines and Initiatives in India:

A. Guidelines of the Reserve Bank of India (RBI):

Guidelines have been issued by RBI which states that to adapt the modern and latest security systems like behavioural biometrics being increase in the number of fraudulence activities in the financial and other transactions.

1. *RBI Digital Payment Security Controls (2021):* All digital transactions should be subject to robust customer authentication (SCA). Investigate biometric, device-based, and behavioural factors alongside OTPs, it is recommended (RBI, 2020).
2. *Draft Framework for Alternative Authentication Mechanisms (2024):* Behavioural biometrics is clearly defined as a viable alternative to user authentication within the Draft Framework for Alternative Authentication Mechanisms (2024), for high-value mobile transactions, in particular.

3. *Bank Cybersecurity Framework*: Promotes the utilization of AI, ML, and behaviour analysis within real-time fraud detection systems (RBI, 2020).

B. The 2020 Personal Data Protection Act (PDPB) :

This defines behavioural traits as private, sensitive data. India currently has no stand-alone data protection legislation. The Management of Personal Data is governed by the Information Technology (IT) Act 2000. To identify the issues with respect to data protection in the country, the government framed a Committee of Experts on Data Protection in 2017 and was formed under the chairmanship of Justice B.N. Srikrishna. They submitted the report in July 2018. The Personal Data Protection Bill 2019 was submitted in the Lok Sabha on December 2019. To assess the bill and report, the Joint Parliamentary Committee was formed and assign with the power in December 2021. Again in the year August 2022, the bill was recalled from the Parliament. It was presented once again in the parliament for the public opinion in November 2022. Ultimately, in August 2023, the Digital Personal Data Protection Bill 2023 was introduced in parliament. Prior to collecting, using, or revealing such information, explicit user consent is required. They have set high standards for data minimization, purpose limitation, and retention limitation (NASSCOM-AI Taskforce, 2022).

Advantages:

- Banks must update their privacy policies.
- Data Protection Officers (DPOs) are mandatory for large-scale behavioural biometric implementations.
- Harsh punishments for noncompliance.

C. The 2016 Aadhaar Act :

Even though UIDAI's Aadhaar infrastructure mainly addresses biometric and demographic data, its regulations extend influence over biometric data management conventions. Although they are different from Aadhaar modalities (fingerprint, iris), behavioural biometrics are expected to follow the same security guidelines, encompassing encryption, secure storage, and access control.

D. The 2000 Act on Information Technology (Amended 2008):

Organizations that are not able to safeguard sensitive personal data, including biometric information, are liable under Section 43A of the IT Act. The tasks regarding the processing of behavioural biometrics are defined in the IT (Reasonable Security Practices and Procedures and Sensitive Personal Data or Information) Rules, 2011.

E. Additional Adoption-Supporting Activities:

- *MeitY Digital India Program*: Promotes secure online spaces.

- *CERT-In*: Mandates the reporting of incidents, which indirectly supports good fraud detection methods like behavioural biometrics.
- *NITI Aayog AI Strategy (2018)*: Adoption of ethical AI and adherence to behavioural biometrics best practices are emphasized.

Partnerships and Deployments:

A. Strategic Partnerships: Partnership with Industry Collaborations among banks, fintech firms, and behavioural biometrics vendors are now inevitable for rapid deployment as India becomes a digital-first economy.

Microsoft and BioCatch: In the year 2023, BioCatch, a well renowned global leader joined hands with Microsoft to identify the real time fraud detection module, Microsoft Azure. With secure cloud-based APIs, our alliance made scalable behaviour biometrics available to Indian banks (BioCatch, 2024).

Impact:

1. Deployment time decreased from 12 months to less than 6 months, while the participating institutions experienced a decrease of 30–40% in infrastructure cost.
2. Mastercard's Mobile-First Authentication Platform: For smartphones, Mastercard India launched a behavioural biometric solution in 2024. Users were authenticated through this system based on their mobile handling behavior, such as scroll speed, swipe pressure, and grip strength (Mastercard, 2024).
3. Pilot with HDFC Bank: Decreased mobile fraud attempts by 60%; improved customer onboarding process by 35%.
4. Turant's Biometric System for Language-Agnostic Voice: India's first language-agnostic voice biometric engine was developed by Bengaluru AI firm Turant and was designed for low-bandwidth environments. It accommodates over 22 Indian languages for secure voice-based authentication (Ali & Rahman, 2020).

It is used in rural cooperative societies, public sector banks, and microfinance firms.

B. Government Support through Start-Up India and Digital India: Over 30 cybersecurity and behavioural biometrics companies have been aided by the Indian government through schemes such as MeitY, Start-Up India, and Digital India.

- Seed money, Sandboxes for regulations
- Technological breeding grounds

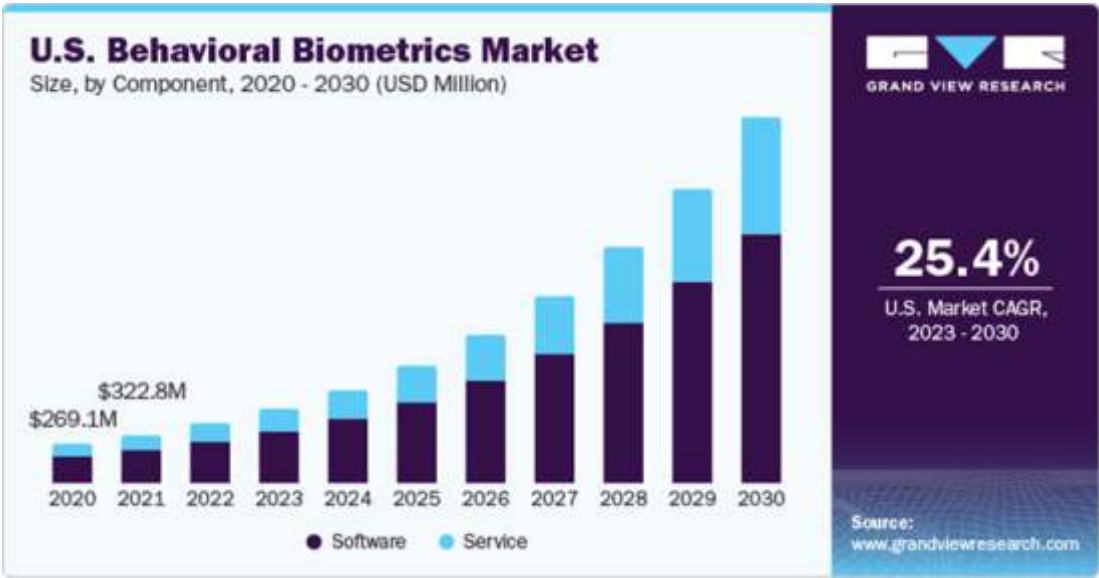
The objective is to increase self-reliance in digital security infrastructure and create local alternatives to global behavioural biometric providers.

Market Size, Growth Analysis, and Future Prospects

A. Global Market Overview

According to Grand View Research (2024):
From the year 2023 to 2030, the worldwide behavioural biometrics market is anticipated to grow at a compound annual growth rate (CAGR) of 27.3%, rising from an estimated USD 1.45

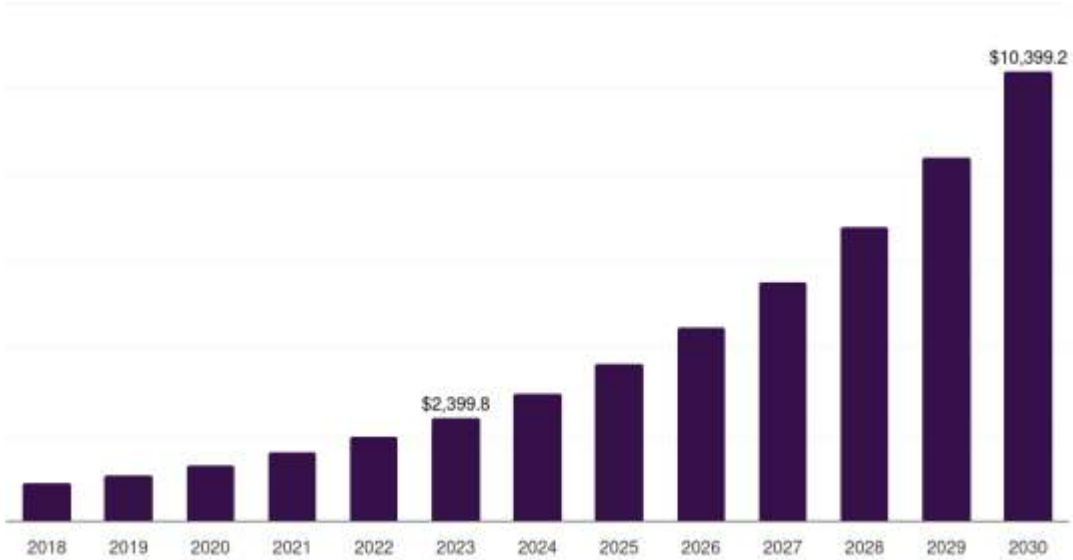
billion in 2022. Globally, the need for digital identification is being driven by an increase in fraudulent activity and online transactions. Additionally, it is anticipated that the market would expand due to financial institutions' increasing need for a multi-layered security approach. The market is also anticipated to rise as a result of the evolving Internet of Things (IoT) ecosystem and the rising demand for improvement.



Source: www.grandviewsearch.com

B. Indian Market Potential

India biometric technology market, 2018-2030 (US\$M)



Source: Grand View Research.

India biometric technology market highlights

In the year 2023, the Indian Market had generated a revenue from the biometric technology was of USD 2,399.8 million. It is forecasted that it will increase to USD 10,339.2 million in the year 2030. The growth of the market would grow at a CAGR 23.2% between 2024 to 2030. Hardware industries and service in India are considered to be as the one of the market segment which could generate highest revenue in the field of biometrics (Grand View Research. (n.d.). *Biometric technology market: India*. Grand)

India is considered one of the fastest-growing behavioural biometrics markets due to:

- Population size (~1.4 billion)
- Rapid digital adoption
- Expanding fintech landscape (Mordor Intelligence, 2023)

C. Upcoming Innovations in Technology

1. *Multimodal Biometrics*: Combining fingerprint or face data with behavioural traits.
2. *Federated Learning Models*: Offering AI that learns across multiple banks without data centralization but ensuring privacy.
3. *Zero-Trust Architectures*: As part of next-generation security models, behavioural biometrics is used in enterprise authentication.
4. *Decentralized Digital Identity*: To establish tamper-proof identification, utilize blockchain technology with behavioural layers.

Strategies to Boost User Acceptance

Technology readiness aside, user perception and trust are determinants of adoption success.

A. Education and Awareness Campaigns

Banks should have explainers on behavioural biometrics, webinars, and social media campaigns.

- Featured in videos for customer onboarding.
- Easy-to-understand infographics in local languages for urban and rural branches (Singh & Rath, 2021).

B. Assurance of Data Privacy

Employ models based on consent:

- Describe what information is gathered and how it is safeguarded.
- Assure users that there is no connection to their financial or personal transactions.
- Every system needs to have clear opt-out features (NASSCOM-AI Taskforce, 2022).

C. Smooth User Experience Design

Accurate, swift, and unnoticed validation is essential. Take control of such systems that produce many false positives or

require frequent re-authentication requests. Maintain openness while allowing users to verify the security decisions rendered by the system (Chowdhury & Ahmed, 2021).

D. Including Underrepresented Groups

Develop adaptive models that consider elderly individuals, those with neurological disorders, and disabled users. Ensure that age, tension, or unfamiliarity with a device do not lead systems to punish inconsistent behaviour (Ali & Rahman, 2020).

Recommendations

A. Financial Institutions and Banks

1. *Phased Implementation with Pilot Programs*: Banks should adopt a phased approach, starting with pilot programs targeting high-risk areas such as account openings, high-value transactions, and logins from unrecognized devices or IP addresses. These pilots should leverage modular solutions to minimize costs, as suggested by Verma (2022).
2. *Dedicated Fraud Analytics Teams*: Establish specialized teams to monitor behavioural biometric alerts and integrate insights with existing fraud detection systems. These teams should be trained to interpret AI-driven behavioural anomalies, ensuring rapid response to potential threats (BioCatch, 2024).
3. *Customer-Centric Communication*: Develop transparent communication strategies to educate customers about behavioural biometrics, addressing privacy concerns and highlighting benefits like seamless authentication. Banks can use onboarding videos and infographics in local languages to build trust, as recommended by Singh and Rath (2021).
4. *Partnerships with Fintech*: Collaborate with fintech firms to co-develop cost-effective, scalable solutions tailored to India's diverse user base, including rural and semi-urban populations (Ali & Rahman, 2020).

B. Regulators and Policymakers

1. *Finalize Data Protection Legislation*: Expedite the implementation of the Digital Personal Data Protection Bill (2023) to provide clear guidelines on handling behavioural data. This should include standards for consent, data minimization, and retention, aligning with ethical frameworks proposed by the NASSCOM-AI Taskforce (2022).
2. *Industry-Wide Collaboration*: Establish Reserve Bank of India (RBI)-led task forces or self-regulatory organizations (SROs) to foster collaboration among banks, technology providers, and consumer advocacy groups. These bodies can develop best practices for behavioural biometrics deployment (RBI, 2020).
3. *Standardized Evaluation Frameworks*: Create standardized metrics to assess the performance, security, and inclusivity

of behavioural biometric systems. These frameworks should ensure compliance with RBI's Digital Payment Security Controls (2021) and promote interoperability across platforms (Grant Thornton Bharat, 2024).

4. *Incentives for Adoption:* Offer financial incentives, such as tax breaks or subsidies, to small and cooperative banks to offset the high initial costs of behavioural biometric systems, enabling broader adoption in rural areas (Verma, 2022).

C. Technology Providers

1. *Privacy-First Innovations:* Develop edge-computing models and federated learning algorithm to process behavioural data locally, reducing reliance on centralized data storage and addressing privacy concerns (NASSCOM-AI Taskforce, 2022). These innovations should prioritize inclusivity for users with disabilities or neurological conditions (Ali & Rahman, 2020).
2. *Flexible Pricing Models:* Offer pay-per-use or subscription-based pricing to make solutions accessible to smaller banks and fintech. Such models can lower the financial barriers highlighted by Verma (2022) and encourage adoption in cost-sensitive markets.
3. *Regular Testing for Bias and Accuracy:* Conduct periodic audits of behavioural biometric algorithms to mitigate biases and ensure accuracy across diverse user demographics, including age, gender, and regional variations (Chandra & Arora, 2021).
4. *Integration with Existing Systems:* Design solutions that seamlessly integrate with legacy banking systems, minimizing disruption and reducing implementation costs, as emphasized by Ravi et al. (2018).

D. Researchers and Educational Institutions

1. *Dedicated AI-Biometrics Research Labs:* Establish interdisciplinary research centers in collaboration with banks and technology firms to study India-specific behavioural datasets. These labs should focus on improving algorithm accuracy and addressing environmental variability, such as device or stress-induced behavioural changes (Chowdhury & Ahmed, 2021).
2. *Foster Advanced Research:* Encourage Ph.D. and postdoctoral research on ethical AI and behavioural biometrics, with a focus on developing open-source libraries that enhance accessibility and reduce costs for smaller institutions (Chandra & Arora, 2021).
3. *Consumer Perception Studies:* Conduct empirical studies on consumer attitudes toward behavioural biometrics to inform user-centric design and awareness campaigns. Such research can address gaps in understanding noted by Singh and Rathi (2021).

4. *Cross-Sector Applications:* Explore applications of behavioural biometrics beyond finance, such as in healthcare and e-governance, to broaden its impact and justify investment (FIDO Alliance, 2023).

E. Industry Bodies (NASSCOM, FICCI, etc.)

1. *Policy Advocacy and Roundtables:* Organize regular conferences and policy roundtables to align stakeholders on ethical and technical standards for behavioural biometrics. These forums should include regulators, banks, and consumer representatives to ensure balanced perspectives (NASSCOM-AI Taskforce, 2022).
2. *National Certification Standards:* Develop certification programs for behavioural biometric providers to ensure compliance with RBI guidelines and global best practices, enhancing trust and market credibility (Grant Thornton Bharat, 2024).
3. *Support for Pilot Studies:* Facilitate pilot projects and benchmarking studies by connecting banks with technology providers and academic researchers. These initiatives can validate scalability and efficacy, as demonstrated by Mastercard's pilot with HDFC Bank (Mastercard, 2024).
4. *Public-Private Partnerships:* Advocate for public-private partnerships to fund innovation in behavioural biometrics, leveraging schemes like Digital India and Start-Up India to support local startups (RBI, 2020).

Conclusion

Behavioural biometrics represents a transformative opportunity for India's financial sector which offers a robust, user-centric solution to combat escalating digital fraud and overcome the limitations of traditional authentication methods. As evidenced by case studies like BioCatch (2024) and Mastercard (2024), the technology has proven effective in reducing fraud by up to 60% and enhancing user experience through seamless authentication. Having the active user of approximately more than 1.3 billion and with the market growth to USD 1.25 billion by 2033 (Mordor Intelligence, 2023), India's digital economy shown a path for more innovation in the years ahead.

However, realizing this potential requires overcoming significant hurdles, including high costs, privacy concerns, and low consumer awareness, as highlighted by Verma (2022) and Singh and Rathi (2021).

This research underscores the critical role of stakeholder collaboration in driving adoption. Financial institutions must prioritize phased implementation and user education, while regulators should finalize data protection laws and incentivize adoption (RBI, 2020). Technology providers need to innovate

with privacy-first, inclusive solutions, and researchers must address India-specific challenges through targeted studies (Chandra & Arora, 2021). Industry bodies like NASSCOM can bridge these efforts by fostering policy alignment and certification standards (NASSCOM-AI Taskforce, 2022).

Looking ahead, behavioural biometrics can position India as a global leader in ethical, AI-driven authentication. By balancing technological advancement with trust, inclusion, and regulatory compliance, stakeholders can create a secure, accessible digital ecosystem. This transformation extends beyond finance, with potential applications in e-commerce, healthcare, and e-governance, aligning with India's Digital India vision. With concerted action, India can set a global benchmark for responsible behavioural biometrics adoption within the next decade, ensuring a safer and more inclusive digital future.

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A Comparative Financial Study of Exchange - Traded Funds and Mutual Funds in India

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**Krishna Kant

Abstract

*This research study provides a comprehensive comparative analysis of **Exchange-Traded Funds (ETFs)** and **Mutual Funds**, two of the most widely used investment vehicles in modern financial markets. The study investigates their performance, cost structures, risk profiles, tax efficiencies, trading mechanisms, and suitability for different investor types. Through a blend of **quantitative and qualitative research**, including surveys and group discussions with retail investors and financial advisors, the report evaluates investor preferences, awareness levels, and behavioural patterns.*

*Key findings reveal that **ETFs are increasingly preferred** for their **lower costs, liquidity, and tax efficiency**, whereas **mutual funds remain dominant** due to **professional management and long-term stability**, particularly among less experienced investors. The research also includes case studies of the **UTI Nifty 50 Index Fund** and **Nippon India ETF Nifty BEES**, highlighting real-world applications and performance comparisons.*

*The study concludes that **investment choices depend heavily on investor goals, knowledge, and risk tolerance**, and offers actionable recommendations for different investor profiles. By illuminating the evolving trends and challenges in fund-based investing, this report serves as a practical guide for investors, advisors, and policymakers navigating the dynamic Indian investment landscape.*

Keywords: Exchange-Traded Funds (ETFs), Mutual Funds, Investment Strategies, Cost Efficiency, Risk Management, Tax Efficiency, Passive Investing, Active Fund Management, Liquidity, Portfolio Diversification, Index Funds, Investor Behavior, Financial Markets, Asset Allocation, Fund Performance, Tracking Error, SIP (Systematic Investment Plan), Expense Ratio, Wealth Creation, Indian Capital Market.

1. Introduction

Investing in financial markets has evolved significantly over the past few decades, offering investors a variety of investment vehicles to grow their wealth. Among the most popular options are **Exchange-Traded Funds (ETFs)** and **Mutual Funds**, both of which provide diversification, professional management, and access to different asset classes. Despite their similarities, ETFs and Mutual Funds **differ in terms of structure, trading mechanisms, cost, and tax efficiency**. These differences make it crucial for investors to understand which option best suits their investment goals and risk tolerance.

The debate over **ETFs vs. Mutual Funds** has intensified as ETFs have gained immense popularity in recent years. First

introduced in the early 1990s, ETFs grew exponentially and questioned the dominance of traditional investment funds. Investors and financial advisors often compare the advantages and disadvantages of these two investment areas, particularly in terms of **liquidity, fees, risk and performance**.

Evolution of Investment Funds

1.1 The Rise of Mutual Funds

Mutual Funds were a cornerstone of Investment portfolios for over a century. The **first modern Mutual Fund, Massachusetts Investors Trust (MIT)**, became released in **1924**, paving the manner for pooled investment vehicle that buyers to get right of

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entry to various portfolios controlled via way of means of professionals. Over time, Mutual Funds received reputation because of their capacity to offer diversification, expert management, and simplicity of funding.

By the late 20th century, Mutual Funds had become the preferred investment vehicle for retirement savings. However, Mutual Funds come with certain drawbacks, such as **higher management fees, lower tax efficiency, and limited trading flexibility** which have led some investors to explore alternative investment options.

1.2 The Emergence of ETFs

Exchange-Traded Funds (ETFs) emerged as a game-changer in the investment world. The first **US ETFs, the SPDR S&P 500 ETF (SPY)**, was introduced in 1993 by State Street Global Advisors. This product revolutionized the investment **landscape** by combining the benefits of **diversifying investment funds** with the flexibility of stock trading. **India's first ETF was listed on the National Stock Exchange (NSE) on January 8, 2002.** It was the Nifty BEES ETF, which **tracks the Nifty 50 Index**.

ETFs quickly gained traction due to their lower expense ratios, intraday trading capabilities, and tax efficiency. Unlike Mutual Funds, which are priced only once per day at the Net Asset Value (NAV), ETFs trade throughout the day on stock exchanges, allowing investors to buy and sell them like stocks. This feature made ETFs particularly attractive to active traders, institutional investors, and cost-conscious retail investors.

Overview and benefits of ETFs

An Exchange-Traded Fund (ETF) is a type of investment fund in which a diversified portfolio of assets, such as stocks, bonds, or other securities, has a type of asset portfolio located on a stock exchange, such as individual stocks. ETFs are designed to follow the performance of a specific index, sector, or asset class. They combine features of both mutual funds and stocks, offering diversification, lower expense ratios, and trading flexibility.

how ETFs works?

1. ETF providers consider the universe of assets such as stocks, bonds, currency, and build their own basket of tickers.
2. Investors can buy a share in that basket in the same way they would buy stock in a firm.
3. Like shares, buyers and sellers handle ETFs all day.

Benefits of ETFs:

- **Diversification:** Provides exposure to a wide range of securities through a single investment.
- **Low Cost:** Lower expense ratios due to passive management.

- **No Minimum Investment:** Investors can buy even a single unit.
- **High Liquidity:** Traded intraday like stocks, offering real-time pricing.
- **Transparency:** Daily disclosure of holdings enhances clarity.
- **No Manager Bias:** Passive structure eliminates human error and emotional decisions.
- **Risk Management:** Enables hedging through sectoral, gold, or international ETFs.
- **Flexible Investment Horizon:** Suitable for both short-term trading and long-term wealth creation

Overview and benefits of Mutual funds

A mutual fund is a financial vehicle that pools money from multiple investors to invest in a diversified portfolio of securities, such as stocks, bonds, money market instruments, or other assets. These funds are managed by professional fund managers who allocate the pooled funds to generate returns based on the fund's investment objectives.

How Mutual funds works?

1. Investors contribute money in a mutual fund.
2. The fund pools this money and invests in various securities.
3. The fund manager makes investment decisions based on the fund's strategy.
4. The fund generates returns through capital gains, dividends, or interest income.
5. Investors earn profits through NAV appreciation or dividend payouts.

Benefits of Mutual Funds

- **Diversification:** Invests in a mix of equities and debt instruments to reduce risk.
- **Professional Management:** Managed by experts using research and risk-control strategies.
- **Affordability & SIP:** Low entry cost; SIPs and SWPs enable regular investing and withdrawals.
- **Investment Variety:** Offers equity, debt, and sectoral funds to suit different goals.
- **Cost Efficiency:** No brokerage; cost-effective for diversified exposure.
- **Global Access:** International mutual funds offer global diversification.
- **Reinvestment Benefits:** Dividends and gains are reinvested, enhancing compounding returns.
- **Transparency & Regulation:** Regular disclosures and oversight by SEBI ensure investor protection.

Problem statement

With both ETFs and Mutual Funds offering diversification and professional management, choosing the right option remains a challenge for investors. While ETFs are gaining popularity due to

lower costs and tax efficiency, Mutual Funds continue to appeal for their long-term stability and active management. This study seeks to address the key question: **Which investment vehicle—ETFs or Mutual Funds—offers better advantages in terms of cost, risk, tax efficiency, and performance?**

2. Literature Review:

1. (Dr. K. M. Sudha, 2020) conducted a study on **“Comparative Study of Selected Investment Funds.”** The purpose of this study is to compare the risk and returns from investment funds with five years of selected investment funds. This study will assess volatility based on investments, a five-year period of revenue analysis. The tools used for analysis are simple mean and standard deviation methods, and simple comparative analysis and ranking methods. The expansion of the equity fund category is not recommended as the fluctuating market is subject to high risk.

2. (Dr. Nidhi Sharma, February 2019) We conducted a survey on **“Investment Fund Performance Analysis: Comparative Study with Selected Hybrid Investment Funds - Indian Scheme.”** The aim of this study is to measure and compare the performance of selected hybrid investment fund systems in India. The selection of hybrid schemes is based on the top 10 of the top rankings defined by Crisil, which are categorized when navigating the scheme. The main data and tools used in this study are NAV, average return, beta, R-square, and standard deviation.

3. (Anil Kumar Goyal, June 2018) We conducted research work on **“Comparative study on the return of selected investment fund programs using NIFTY50”.** The purpose of this study is to compare the average long-term capital of each selected company and compare it with NIFTY50 and investment funds. The research methodology was based on secondary data from NAVS and NIFTY50 and was collected online for one year. Prices for the NIFTY50 were collected by Yahoo Finance. The results of this study were compared to the monthly average of long returns on the benchmark NIFTY50, and found that SBI was superior to volatility and returns.

4. (Rani, 2018) conducted a study on **“Investment Fund Performance Analysis: A Study on Balanced Schemes”.** The purpose of this study is to examine the performance of selected investment funds from the public and private sectors, particularly for a balanced system during the experiment. Data analysis is the basis of quantitative outcomes for selected schemes. This study provided the entire investment fund industry in India in 2018.

5. In 2006, five years after the emergence of the first academic literature on ETFs, Laurent Deville wrote a survey «Exchange Traded Funds: History, Trading and Research».

The author divides the research published at that time into four groups:

- Does the ETF structure allow more effective index fund pricing?
- Are ETFs an alternative to index mutual funds?
- How do exchange-traded funds influence the market quality and volume of underlying assets and their derivatives?
- All other questions, including competitions among stock exchanges and possible ways of applying ETFs.

Besides the academic literature review, Deville describes in detail the history of the ETF market, the fund's operating mechanism and future research perspectives. Deville's survey covered most directions investigated in the papers published before 2006.

Since then, new research came out searching for answers both to the new and to the previously stated questions

6. Charupat and Miu [2013] partly filled this gap. The authors covered research devoted to ETF price efficiency, tracking error estimation, and the fund's effect on underlying assets and their derivatives.

7. Madhavan [2014] focused mostly on research investigating recently emerged products: actively managed funds, leveraged and so-called smart-beta products.

3. Objectives of the Study:

This study aims to evaluate and compare Exchange-Traded Funds (ETFs) and Mutual Funds in terms of cost, performance, risk, liquidity, and investor suitability. The key objectives include:

- To compare expense ratios, brokerage charges, and overall cost-effectiveness of ETFs and Mutual Funds.
- To analyze differences in trading flexibility and liquidity between ETFs and Mutual Funds.
- To assess risk levels, volatility, and tracking errors of both investment vehicles.
- To evaluate their suitability for various investment strategies and diversification goals.
- To examine the impact of macroeconomic factors like interest rates and inflation.
- To compare sector-specific and thematic investment efficiency in ETFs and Mutual Funds

4. Research Methodology: Research methodology will involve collecting, analysing, and interpreting first-hand information from investors, financial experts. The key steps in this methodology are:

1. Research Design

- This study follows a quantitative and qualitative research approach to collect numerical data (performance, cost, returns), and opinions/knowledge (investment preferences, market trends).
- Comparative research design will be used to assess the differences between ETFs and Mutual funds based on investor experience and market data.

2. Data Collection Methods

Primary data will be collected using the following methods:

- **Questionnaires**
 - a) Conduct surveys with individual investors, traders, and financial advisors to understand their preferences and perceptions of ETFs and mutual funds.

- b) Questions will cover topics like investment behaviour, risk appetite, cost awareness, Preference and satisfaction levels with ETFs and mutual funds.

- **Group Discussions**

- a) Organize discussions with groups of retail investors and Finance advisors to understand their investment strategies and decision-making factors.
- b) Discussions will focus on market trends, tax efficiency, regulatory challenges, and the future of ETFs vs. Mutual funds in India.

3. Sample Selection

- **Target Audience:** Retail investors, financial advisors.
- **Sample Size:** A minimum of 120 respondents for surveys and 2 Group Discussions.

Table No. 1.0: Gender, Age, Location, Educational qualifications, occupation and Income wise Demographic Pattern of Individual Investors.

Demographic category of Investors	Parameters	Number of Respondents	
		Total (120)	(%)
Gender	Male	80	66.67%
	Female	40	33.33%
Age	Below 25 years	43	35.83%
	25 to 30 years	30	25%
	30 to 40 years	25	20.83%
	40 to 50 years	15	12.50%
	Above 50 years	7	5.84%
location	Rural	30	25%
	urban	90	75%
Educational qualifications	Primary	13	10.84%
	Secondary	20	16.66%
	Undergraduate	45	37.50%
	Postgraduate	18	15%
	Professional degree	24	20%
Occupation	Student	40	33.33%
	Part time work	25	20.83%
	Private employment	30	25%
	Government employment	13	10.84%
	Professional or business	12	10%
Annual income	Up to Rs 3 lakhs per annum	45	37.50%
	Rs 3 – 6 lakhs per annum	25	20.84%
	Rs 6 – 10 lakhs per annum	30	25%
	Rs 10 – 12 lakhs per annum	15	12.50%
	Above Rs 12 lakhs per annum	5	4.16%

4. Data Analysis Techniques

- **Descriptive Analysis:** Summarizing survey data with percentages.
- **Comparative Analysis:** Evaluating return expectations, risk tolerance, and cost considerations between ETF and mutual fund investors.
- **Statistical Tools:** Use of software like Excel for data visualization and presentation on pie-chart.

5. Findings

The findings of research studies comparing ETFs (Exchange-Traded Funds) vs. Mutual Funds generally focus on factors like costs, performance, preference and liquidity. Here are some key takeaways:

- In majority of the respondents the knowledge level is confined to good knowledge. Approximately 12.50% of the respondents do not have proper knowledge about ETFs and Mutual funds.
- The respondents are well acquainted with mutual fund terms and many respondents do not know technical terms like EXIT LOAD, CAGR, XIRR etc.
- The respondents are not well aware about the ETFs (Exchange Traded Funds).
- More than 58.33% respondents prefer mutual funds for long term investing.
- Approximately 46% respondents prefer Equity mutual funds and 30% respondents prefer Index mutual funds.
- Approximately 42% respondents prefer Equity ETFs and 25% respondents prefer Index ETFs.
- More than 75% respondents prefer actively managed mutual funds.

6. Limitations of the Study

- **Sample Bias:** Limited investor representation; potential for personal biases; demographic influences.
- **Geographic Scope:** Focused on Indian market; findings may not apply globally.
- **Market Conditions:** Results influenced by current market trends; may not hold in different economic scenarios.
- **Time Frame:** Data reflects investor opinions during a specific period; may not capture long-term shifts.
- **Self-Reported Data:** Responses may be inaccurate due to limited understanding or biased self-assessment.

7. Conclusion

- Action and financial capacity play an important role in choosing ETFs and mutual funds. People with high market perception and risk tolerance prefer ETFs, but traditional investors may adhere to mutual funds
- ETFs are better for cost-conscious, tax-sensitive, and

self-directed investors who prefer intra-day trading flexibility.

- Mutual funds, particularly actively managed ones, appeal to investors who seek professional management, long-term stability, and a hands-off approach, despite potentially higher fees and tax implications.
- ETFs typically have lower expense ratios compared to actively managed mutual funds. This cost advantage stems from their passive management style, which involves tracking an index rather than active stock selection. The reduced fees can contribute to better net returns for investors over time.
- ETFs and index mutual funds work in the long term similarly, and actively managed mutual funds are difficult to surpass benchmark. ETFs offer similar or better risk-free returns, but the "safer" perception of mutual funds remains same.

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Business Expertise of Women Directors and Firm Performance: The Moderating Role of Multiple Directorships

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Abstract

This study investigates the impact of business expertise possessed by women directors on the performance of firms operating in India's IT sector. It also explores the moderating role of multiple directorships held by women directors in this relationship. The research employs the two-step system GMM technique to mitigate potential endogeneity concerns, examining a panel dataset of 37 IT firms from the BSE IT Index spanning a decade from April 1, 2013, to March 31, 2023, while accounting for governance and firm-specific characteristics. The findings indicate that women directors' specialization in business management, finance, or accounting positively and significantly impacts firm performance. Drawing on human capital and upper-echelon theories, the research highlights the value of cognitive diversity brought by women with business and managerial expertise to boards, which shapes strategic decisions and organizational outcomes, particularly in the competitive IT sector. However, the study also finds that the moderating effect of holding multiple directorships negatively affects the association between business expertise and firm success. This suggests that the overcommitment associated with holding multiple board positions may dilute the beneficial influence on governance. Based on these findings, the study concludes that restrictions should be placed on the directorship positions of women directors to prevent role overload. This research offers important insights for enhancing corporate governance in India's IT sector, emphasizing the need for qualified women directors to drive organizational success in dynamic and competitive industries.

Keywords – Women directors, Business Expertise, Multiple Directorships, Firm Performance, Indian IT sector, Two Step System GMM

1. Introduction

The corporate landscape witnessed an enormous transformation in the late 20th century as corporations shifted their focus from traditional industrial practices to a knowledge-centric economy, emphasizing the importance of knowledge creation, diffusion, and application in driving organizational value (Dovgal et al., 2021). Traditionally, studies on governance have primarily concentrated on structural elements such as independence, size, and demographic diversity, including ethnic background, age, and gender (Haniffa & Cooke, 2005; Garg, 2007; Abdullah & Ku Ismail, 2017). However, in this evolving economic landscape, contemporary governance literature highlights that cognitive diversity, which includes education, expertise, and skills, has become a major driver of competitive edge and performance outcomes (Kilduff et al., 2000; Sarto et al., 2019). As organizations increasingly recognize the value of

diverse cognitive perspectives, the role of education specialization in business within boards becomes vital in shaping organizational outcomes (Saha & Maji, 2023; Alam et al., 2025).

Human capital and upper-echelon theories are two theoretical frameworks that highlight the importance of cognitive diversity in governance. Human capital theory posits that cognitive diversity is central to knowledge-based resources, where a firm's performance depends significantly on its potential to leverage knowledge and capabilities to extract value (Christensen et al., 2020). Similarly, the notion of upper echelons (Hambrick & Mason, 1984) posits that the company's strategic decisions and bottom-line performance are shaped by the cognitive frameworks of its top management. Cognitive

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traits influence how directors interpret firm information, assess risks, and make strategic decisions by affecting their perception, problem-solving expertise, and risk-taking behavior (Hough & Ogilvie, 2005; Gallén, 2006; Rashid & Boussabiane, 2021). Among these cognitive traits, business expertise, particularly financial and managerial expertise, stands out as a critical determinant of effective governance and firm performance (Kirkpatrick et al., 2017). Directors with strong financial and managerial expertise are better equipped to implement advanced financial strategies, navigate complex corporate challenges, and ultimately enhance firm performance (Graham & Harvey, 2002).

In recent years, it has been recognized that having a diverse range of genders in boardrooms is crucial for effective governance, influencing strategic decision-making, corporate policies, and risk management approaches. (Rao & Tilt, 2016; Abou-El-Sood, 2019). Researchers argue that female directors bring unique perspectives, foster innovation, and improve strategic oversight and accountability (Chen et al., 2021). Consequently, they improve decision-making, governance, and overall firm performance when compared to boards that have traditionally been dominated by males (Terjesen et al., 2016; Ben Slama et al., 2019). However, existing studies have primarily concentrated on quantitative and structural diversity metrics, such as the proportion of board positions occupied by female directors without delving into the qualitative dimensions of women's expertise such as their educational background, financial literacy, and strategic competencies (Sanan, 2016; Li & Chen, 2018; Jyothi & Mangalagiri, 2019). Extensive studies have examined how educational backgrounds influence company success. (Darmadi, 2013; Amin & Sunarjanto, 2016; Fernández-Temprano & Tejerina-Gaite, 2020). However, the empirical literature specifically investigating the role of the female director's educational background on company performance has focused on developed economies, with notable contributions from Nekhili and Gatfaoui (2013), Bennouri et al. (2018) and Gull et al. (2018). This leads to a significant gap in research, especially evident in emerging markets like India, where socio-cultural barriers hinder women's access to board positions despite their high professional qualifications (Patwardhan et al., 2016; Sunita & Jhunjhunwala, 2023). While gender quotas and regulatory initiatives have sought to enhance female representation, they often focus on numerical inclusion rather than the substantive governance contributions of women directors. Consequently, there is limited empirical evidence on how business expertise among female directors affects governance quality and firm performance, highlighting the need for further exploration within the Indian context.

The business expertise of women directors is undoubtedly crucial. However, another often overlooked dimension is the role of women holding multiple directorships, commonly

referred to as “busy directors.” The resource-based perspective (Pfeffer & Salancik, 1978) suggests that these directors bring valuable cross-sector experience, extensive professional networks and external insights, enhancing governance, especially in dynamic business environments (Ferris et al., 2003; Sarkar & Sarkar, 2009). Women with multiple directorships act as linking agents, leveraging their diverse industry exposure to influence risk perception, financial policy, and strategic foresight (Hillman et al., 2007). Despite this potential, the complex interplay between women's business acumen, multiple board directorships, and firm performance remains an unexplored area in existing literature. This gap is further complicated by the Cognitive Load hypothesis. This contrasting perspective argues that overcommitted directors may experience diminished monitoring efficiency, increased fatigue, and weakened oversight capabilities (Méndez, Pathan, & García, 2015). This paradox raises a fundamental question: Does serving on multiple boards amplify or dilute the governance impact of women directors with business expertise? Addressing this question is crucial to understanding the true governance potential of women directors, moving beyond numerical representation.

The Indian IT sector provides an ideal setting to examine unexplored dimensions of corporate governance. As a knowledge-intensive and innovation-driven industry, IT firms require leader's adept at superior financial literacy, strategic agility, and decision-making foresight to navigate technological disruptions, global competition, and regulatory complexities. The Indian IT sector contributed 7.5 percent to India's GDP in 2023, with IT exports reaching 178 billion U.S. dollars in 2022, and employing over 5.4 million people (Statista data, 2023). Furthermore, women's participation in the Indian IT sector is among the highest, with 30% representation surpassing the India Inc. average of 26% (Business Today, 2023). However, despite their strong educational and professional attainments, women hold only 17.1% of IT board seats, indicating deep-rooted socio-cultural barriers to leadership advancement (Kaushik & Pullen, 2018). Given the industry's reliance on strategic decision-makers with financial and managerial expertise, women directors with business acumen are well-positioned to enhance governance and foster innovation. However, existing literature remains limited in capturing their cognitive contributions to decision-making, investment strategies, and financial performance.

2. Literature synthesis and Hypothesis proposition

2.1. Business expertise of women directors and firm performance

Over the years, the focus of the structure of the board and corporate outcomes has shifted from an emphasis on

independence to one on quality. Board quality encompasses a diverse range of attributes, including directors' educational backgrounds, industry experience, cognitive diversity, and demographic diversity. While industry-specific experience is crucial, research suggests that it must be accompanied by business and financial education to effectively address complex governance problems (Pozen, 2010; Bertsch, 2011).

Human capital theory (Becker, 1994) and upper-echelon theory (Hambrick & Mason, 1984) provide a theoretical foundation for understanding how directors with diverse knowledge, skills, and educational backgrounds influence an organization's philosophy, strategic decisions, and performance outcomes. For instance, Graham & Harvey (2002) found that MBA graduates excel in applying advanced financial models, thereby improving corporate decision-making. Similarly, Jeanjean and Stolowy (2009) noted that directors with postgraduate degrees, particularly in finance and accounting, are better equipped to navigate complex financial environments and contribute to strategic decision-making. Supporting these perspectives, Zalata et al. (2022) and Gull et al. (2018) found that female directors with financial expertise are linked to improved earnings quality and reduced earnings manipulation. This not only improves financial reporting quality but also builds investor confidence and potentially enhances long-term firm performance. These findings reinforce the argument that it is not gender diversity alone, but women directors' specific financial and business acumen that drives governance improvements and firm success. Similarly, Nekhili and Gatfaoui (2013) emphasize that demographic factors, including women's educational background and professional experience, play a crucial role in determining both their inclusion on boards and the extent of their influence on board decisions, particularly in the French context. Bennouri et al. (2018) further contend that what matters most is not gender per se, but the professional competence, including business and financial literacy, of women directors that directly contributes to enhanced firm outcomes. Molinero-Díez et al. (2022), in their study of Spanish-listed firms, found that while female directors often hold higher educational qualifications than their male counterparts, those with business-related degrees are more likely to promote corporate social responsibility (CSR) and stakeholder engagement. However, the relationship between such educational specialization and firm value appears to be complex and context-dependent. Expanding the evidence base, Yadav and Sharma (2021), in the Indian context, observed that firms with qualified female directors, particularly those holding degrees in business, finance, or economics, tend to perform better financially. Their findings highlight the importance of moving beyond tokenistic appointments and underscore the need for financial and strategic competencies in corporate governance. Ramadhania et al. (2021), in the Indonesian context, found a positive correlation between the business expertise of female

directors and firm performance, particularly when women directors hold strategic decision-making roles. Their findings support the human capital theory, reinforcing the idea that female directors' knowledge and experience are critical contributors to effective oversight and strategic development. Similarly, in the healthcare sector of Nigeria, Arumona et al. (2019) demonstrated that board-level financial education, including that of women directors, is positively associated with firm performance. Their study indicates that such education enhances strategic execution and resource allocation, with women directors contributing significantly when they possess formal business training or financial certifications.

This growing body of literature supports a competency-based view of board composition. Rather than focusing solely on numerical gender representation, researchers advocate for the inclusion of women with strong business, strategic, and financial expertise to ensure boards are equipped to deal with increasingly complex financial and regulatory environments. However, challenges remain in implementing policies aimed at enhancing women's board representation. Although legal mandates such as the requirement in India for at least one female director are a step forward, concerns persist regarding the effectiveness of such appointments if not backed by relevant qualifications and strategic roles (Yadav & Sharma, 2021). This reflects broader concerns about symbolic compliance versus substantive integration of gender diversity in corporate leadership. Drawing from these insights, educational backgrounds emerges as a critical determinant of firm performance, especially in the case of women directors, who often leverage their qualifications to overcome systemic barriers and contribute meaningfully to board discussions (Eagly & Carli, 2003). The arguments presented in the preceding paragraphs lead us to formulate the following hypothesis:

H1: Business expertise of Women directors (education specialisation in business management, finance or accounting) positively affect firm performance

2.2. Moderating role of women multiple directorships on the relationship between Business expertise of women directors and firm performance

The strategic role of women directors and their interlocks where the same female director serves on multiple corporate boards, has garnered limited scholarly attention in both Western and Indian academic discourse. This gap largely stems from the historically low representation of women on corporate boards. However, a significant shift occurred in India with the implementation of the Companies Act, 2013, which introduced a gender diversity mandate requiring certain classes of companies to appoint at least one woman director to their boards within six months of the law's enactment. In response to

this regulation, many firms began appointing the same women directors across multiple boards, driven by the limited availability of qualified female candidates at the board level. Based on the resource-based view, proponents contend that directors holding multiple board positions gain broader industry exposure, diverse strategic insights, and extensive networking opportunities, which can be utilized for the advantage of the firm (Ferris et al., 2003). Supporting this view, Ismail and Manaf (2016) found that directors with multiple directorships help strengthen external stakeholder relationships, enhancing the firm's reputation and influence. Field et al. (2013) further contend that multiple directorships provide newly public firms with valuable advisory and strategic benefits due to their broad experience and professional networks. Biswas et al. (2024) conducted an in-depth study within the Indian corporate context, examining the effect of women director interlocks, a scenario where the same woman sits on multiple boards. Their findings suggest that such interlocks are associated with enhanced firm performance, particularly in environments with strong governance mechanisms and institutional oversight.

Conversely, the busyness hypothesis offers a contrasting viewpoint. This perspective suggests that directors holding

multiple board positions may experience time and attention constraints that reduce their effectiveness. Bennouri et al. (2018) highlight that this applies to both male and female directors, but busy female directors may be especially prone to symbolic appointments, where their actual involvement in governance is limited. Empirical evidence from Fich and Shivdasani (2006), Adams and Ferreira (2009), and Jiraporn et al. (2009) also supports this concern, indicating that directors with excessive board memberships often struggle to meaningfully engage in monitoring and advisory roles, potentially undermining their contribution to firm governance. This contrasting evidence gives rise to a critical question of whether the number of directorships moderates the association between the business expertise of women directors and company performance. It is proposed that a balanced number of board roles allows for the optimal use of their expertise without exceeding their capacity. Therefore, the subsequent hypothesis is put forward:

H2. Women holding multiple directorships moderate the association between Business expertise of women directors and firm performance

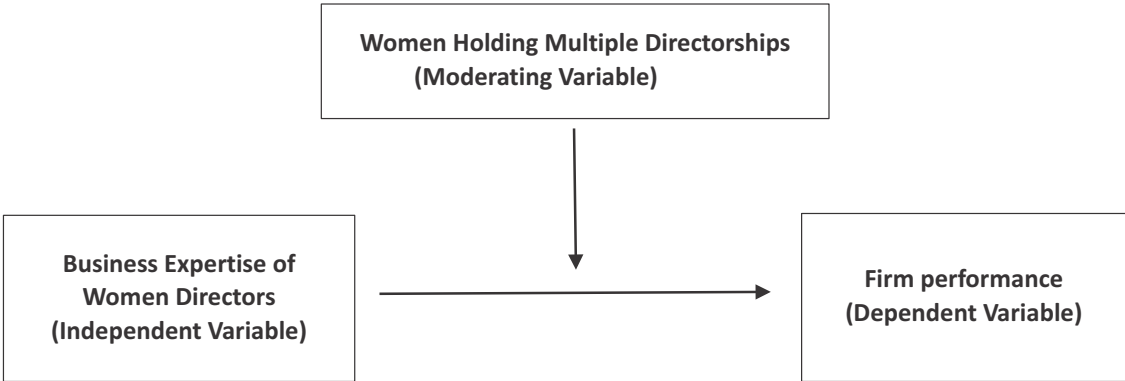


Figure1. Conceptual Model

3. Research Design

3.1. Sample Selection

The research examined the BSE IT Index, which includes the top Indian IT companies based on market capitalisation and represents the most prominent industry participants. Thirty seven sample companies fit the purposive sampling criteria from fifty six leading IT firms as of December 2023, representing over 90% of the index's total market capitalization. The research covers ten years, from 1st April 2013 to 31st March 2023. The selection criteria considered the availability of consistent and complete financial and governance data for the entire study period. The Ace Equity database was used to extract financial

data, and the governance variables were manually queried from the corporate governance section of annual reports.

Measurement of variables

3.2.1. Dependent variable

Log of Market Capitalisation (LnMCap): This study investigates firm financial performance as the dependent variable, utilizing a market-based measurement approach for analysis. Specifically, the study employs the Ln of Market Capitalization as the performance metric, aligning with prior literature that predominantly utilizes market-based metrics to evaluate financial performance (Saha, R., 2023). The projected value

of all future revenue streams is reflected in this approach, which is comprehensive because it inherently incorporates accounting profits.

3.2.2. Independent variables

Business expertise of women director (BExWD): A female director's business expertise is measured by the proportion of female directors with formal education in business management, finance, or accounting, relative to the total number of female directors. This proportion serves as the independent variable.

3.2.3. Moderating variable

Women board multiple directorships (WmD): The quantity of board positions occupied by women directors serves as an indicator of various directorships. This variable serves as a moderator in the current investigation. According to resource dependency theory, directors with multiple board memberships can build stronger and more enduring relationships with external organizations, which can ultimately enhance firm performance (Ismail & Manaf, 2016). A dummy variable is used to include this idea in the study; if a female director holds multiple board positions, a value of 1 is allocated, and otherwise, a value of 0 is allocated (Brahma et al., 2021).

3.2.4. Control variables

Governance variable

Board size (Bsize): At the end of each fiscal year, the company's annual report mentions the total number of board directors Guest (2019).

Board independence (Bind): This variable is calculated using the formula that is the ratio of the number of independent non-executive directors to the board's overall membership (Bhagat & Black, 2001).

Firm variables

Firm size (Fsize): The size of IT-listed enterprises is determined by taking the natural logarithm of their total assets (Bennouri et al., 2018). The skewness level is highest in the company size distribution, and Sanan (2016) explains that this issue can be addressed by applying its natural logarithm.

Firm leverage (Flev): The proportion of debt to equity ratio serves as a metric for assessing the firm's leverage Myers (2020).

Firm age (Fage): The age of sample firms is determined by taking a total number of years (natural logarithm), starting from the year of incorporation and ending on March 31, 2018 (Zahid et al., 2019).

Profitability (Roa): Return on asset, calculated as the ratio of net income to total assets, represents profitability (Singh et al., 2023).

3.3. Data Analysis Technique and Model Specification

In econometrics, endogeneity arises when the residual term is linked to an independent variable, typically when an excluded variable influences both the explanatory and response variables, leading to a confounding effect (Harris & Raviv, 2008). This problem is outlined by Arora & Sharma (2016) in relation to corporate governance and business outcomes relationships. In order to address possible issues about endogeneity, this study employs the GMM estimators (Blundell & Bond, 1998). Since it is more effective at handling unit root problems and has better prediction accuracy, the system GMM technique is preferred over the difference GMM approach (Bond, 2002). A two-step estimation method is implemented, given its advantage of lower asymptotic variance. Additionally, The Sargan test is performed to assess the reliability of instruments and to evaluate constraints arising from over-identification. (Sargan, 1958). Furthermore, to examine whether the idiosyncratic errors demonstrate a trend of temporal correlation, the study utilised Arellano-Bond autocorrelation tests (Arellano & Bond 1991). This study utilizes a dynamic model incorporating a one-year lagged dependent variable to examine firm performance persistence and potential autocorrelation. The following dynamic panel regression model was specifically tailored to test hypothesis 1.

$$\begin{aligned} \text{LnMcap}_{i,t} = & \alpha_i + \delta \text{LnMcap}_{i,t-1} + \beta_1 \text{BExWD}_{i,t} \\ & + \beta_2 \text{BSize}_{i,t} + \beta_3 \text{Bind}_{i,t} + \beta_4 \text{LnFsize}_{i,t} + \beta_5 \text{Flev}_{i,t} \\ & + \beta_6 \text{LnFage}_{i,t} + \beta_7 \text{Profit}_{i,t} + v_{i,t} + \epsilon_{i,t} \dots \dots \dots \end{aligned} \quad (1)$$

To test Hypothesis 2, which examines whether the correlation between women directors' business acumen and organisational outcomes is influenced by the number of board positions they hold, this study employs a dynamic panel regression approach. The following regression models have been developed for this analysis:-

$$\begin{aligned} \text{LnMcap}_{i,t} = & \alpha_i + \delta \text{LnMcap}_{i,t-1} + \beta_1 \text{BExWD}_{i,t} \\ & + \beta_2 \text{Wmdi}_{i,t} + \beta_3 \text{BExWD} * \text{Wmdi}_{i,t} + \beta_4 \text{BSize}_{i,t} + \beta_5 \text{Bind}_{i,t} \\ & + \beta_6 \text{LnFsize}_{i,t} + \beta_7 \text{Flev}_{i,t} + \beta_8 \text{LnFage}_{i,t} + \beta_9 \text{Profit}_{i,t} + v_{i,t} \\ & + \epsilon_{i,t} \dots \dots \dots \end{aligned} \quad (2)$$

Where i represents the firm where i ranges from 1 to N, and t denotes the period, with t also ranging from 1 to N. α_i is the intercept of the equation The variable $\text{LnMcap}_{i,t}$ signifies the market performance of business i during the time t. The term $\delta \text{LnMcap}_{i,t-1}$ denotes the dependent variable's lag during a one-year period. The corresponding coefficient vector β_1 represents women directors' business expertise (BExWD), a time-dependent explanatory variable. while total count of Board

directors (Bsize), Ratio of independent non-executive director(Bind), firm size (Fsize), firm leverage (Flev), firm age (Fage) and profitability(Roa) denotes governance and company-specific control. Women holding multiple directorship is the moderator of the study is denoted by Wmd. $v_{(i,t)}$ and $\epsilon_{(i,t,.....)}$ account for undetected time-invariant firm effects and the spurious error term, accordingly.

After accounting for governance and firm-specific variables, this study investigates how women directors' business experience affects firm performance, taking into consideration the moderating influence of women having numerous directorships.

4. Empirical findings and discussion

4.1. Descriptive Statistics

Table 1a summarizes the important descriptive statistics of important variables, whereas Table 1b provides year-wise numbers and proportion of women with business expertise. This research examines firms in the Indian IT sector that are publicly traded on the BSE over a decade-long period from 2014 to 2023, selecting a sample of 37 companies using purposive sampling. As shown in Table 1a, LnMCap measures the firm's financial performance and has an average value of 7.820. The results show a large range of fluctuation in market performance trends, with values as low as 1.752 and as high as 14.129.

Table 1a. Descriptive statistics (Observations=370)

Variable	Mean	Std. Dev.	Min	Max
LnMCap	7.820	2.421	1.752	14.129
BExWD	0.368	0.444	0	1
Wmd	0.676	0.453	0	1
Bsize	8.172	2.163	3	14
Bind	0.527	0.154	0	0.857
Fsize	7.138	1.985	2.813	11.682
Flev	0.058	0.128	0	1.474
Fage	3.259	0.404	1.098	4.356
Roa	0.104	0.130	-0.787	0.521

Table 1b. Year-wise number and Proportion of women directors with business expertise

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Women on board	16	38	43	46	46	50	57	58	61	60	475
Women with business expertise	6	16	18	14	18	21	18	22	21	21	175
Proportion of women with business expertise	.375	.421	.418	.304	.391	.420	.315	.379	.344	.350	.368

Source(s): Calculated by the authors

The key independent variable representing the business expertise of women directors has a mean of 0.368, suggesting that 36.8% of firms include at least one-woman director with relevant business expertise. As shown in Table 1b, from 2014 to 2023, a total of 475 women served on boards, of which 175 had business expertise. The number of women with business expertise grew overall, though not consistently, rising from 6 in 2014 to 21 in 2023. The proportion fluctuated over the years, peaking at 42.1% in 2015 and reaching its lowest at 30.4% in 2017.

The variable Wmd, representing women with multiple directorships, has a mean of 0.676, indicating that 67.6% of firms have at least one-woman director holding multiple board seats. The standard deviation of 0.453 suggests a moderate level of variability in this occurrence across the sample. Regarding control variables, the average board size has been 8.172 members, stretching from 3 to 14, conforming to optimal governance practices regarding decision-making efficiency and diversity. Board independence is at an average of 52.7%, which suggests compliance with governance standards encouraging

sound oversight. Firm size (logarithm of total assets) ranges from 2.813 to 11.682, indicating significant heterogeneity among firms. IT firms' leverage ranges from 0 to 1.474, supporting the asset-light models generally witnessed in the IT sector. Roa has an average of 10.4% but ranges from -0.787 to 0.521, suggesting some firms are highly profitable while others are underperforming relative to this metric.

4.2. Correlation Analysis

Table 2 illustrates that all variables exhibit correlation values

below 0.8, indicating that multicollinearity is absent in the model (Kennedy, 1985). The strongest positive correlation is observed between board size and firm size at 0.5377, while the most significant negative correlation is between firm leverage and board independence at -0.1238. Since all VIF scores are beneath 10 (Hair et al., 2010). The model's variables can be analyzed without encountering substantial multicollinearity concerns.

Table 2. Correlation analysis

	BExWD	Wmd	Bsize	Bind	Fsize	Flev	Fage	Roa
BExWd	1.0000							
Wmd	0.1671***	1.0000						
Bsize	0.1076**	0.0589	1.0000					
Bind	0.0825	0.1681***	0.1431***	1.0000				
Fsize	0.0767	0.2166***	0.5377***	0.2095***	1.0000			
Flev	-0.0559	0.0177	-0.0457	-0.1238**	0.0201	1.0000		
Fage	0.1113**	0.2126***	0.3067***	0.4370***	0.3856***	-0.0549	1.0000	
Roa	0.1659***	0.1170**	0.3764***	0.1291**	0.4515***	0.0262	0.2041***	1.0000
Vif	2.97	1.73	1.50	1.42	1.73	1.03	1.45	1.33

Notes(s): At the 1percent, 5percent, and 10percent levels of significance, ***, **, and *, respectively, denote statistical significance.

Source(s): Calculated by the author

4.3. Regression Findings

Table 3 provides an outcome of a two-step dynamic panel regression carried out with the System GMM on Models 1 and 2. The significant and positive coefficient of the lagged LnMC in both models suggests a strong persistence in market capitalization. Furthermore, the non-significance of the Sargan-Hansen over-identifying test limitations, along with the absence of any association between the instruments and the residual, confirms the instrument's validity. Hence, it represents the suitability of the variables that the instrumental and used in the dynamic regression models. Moreover, the values from the second-order serial correlation test are not statistically significant, indicating the absence of serial correlation within the analysis. Therefore, the findings can be relied upon and validated because the two-step dynamic panel System GMM's assumptions have been satisfied.

H1. Business Expertise of women directors and firm performance is positively related (Accepted)

Model I in Table 3 reports a coefficient of 0.1258 for the business expertise of women directors, with a p-value of 0.009, which

implies that enterprises derive advantages from their expertise. This exhibits an advantageous and statistical effect on organisational outcomes, with a level of significance observed at 1 percent. The findings align with human capital and upper echelons theories, demonstrating that the business expertise of women directors positively influences corporate performance. This suggests that Indian firms perform better when women with expertise in business management, finance, or accounting serve on their boards. The results align with the findings of Nekhili and Gatfaoui (2013); Yadav and Sharma (2021) and Zalata et al. (2022), who argue that gender-diverse boards with women directors possessing business acumen improve the governance quality and financial performance as they engage in navigating the complex financial landscape. Similarly, Graham and Harvey (2002) claim that directors with technical and financial expertise perform better in capital budgeting decisions, ultimately contributing to long-term growth strategies of an organisation. Similarly, according to Bennouri et al. (2018), women directors' business knowledge positively impacts business performance, especially in niche markets within specialized sectors. The

Indian IT sector, as a knowledge-intensive and dynamic industry, further underscores the need for advanced financial models and innovative resource allocation (Torchia et al., 2018). Thus, in such a dynamic and competitive industry, female directors with business acumen are crucial for better governance, strategic decision-making, and financial results.

H2. Women holding multiple directorships moderates the

relationship between business expertise of women directors and firm performance (Accepted)

Table 3 of Model II examines how women holding multiple directorships affect the link between their business expertise and firm performance. The findings reveal a dynamic between the business expertise of women directors and their holding multiple directorships.

Table 3. Dynamic Panel System GMM Results

Variables	Model I		Model II	
	Coef	(p-value)	Coef	(p-value)
Lag of LnMCap	0.7939	0.000***	0.6597	0.000***
BExWd	0.1258	0.009***	1.2284	0.047**
Wmd			1.6527	0.000***
BExWd*Wmd			-1.6682	0.044**
Bsize	-0.0446	0.000***	-0.0175	0.617
Bind	0.4432	0.017**	-1.2324	0.056*
Fsize	0.2240	0.000***	0.2740	0.000***
Flev	-0.6725	0.000***	-0.1841	0.357
Fage	-0.1930	0.001***	0.0109	0.971
Roa	0.8861	0.013**	1.7972	0.008***
Constant	0.9761	0.000***	0.6901	0.310
Sargan-Hansen Test for Over-Identification	0.3375		0.6981	
Arellano- Bond test for Autoregressive process (1)	0.0378		0.0265	
Arellano- Bond test for Autoregressive process (2)	0.8329		0.7582	

Notes(s): At the 1percent, 5percent, and 10percent levels of significance, ***, **, and *, respectively, denote statistical significance. The system GMM model automatically controls for time-invariant effects.

Source(s): Calculated by the authors

Directorship has a significant and negative association (-1.6682, p-value is 0.044**) with firm performance with significance observed at the 5 percent level. Thus the reported findings put forward that while women directors with business expertise contribute positively to firm performance, their effectiveness diminishes when they hold multiple board positions. The observed negative moderating effect can be explained through several potential channels. First, time and attention constraints are commonly associated with holding multiple directorships. This result may be attributed to the busyness hypothesis as laid down by Fich & Shivdasani, (2006) and Bennouri et al. (2018), which suggests that directors with multiple board directorships may become overburdened, leading to reduced attention and engagement in firm-specific strategic decision-making. This is particularly relevant in the Indian IT sector, a dynamic and knowledge-intensive industry that requires highly engaged and focused leadership due to its rapid technological advancements

and intense competitive pressures. Further, Falato et al. (2014) also noted that having the same director on multiple boards can result in value destruction, especially during acquisitions, which may indicate underperformance and ultimately reduce shareholder value.

Second, the challenge of managing the demands from multiple boards simultaneously can make it difficult to exercise effective oversight. According to Dang and Nguyen (2014), women directors in quota-mandating countries tend to occupy multiple board positions, which exacerbates the issue of balancing competing commitments across various boards. This issue is particularly relevant in India, following the introduction of the Companies Act 2013, which requires publicly traded organisations to appoint one female to the corporate board. While the law aimed to increase gender diversity, it has led to an increased demand for women directors, resulting in many being

appointed to multiple boards. Although women directors with business expertise are often highly sought after for these roles, the excessive commitments associated with holding multiple directorships may limit their ability to provide effective oversight, ultimately reducing their direct influence on company performance.

5. Implications for Practitioners and Managers

The study's empirical findings offer substantial insights for regulatory bodies, policymakers, and management in the IT Sector. Organizations should prioritize business expertise when appointing women directors, recognizing their potential to enhance governance quality and drive firm performance. Corporate decision-makers should focus not only on increasing gender diversity on boards but also on ensuring that women directors possess the necessary industry experience and strategic insight to contribute meaningfully to firm outcomes. While the Companies Act of 2013 mandates at least one-woman director, it should emphasize appointing women with relevant expertise to enhance strategic alignment and governance.

However, the negative moderating effect of multiple directorships highlights a critical challenge. Firms and regulatory bodies should set reasonable caps on the number of director board seats to prevent role overload and ensure that women directors can effectively apply their expertise. Overcommitted directors may face time constraints, reducing their ability to engage deeply in firm-specific governance and strategic decision-making. Human resource and board nomination committees should incorporate mechanisms to evaluate the caliber and quantity of multiple board seats held by women directors. Encouraging targeted leadership development programs, mentorship initiatives, and boardroom training for women executives can help firms build a sustainable pipeline of highly skilled women leaders, thereby enhancing the long-term governance and competitive strength of IT firms

6. Conclusion

This empirical investigation delves into the connection between corporate success and business expertise, along with the moderating role of women serving on multiple boards in this relationship. Dynamic panel regression of a 10-year sample (2014–2023) of 37 IT index-listed firms is used for the present study. The finding suggests that appointing qualified women with business and financial acumen to leadership positions improves firm performance. As the Indian IT sector continues to grow in a competitive global environment, leveraging the expertise of women directors can strengthen corporate

governance, innovation, and long-term strategic decision-making. This study also reveals that women holding multiple board directorships may weaken the positive link between their business expertise and firm performance, as cognitive overload can impair their engagement and oversight capabilities. This research enriches the discourse on corporate governance within Indian IT firms by emphasizing the significance of female directors' cognitive attributes. Together, these findings highlight the need for policies that leverage women's business expertise while preventing role overload in Indian IT firms to achieve stronger corporate governance, enhanced critical thinking, and improved operational efficiency. However, our findings go beyond mere presence, suggesting that qualifications and expertise are critical determinants of the value addition by women directors.

7. Limitations and Scope of Future Research

This research sheds light on the interaction between women's business acumen, directorships, and firm value; however, several limitations persist that future research could investigate further. First of all, this paper has focused on the Indian IT sector, which has unique characteristics such as high innovation intensity and knowledge-driven operations. Consequently, the results may not be wholly generalizable to other sectors that are governed under different structural and operational paradigms. Secondly, this research employed quantifiable measures of business expertise. It is recommended that Academicians and researchers carry out qualitative studies using questionnaires and interviews to fully capture qualitative insights into boardroom dynamics, decision-making processes, and the interpersonal influence of women directors. Another promising avenue for research is identifying the optimal threshold for multiple directorships and determining at what point excessive board commitments begin to impact governance effectiveness. Additionally, examining the interplay of cultural and structural factors influencing the efficacy of family-owned women directors could offer deeper insights into improving board effectiveness in India's unique corporate landscape.

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