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Fintech, Business, and Development

Edited by
Chandan Kumar Jha and Chandan Sharma

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Guest Editors

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Preface

In recent years, the convergence of financial technology, business innovation, and development economics has reshaped the landscape of global growth and inclusion. This Special Issue, “Fintech, Business, and Development”, is a response to this transformation—a curated exploration of how digital finance is influencing enterprise strategies, public policy frameworks, and the developmental trajectories of emerging economies.

This Reprint brings together researcher papers to examine themes such as financial inclusion, digital infrastructure, entrepreneurial ecosystems, and the regulation of algorithmic finance. Our contributors represent diverse backgrounds—economists, technologists, entrepreneurs, and public administrators—and their work spans microenterprise mobilization to macroeconomic forecasting.

The intent is neither to celebrate technology uncritically nor to reduce business to mere profit metrics. Instead, we aim to foster a conversation that is intellectually rigorous, ethically grounded, and globally relevant. Whether addressing digital lending in rural India or blockchain governance in Latin America, each chapter is a stepping stone toward understanding how innovation can be harnessed to serve developmental goals.

This Reprint is designed for readers who believe that markets must be inclusive, technology must be purposeful, and progress must be equitable. It is our hope that these pages will inform scholars, energize policymakers, and inspire changemakers to think boldly about the future we are collectively building.

Chandan Kumar Jha and Chandan Sharma

Guest Editors

Review

Digital by Default? A Critical Review of Age-Driven Inequalities in Payment Innovation

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Abstract: This paper offers a systematic literature review of age-related disparities in the adoption of digital payment systems, a phenomenon that is becoming increasingly relevant as financial transactions become predominantly digital. Using the SPAR-4-SLR protocol, 66 scholarly contributions published between 2014 and 2024 are examined and categorised into four thematic clusters: demographic determinants, behavioural drivers, structural barriers linked to the grey digital divide, and emerging insights from neurofinance. The review highlights a multifactorial set of barriers that limit older adults' engagement with digital payments, including usability challenges, cognitive and physical limitations, digital skill gaps, and perceived security risks. These obstacles are further amplified by structural inequalities such as socio-economic status, geographic location, and infrastructural constraints. While digital payments are often presented as tools of inclusion, the findings underscore the risk of exclusion for ageing populations without tailored design and policy interventions. The review also identifies areas for further research, particularly at the intersection of ageing, cognitive function, and human–technology interaction, proposing a research agenda that supports more inclusive and age-responsive financial innovation.

Keywords: digital payments; ageing population; fintech inclusion; technology adoption; grey digital divide; elderly users; systematic literature review; financial technology; digital literacy; neurofinance

1. Introduction

The benefits of the digital age, such as cost savings, increased efficiency, and improved overall well-being, are well documented in the literature (Goldfarb & Tucker, 2019; Goolsbee & Klenow, 2006; Jorgenson et al., 2008).

The swift digitalisation of financial systems has significantly altered the manner in which individuals engage with payments, with digital payment platforms often serving as the gateway to digital finance (Panetta & Leo, 2022). The integration of digital payments into everyday life has helped many users—especially those who were initially reluctant—to mitigate distrust and technological resistance, fostering greater confidence and ease in the use of digital tools. Moreover, the popularity of digital payment systems has increased significantly, driven by their perceived simplicity and operational efficiency—trends that were notably accelerated by the COVID-19 pandemic, which served as a catalyst for their widespread adoption across diverse demographic groups and geographic regions (Baviskar et al., 2023; Saha & Kiran, 2022). Nevertheless, this promising digital transition has also revealed persistent inequalities in the acceptance and adoption of new technologies, shaped along demographic variables such as age, education, gender, and socio-economic status (Colline et al., 2022; M. A. Khan, 2021).

However, access to these benefits remains unevenly distributed, particularly for those without internet access or digital literacy abilities (Forman et al., 2005, 2012; Goldfarb & Prince, 2008). Older adults are particularly susceptible to what has been called the “grey digital divide” (Y. Zhang et al., 2024), leading to significant social and financial consequences that impact their overall well-being, health, and quality of life (Fox & Connolly, 2018; Miller & Tucker, 2011; Tarricone et al., 2022). More specifically, the term “grey digital divide” refers to a specific form of digital exclusion that affects older adults, particularly in relation to access, skills, motivation, and confidence in using digital technologies (Mubarak & Suomi, 2022). Unlike the general digital divide, which often focuses on infrastructural gaps, the grey digital divide emphasises cognitive, emotional, and generational barriers that disproportionately affect ageing populations in the context of digital transformation (Chee, 2024). This concept provides a crucial analytical lens for understanding how age intersects with broader technological, social, and behavioural inequalities (Diana et al., 2025).

The world is undergoing a profound demographic transformation, marked by an unprecedented acceleration in population ageing. In this context, understanding intergenerational dynamics is therefore essential for addressing disparities in access and fostering the development of inclusive and resilient financial ecosystems. Advancing research in this field is essential, particularly to inform the development of digital financial solutions and public policies aiming to bridge the digital divide and ensure equitable access to financial services. This situation poses challenges for governments in addressing the needs of an ageing population (Yao et al., 2021). The share of people aged 60 and over is projected to increase significantly, rising sharply from approximately 12% in 2020 to over 20% by 2050 (Doerr et al., 2022; Vollset et al., 2020). This trend (see Figure 1a,b) is evident across advanced economies, emerging markets, and developing economies, driven by increased life expectancy and persistent reductions in fertility rates.

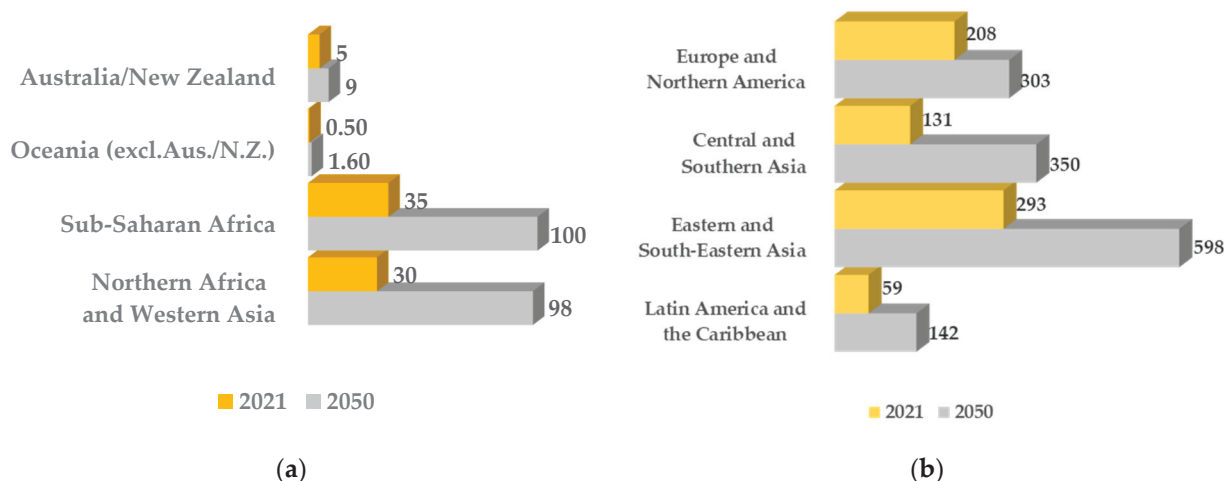


Figure 1. Number of people aged 65 years or above (millions) by region (2021 and 2050). Source: UN (2023). (a) Regions with fewer than 50 million people aged 65 and over in 2021 and 2050 (projections). (b) Regions with 50 million or more people aged 65 and over in 2021 and 2050 (projections).

The expansion of the elderly population is reshaping economic and financial systems worldwide. Among the sectors that are most affected, digital payment systems—which underpin virtually all daily transactions—stand out as particularly crucial. As societies transition toward digital economies, ensuring that no one is left behind becomes imperative. A truly inclusive digital transformation must address the specific needs of older adults, fostering accessibility, trust, and ease of use within payment ecosystems. For instance, initiatives aiming at promoting digital literacy among older adults often fall short due to high costs and a lack of confidence in technology (Forman et al., 2012; Helsper & Reisdorf,

2017). This situation calls for tailored interventions that address these vulnerabilities in a targeted and sustainable way. Understanding these intergenerational dynamics is vital for addressing digital accessibility inequalities among older people and for designing effective aged care systems. To create truly inclusive, customer-centred financial systems, it is essential to understand how individual characteristics shape engagement with digital payments and to identify factors that are particularly relevant for older users. By acknowledging the diverse needs of different demographic groups, digital payment systems can be better suited to integrating accessibility, usability, and an enhanced overall user experience. Despite growing attention, significant gaps remain in our understanding of how age, along with other demographic factors, affects perceptions of the acceptability and use of digital payment systems in different contexts. There is no integrated data that provides an overall picture, although certain factors, such as age and income, have been examined individually (Lohana & Roy, 2023; Said et al., 2021). Moreover, the existing evidence tends to focus heavily on individual countries (e.g., India or Sweden), limiting the generalisability of the results. To address these gaps, this study conducts a comprehensive systematic literature review, guided by the following main research question (RQ):

RQ: What role does age—particularly among older adults—play in shaping the adoption and use of digital payment systems?

To explore this issue comprehensively, the study addresses two key sub-research questions:

- RQ1: What are the main barriers (e.g., lack of trust, usability issues, security concerns) preventing elderly people from adopting digital payment systems?
- RQ2: How does the digital divide (e.g., lack of digital literacy, limited internet access) contribute to the difficulties that elderly people face in adopting digital payment systems?

By focusing on this crucial theme, we aim to generate valuable insights that could encourage governments, policymakers, and financial institutions to develop initiatives tailored to older users. Such initiatives would help to bridge the digital access gap, particularly for senior citizens, and promote equitable access to digital financial services for all demographic groups.

The rest of the paper is organised as follows: Section 2 outlines the methodology adopted, detailing the SPAR-4-SLR protocol for assembling, arranging, and assessing the relevant literature. Section 3 presents the main findings from the systematic review, organised into thematic clusters. Finally, Section 4 concludes by outlining policy recommendations and avenues for future research.

2. Materials and Methods

This paper analyses research trends in the domain of digital payments, aiming at understanding the role of age in influencing the adoption and use of these systems, especially among older adults. Employing an integrated methodological framework, the study combines elements of cumulative research analysis with a systematic literature review (SLR) covering an extensive timeframe. The SLR approach follows a transparent, structured, and reproducible protocol (Akello et al., 2022; Lim & Weissmann, 2023; Rao et al., 2023), allowing researchers to systematically evaluate the existing literature, highlight prevailing research trends, identify knowledge gaps, and suggest viable future research directions (Lim et al., 2021). While various frameworks exist for conducting systematic literature reviews (Paul et al., 2021), this study aligns with the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses; (Moher et al., 2015) to ensure transparency, replicability, and rigour in reporting, as documented in Appendix A. However, to guide the analytical stages of the review and structure the synthesis of the results, we adopt the SPAR-4-SLR protocol (He et al., 2024; S. Kumar et al., 2024; Paul et al., 2021). SPAR-4-SLR provides a structured, process-orientated framework articulated

in three phases—assembling, arranging, and assessing—which supports methodological coherence, minimises bias, and facilitates the generation of robust, generalisable insights. The integration of both protocols ensures a transparent reporting process (via PRISMA) and a rigorous, thematically structured analysis (via SPAR-4-SLR). Specifically, during the “assembling” stage, relevant literature was systematically identified and collected. In the “arranging” stage, the sample was refined by applying predefined inclusion and exclusion criteria. Finally, the “assessing” stage involved analysing and synthesising the selected studies, which enabled the categorisation of existing research into four principal thematic clusters. Figure 2 provides a visual summary of this methodological framework, with further details provided in the subsequent paragraphs.

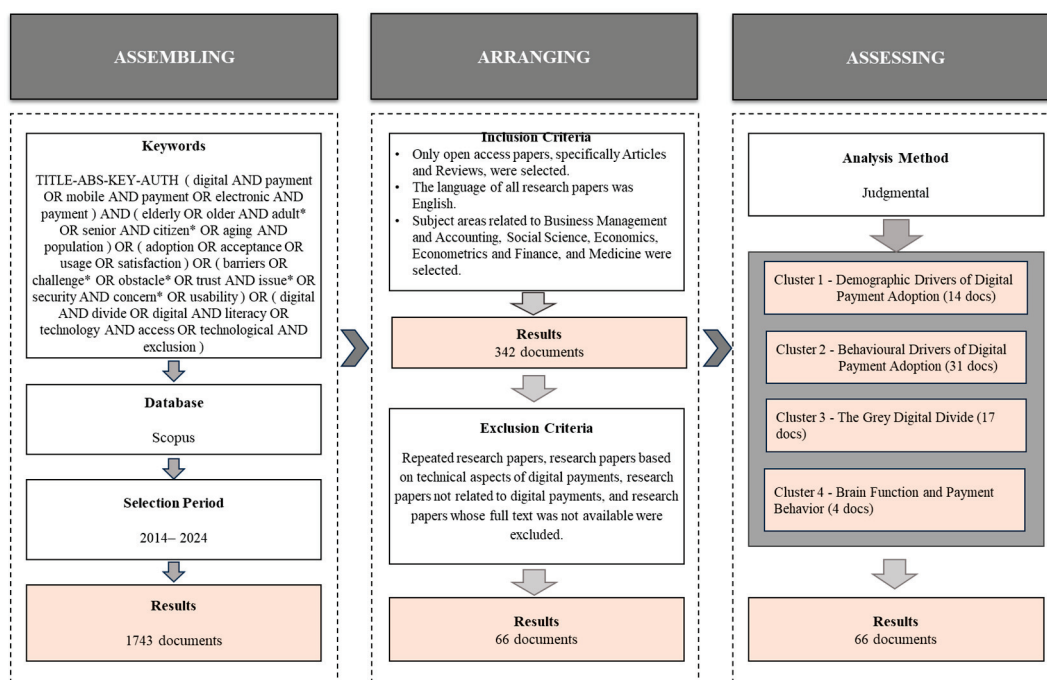


Figure 2. The methodological flowchart used for reviewing the literature on digital payment adoption by the elderly, adhering to the SPAR-4-SLR protocol. *Notes:* “TS”, such as “topic” in Web of Science, refers to searches for topic terms in the following fields within a record: title, abstract, author keywords, and keywords plus. The asterisk (*) serves as a truncation operator in Scopus search queries, enabling the retrieval of all terms that share the same initial root but differ in their endings.

The Assembling Step: Once the research questions (RQ1 and RQ2) had been clearly defined, relevant keywords were identified to guide the search for scholarly contributions aligned with the study’s objectives (Figure 2). Specifically, the search terms included combinations of keywords such as “digital payment*”, “elderly”, “older adult*”, “ageing population”, “technology adoption”, “financial inclusion”, and “digital divide” (see Figure 2 for the string used). Boolean operators (AND, OR) were used to refine the query, and truncation symbols (*) ensured the inclusion of variations (e.g., “payment”, “payments”).

Scopus was selected as the primary database due to its extensive coverage of scholarly work in the domain of digital payments, thereby reducing the likelihood of omitting significant references. Search queries were then systematically developed and refined, based on prior studies on digital payment such as that by Panetta et al. (2023), leading to the initial identification of fewer than 2000 articles. To enhance methodological rigour and ensure a comprehensive literature retrieval process, an additional author-based search was conducted, as recommended by Donthu et al. (2021). This cross-validation step served to confirm that the keyword-driven search strategy effectively captured the core contributions

of leading scholars in the field. Specifically, this author-based search involved identifying key scholars frequently cited in the domain of digital payment adoption and ageing, based on highly cited articles and reference co-occurrence across the initial search results. We manually reviewed the publication records of these authors in Scopus, using their author IDs to retrieve additional potentially relevant papers. This step helped to confirm that the keyword-based search had not missed central contributions and ensured alignment with the most active academic voices in the field.

The timeframe from 2014 to 2024 was selected to ensure the relevance and timeliness of the literature reviewed. Over the past decade, the adoption and development of digital payment systems have accelerated significantly, driven by rapid technological innovation, widespread smartphone penetration, and shifts in consumers' behaviour. Furthermore, this period captured the transformative effects of the COVID-19 pandemic, which profoundly impacted the use of digital payments across all age groups and brought particular attention to the challenges and opportunities faced by elderly users. Limiting the analysis to this timeframe ensured that the findings would reflect the most recent technological, social, and regulatory developments shaping digital payment adoption.

The Arranging Step: Applying defined inclusion and exclusion criteria, the initial sample of 1743 articles was reduced to a final sample of 66 scholarly contributions. In particular, the first round of filtering (inclusion criteria), based on Scopus's built-in filters, retained only articles published in English and classified under the subject areas of *Business, Management and Accounting, Social Science, Economics, Econometrics and Finance, and Medicine*. This step effectively excluded technical contributions from unrelated fields. To ensure academic quality, only peer-reviewed journal articles and review papers were included, while conference proceedings and book chapters were excluded. The inclusion criteria required that studies (i) were published in peer-reviewed journals between 2014 and 2024; (ii) were written in English; (iii) addressed the adoption or use of digital payment systems; and (iv) explicitly mentioned age or generational aspects. The exclusion criteria eliminated conference proceedings, book chapters, non-English papers, and contributions unrelated to the behavioural or demographic analysis of payment systems. Articles that addressed broader fintech themes without a clear reference to payments or age were also excluded during full-text screening.

The inclusion of the "Medicine" subject area was deemed appropriate due to the study's specific focus on the population. Relevant studies exploring behavioural economics, neuroeconomics, and the adoption of digital financial tools by older adults are often published in interdisciplinary medical journals, particularly those addressing cognitive function, health-related financial decision-making, and technological use in later life. Including this category thus allowed for a more comprehensive examination of the intersection between health sciences and economic behaviour.

To further enhance the credibility and accessibility of the selected documents, we retained only open access papers that adhered to institutional editorial standards. As our primary aim was to explore the relationship between digital payments and age, an additional filter retained only papers that explicitly referenced both terms. After applying Scopus's open access filter and confirming full-text availability, 342 relevant articles published between 2014 and 2024 were identified. We then examined abstracts and full texts to eliminate off-topic studies, yielding a final sample of 66 articles.

The Assessing Step: The papers included in the final sample were thoroughly analysed and synthesised through a full-text reading process. Subsequently, the final stage of the study systematically explored the selected articles by examining both their abstracts and main texts, following specific interpretative pathways identified through cluster analysis. After the full-text reading process, we reviewed the main conceptual and methodological

characteristics of each study (e.g., research focus, dependent and independent variables, analytical framework, country coverage) and tabulated them to assess their alignment with the emerging themes of the review. This allowed us to group the contributions into coherent analytical clusters, thus ensuring a structured synthesis consistent with both the SPAR-4-SLR protocol and PRISMA guidelines.

Given the relatively limited size of the final sample (66 articles), a judgemental clustering approach was adopted. Unlike statistical clustering techniques, which are typically suited to large datasets but are prone to generating unstable or less meaningful groupings in smaller samples, this qualitative, judgement-based categorisation allowed for a more nuanced and meaningful interpretation of the literature, better capturing thematic commonalities and emerging trends. Through this process, four thematic clusters were identified. Three clusters emerged as predominant: (i) Demographic Drivers of Digital Payment Adoption, (ii) Behavioural Drivers of Digital Payment Adoption, and (iii) The Grey Digital Divide. In addition, a fourth cluster, (iv) Brain Function and Payment Behaviour, was identified. Although comprising a smaller number of contributions, this final cluster was deliberately highlighted due to its significant potential for informing future research directions, reflecting the authors' strategic assessment of its relevance. To support the synthesis of the results, we systematically tabulated the key characteristics and findings of each study—including the topic, country, dependent and independent variables, and methodological approach—and organised them into structured summary tables for each thematic cluster. This tabular presentation facilitated comparison across studies and enhanced the clarity of the review. Where appropriate, we also developed visual tools (e.g., conceptual maps, cluster diagrams) to highlight thematic relationships and strand-level differences among the included papers. The results of the cluster analysis are summarised in dedicated tables, which tabulate the key characteristics and findings of each study included in the review. This systematic presentation facilitates comparison across thematic groups and supports transparency and replicability, in line with PRISMA recommendations. As this review followed a qualitative synthesis approach without performing meta-analytical calculations, no formal statistical methods were applied to assess the risk of bias due to missing results (e.g., publication bias). However, we sought to mitigate potential reporting bias through a comprehensive literature search, clearly defined inclusion/exclusion criteria, and transparent documentation of the screening and synthesis process. Given the qualitative nature of this systematic literature review, no formal statistical methods (e.g., GRADE) were used to assess the certainty of the evidence. However, efforts were made to ensure a robust and credible synthesis by adopting a transparent protocol (SPAR-4-SLR), triangulating findings across clusters, and relying on peer-reviewed, open access articles selected through well-defined inclusion and exclusion criteria.

3. Results

This section synthesises and critically discusses the key findings of the systematic literature review, organised around four thematic clusters. Each cluster represents a distinct yet interconnected strand of research concerning the use of digital payment systems by older adults. The clusters are discussed in dedicated subsections, where the main contributions of the papers included are summarised, compared, and critically interpreted. This structure facilitates a deeper understanding of both the prevailing insights and the gaps within the existing literature. Following the cluster-specific discussions, a synthesis is presented that explicitly aligns the findings of the review with the two guiding research questions (RQ1 and RQ2). This integrative analysis draws on insights from all four thematic clusters to offer a comprehensive response to the research questions. The synthesis also outlines key implications for future research, policy, and practice, with particular emphasis on

designing inclusive, age-sensitive digital financial systems. While no formal statistical tools were applied to assess the risk of bias due to missing results, the review minimised such risks through a comprehensive and transparent inclusion strategy. Furthermore, although we did not apply formal frameworks such as GRADE, confidence in the body of synthesised evidence is supported by the robustness and consistency of the findings across multiple thematic strands. This strengthens the interpretability of the results discussed in the following sections. Although no formal statistical methods were applied to assess the risk of bias due to missing results, the comprehensive search strategy and transparent inclusion criteria aimed to minimise potential reporting biases.

3.1. Cluster 1: Demographic Drivers of Digital Payment Adoption

This cluster gathers 14 studies published between 2008 and 2024, with a notable concentration of contributions emerging after 2021. Geographically, the majority of research in this area is conducted in India, which accounts for nearly 60% of the total number of studies. This reflects the country's rapid evolution in digital payment adoption, particularly in the wake of significant financial and technological transitions. While several studies within this cluster explore age-related differences in digital payment behaviour, the overall scope extends to a broader demographic perspective, encompassing factors such as education, income, gender, technological access, and exposure to awareness programmes. This diversity underscores the multifaceted nature of demographic influences on digital financial engagement. As highlighted in the literature review by Colline et al. (2022), digital payments offer benefits across generation lines, from Generation Z to Baby Boomers (see Table 1 for the definition of different generations). This generational breadth suggests that digital payment systems possess wide demographic appeal, enhancing their relevance and attractiveness across diverse user segments.

Table 1. Definition of generations: characteristics and useful references.

Generation	Birth Years	Definition	References
Silent Generation	1928–1945	Characterised by a strong work ethic, loyalty, frugality, and a preference for stability. Shaped by the Great Depression and World War II.	Sabaitytė and Davidavičius (2017)
Baby Boomers	1946–1964	Known for ambition, social change advocacy, a strong work ethic, and hierarchical views of work. Influenced by post-war economic prosperity and civil rights movements.	Patterson (2006)
Generation X	1965–1980	Independent, sceptical of authority, adaptable, and entrepreneurial. Value work–life balance and experienced economic shifts and the rise of technology.	Bulbeck (2012)
Generation Y (Millennials)	1981–1996	Digital natives with an emphasis on technology, social justice, and work–life balance. Value transparency, collaboration, flexibility, and meaningful work.	Jung and Yoon (2021); Bencsik et al. (2016)
Generation Z	1997–2012	Digital natives focused on authenticity, inclusivity, mental health, and sustainability. Prefer flexible work environments and have an entrepreneurial mindset.	Nabahani and Riyanto (2020); Schroth (2019); Basid and Atmaja (2022)

Age and generational factors are the central themes in the studies by A. Kumar and Lim (2008) and Lohana and Roy (2023), both of which demonstrate that generational differences significantly influence perceptions, and satisfaction with, digital payment systems. In particular, older cohorts—such as Baby Boomers—tend to exhibit slower adoption rates compared to younger generations. Similarly, Saha and Kiran (2022) highlight that older adults often require stronger support structures, such as enhanced security, usability, and targeted education initiatives, to facilitate their transition toward digital financial practices. Collectively, these contributions underscore the importance of allowing sufficient time for older individuals to learn and adapt to digital payment technologies. They also point to the critical role of user-friendly interfaces and dedicated instructional support in promoting adoption among senior users. The findings reinforce the need for inclusive design principles and intergenerational learning strategies to ensure that older adults are not excluded from the digital financial ecosystem. Beyond age, education and income levels emerge as critical enablers of digital payment adoption. Studies by Behera et al. (2023) and Said et al. (2021) demonstrate that individuals with higher educational attainment and greater income levels are more likely to adopt and maintain the use of digital payments. Similarly, Baviskar et al. (2023) and Saroy et al. (2022) emphasise how external factors—such as smartphone accessibility, government initiatives, and the recent pandemic—have widened digital payment adoption, particularly among better-connected and better-informed populations. Behera et al. (2023) further report a notable shift in digital payments after the COVID-19 pandemic, particularly among more educated and wealthier individuals, reflecting an evolving financial transaction landscape. Additionally, Andaregie et al. (2024) analyse nationally representative data from Ethiopia, identifying mobile device ownership, ATM/debit card access, and internet connectivity as pivotal technological enablers for digital payment adoption. Their findings reinforce the idea that socio-economic factors, such as education, income, and financial inclusion, significantly influence the likelihood of adopting digital financial services, further highlighting the intersection between technological access and demographic characteristics.

Other studies delve into the intersection of multiple demographic dimensions and their collective impact on digital payment adoption. Research by M. A. Khan (2021), Jaiswal et al. (2022), and Lohana and Roy (2023) indicates that a confluence of characteristics, such as age, gender, education, and marital status, shapes users' perceptions of service quality, security, satisfaction, and loyalty with digital payment systems. These studies emphasise that digital payment experiences are not solely influenced by a single demographic variable, but are instead the result of complex interactions between various socio-demographic factors. Additionally, some studies address issues of digital exclusion and inequality. Sanchez-Diaz et al. (2021) highlight that older and marginalised populations faced significant barriers to accessing online financial services during the COVID-19 pandemic. This underscores the importance of addressing digital divides and ensuring that all demographic groups have equitable access to digital financial services, particularly in times of crisis. Table 2 summarises the key studies included in cluster 1.

While demographic characteristics, such as age and income, play a significant role in the adoption of digital payment systems, their influence is often mediated by psychological and behavioural variables. The next cluster explores these behavioural dimensions in greater depth, relying on theoretical frameworks such as the TAM and UTAUT to understand users' intentions and decision-making processes.

Table 2. Cluster 1: Demographic influences on digital payment adoption (alphabetical order).

Authors (Year)	Country	Research Questions	Main Findings
Andaregie et al. (2024)	Ethiopia	How do socio-economic characteristics influence digital payment adoption?	Mobile ownership, ATM/debit cards, and internet access significantly impact digital payment adoption.
Al-Qudah et al. (2024)	Malaysia	What variables affect Millennials' acceptance of digital payments within Generation Z?	Perceived convenience, security, cost, and social influence impact digital payment adoption. Privacy and security concerns, lack of information, and aversion to change are prevalent challenges among Millennials.
Baviskar et al. (2023)	India	- How did COVID-19 affect the adoption of digital payments for household expenses in India? - What are the key factors influencing the long-term sustainability of digital payment adoption?	The UAE's ¹ digital transformation strategy is bolstered by high electronic payment adoption, with positive correlations between education and income levels, but no significant associations found with gender, marital status, age group, or professional position.
Behera et al. (2023)	India	- How do education, income, and network issues impact digital payment adoption in Odisha ²? - What factors drive the increase in digital payment use and the decline in cash transactions post-COVID-19?	The use of digital payments rises with educational attainment and income levels, but the percentage of cash transactions has diminished following the recent pandemic.
Colline et al. (2022)	Global (Literature Review)	- What are the principal variables affecting the uptake of digital payments? - How do security and tech advances impact adoption?	Digital payment adoption is influenced by security, convenience, efficiency, and transparency, but faces barriers like age, internet access, and technological literacy.
Jaiswal et al. (2022)	India	- What are the determinants of pre- and post-adoption dynamics of mobile wallet usage? - How do demographic variables moderate continued usage?	The study highlights that performance expectancy, effort expectancy, facilitating conditions, and individual mobility are key drivers of confirmation. Satisfaction partially mediates the link between confirmation and continuance intentions, while age and education moderate the confirmation–satisfaction relationship.
M. A. Khan (2021)	India	How do demographic factors and service-related attributes influence digital payment adoption in India?	Digital payment adoption is influenced by demographic factors, service quality, reliability, satisfaction, security, and user-friendliness, with government efforts and increased smartphone penetration likely to boost adoption.
A. Kumar and Lim (2008)		- How does age affect mobile service quality perceptions? - How do perceived economic and emotional values impact satisfaction in different age groups?	The study reveals significant differences in satisfaction between Gen Y and baby boomers, with network quality being crucial for both groups, while emotional value is more significant for Gen Y.
Lohana and Roy (2023)	India	In what ways do demographic characteristics affect the use of digital payment systems following the demonetisation period?	Gender, age, education, marital status, and income impact the use of digital payments.
Saha and Kiran (2022)	India	- What determinants affect the behavioural intention of baby boomers to embrace UPI ³? - In what manner does perceived security influence the relationship among privacy risk, ubiquity, and behavioural intention?	COVID-19 significantly influenced UPI adoption among baby boomers, with perceived security playing a crucial role in influencing risk, ubiquity, and behavioural intention.

Table 2. Cont.

Authors (Year)	Country	Research Questions	Main Findings
Said et al. (2021)	United Arab Emirates	- Which demographic factors influence the adoption of e-payment technologies in Dubai? - How do income and education levels affect users' behaviour toward adopting new technologies?	The UAE's digital transformation strategy is bolstered by high e-payment adoption, with positive correlations between education and income levels, but no significant associations found with gender, marital status, age group, or professional position.
Sanchez-Diaz et al. (2021)	Sweden	How do demographic factors influence the usage of digital payment systems during the post-demonetisation period?	Significant inequalities in access to OHDS ⁴ , with marginalised groups (e.g., elderly, high-risk COVID areas) facing compounded marginalisation due to limited access.
Saroy et al. (2022)	India	- What factors propel the adoption and continued use of digital payments post-COVID-19? - What challenges hinder the long-term sustainability of this shift?	The lockdown determined by COVID-19 led to a significant shift towards digital payments, affecting trust, fraud, and consumer protection, requiring increased access to digital literacy and technology.

¹ UAE stands for United Arab Emirates; ² Odisha is a state located in Eastern India; ³ UPI stands for Unified Payments Interface, an instant real-time payment system developed by the National Payments Corporation of India (NPCI) to facilitate inter-bank transactions through mobile phones; ⁴ OHDS refers to Online Home Delivery Services.

3.2. Cluster 2: Behavioural Drivers of Digital Payment Adoption

This cluster consists of 31 studies published between 2016 and 2024, all of which employ structured behavioural models—primarily the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT)—to investigate the factors influencing digital payment adoption. Unlike the previous cluster, which was organised around demographic categories, this cluster is structured according to the theoretical frameworks employed to analyse users' behavioural intentions. The majority of the studies within this cluster are recent, reflecting the growing scholarly attention on digital financial adoption, particularly in the wake of the COVID-19 pandemic.

A substantial body of research in this cluster systematically identifies perceived ease of use and perceived usefulness as consistent and reliable determinants of digital payment adoption (general behavioural determinants identified through the TAM and UTAUT). Core studies supporting these findings include those by Tang et al. (2021) and Daştan and Gürlér (2016), both of which confirm that practical benefits and simplicity are pivotal drivers of users' intention to adopt digital payments. These results are echoed by Sivathanu (2019) and Sholihah and Ariyani (2023), who apply similar models across different demographic and geographic contexts.

Concerns regarding privacy, perceived risk, and trust emerge prominently as mediating factors influencing adoption behaviour. Kamal et al. (2023) and Zhong and Moon (2022) find that security concerns—particularly among older adults and less digitally confident users—significantly reduce trust and adoption intentions. Similarly, Ebubedike et al. (2022) and J. Zhang et al. (2019) show that interface design, perceived control, and risk aversion play a crucial role in shaping users' adoption behaviours.

Additionally, several studies in cluster 2 identify social factors and external support as significant predictors of digital payment adoption. Poudel et al. (2023), Al Arif et al. (2023), Sutresna et al. (2023), Patil et al. (2020), and, more recently, Purwanto et al. (2023) demonstrate that family, community, and cultural environments can enhance the acceptability of digital financial technologies. This evidence is particularly important in contexts where collective norms or traditions influence user behaviour, underscoring the need for culturally sensitive interventions.

Age emerges as a recurrent theme across several studies (age as a critical factor in behavioural intentions), highlighting the nuanced ways in which different generations approach digital payment technologies. Research by Zhu et al. (2023) extended the Theory of Planned Behaviour to model elderly users' digital payment intentions during COVID-19, revealing that older individuals experienced heightened perceived risk and were more dependent on intergenerational support for adoption. Similarly, Berraies et al. (2017), Santosa et al. (2021), and Thoumrungroje and Suprawan (2024) provide evidence that Baby Boomers and Generation X prioritise usability, security, and functionality, revealing a more cautious and pragmatic approach compared to younger cohorts. Findings across studies suggest that older adults' acceptance of digital payments is less influenced by trendiness or innovation, and more by clear functionality, trustworthiness, and the ease of integrating new systems into established routines. This pattern underscores the necessity of designing digital financial products that cater specifically to the cognitive, emotional, and experiential profiles of older users. Santosa et al. (2021) and Thoumrungroje and Suprawan (2024) find that age serves as a strong moderator of intention and satisfaction, with older adults valuing usability and stability over novelty or trendiness.

A distinct, well-defined substream within this cluster pertains to the impact of COVID-19 on digital payment adoption. The COVID-19 pandemic acted as a catalyst for digital payment adoption, accelerating usage and producing significant behavioural shifts. Sutresna et al. (2023) documented how social influences and performance expectations shaped adoption behaviours in rural Indonesia during the pandemic. Beura et al. (2023) focused on the role of perceived experience in promoting the sustained intention of digital payment users in India's post-pandemic environment. Zhu et al. (2023) similarly framed their exploration within a pandemic context, emphasising how external shocks modified perceived risks and motivational factors, particularly among elderly users. Chaveesuk et al. (2022) and Sutresna et al. (2023) further noted that social distancing considerations contributed to increased digital payment usage, particularly by enhancing perceived ease of use and satisfaction, in line with the TAM. Niankara and Traoret (2023) extended this observation to a global perspective, linking financial inclusion efforts during the pandemic to an uptick in digital payment adoption.

However, a more critical examination of the existing literature suggests that while the COVID-19 pandemic accelerated the adoption of digital payment systems among older adults, this shift was largely driven by necessity, rather than by a genuine readiness to embrace digital technologies. For many, the increased usage of digital tools mainly reflected a pragmatic response to the temporary unavailability of physical alternatives, rather than an enduring transformation in digital trust or behaviour. Empirical evidence indicates that, once in-person services resumed, a proportion of older users reverted to traditional payment methods, such as cash or branch-based banking, highlighting the fragility of behavioural change when it is not supported by adequate digital literacy, accessible interface design, and emotional reassurance.

Moreover, the crisis exposed stark inequalities: older adults with higher levels of education or a strong intergenerational support network adapted more easily, whereas those from lower socio-economic backgrounds or with limited prior exposure to digital tools often encountered heightened levels of stress, confusion, or even exclusion. These findings highlight that crisis-driven adoption does not equate to long-term inclusion. The most pronounced and persistent behavioural shifts were observed in settings where government policy, technology infrastructure, and social support systems aligned to reduce barriers and incentivize adoption. However, significant barriers—especially psychological- and trust-related barriers—remain for a subset of older adults, and regional disparities persist. The long-term sustainability of these behavioural shifts will likely depend on

continued support, infrastructure development, and targeted interventions to address remaining barriers. Consequently, policy design and interventions must address these deeper, structural barriers to ensure that digital engagement among older adults is both sustainable and equitable.

In addition to the drivers discussed, several studies address the socio-economic and infrastructural enablers of digital payment adoption (socio-economic contexts and digital literacy). Petrikova and Kocisova (2024) and Purwanto et al. (2023) demonstrate a nonlinear relationship between age and digital payment adoption across the Euro Area, reinforcing the view that structural conditions significantly mediate behavioural intentions. Similarly, financial literacy, digital infrastructure, and service accessibility are stressed as pivotal conditions for expanding adoption rates (Patnaik et al., 2023; Purwanto et al., 2023; Seldal & Nyhus, 2022). A lack of digital skills, even among financially literate users, is repeatedly cited as a key barrier that needs tailored interventions. These insights further highlight how generational divides interact with broader structural factors to influence digital payment behaviours. This stream suggests that perceived behavioural control, though often framed as psychological, is deeply influenced by material conditions.

Taken together, the findings in this cluster (detailed in Table 3) suggest that the intention to adopt and continue using digital payment systems is shaped by a dynamic interplay of technological perceptions (ease of use, usefulness, security), social and environmental influences, digital literacy, and macro-level shocks such as the COVID-19 pandemic. Importantly, while traditional TAM and UTAUT models remain robust explanatory frameworks, newer models increasingly incorporate contextual factors such as crisis environments, infrastructural readiness, and generational divides. Future efforts to promote digital payment adoption, particularly among older adults, must thus adopt multifaceted strategies that simultaneously address psychological, infrastructural, and social barriers.

Table 3. Cluster 2: Behavioural models and determinants of digital payment usage (alphabetical order).

Authors (Year)	Country	Research Questions	Main Findings
Al Arif et al. (2023)	Indonesia	What factors influence Indonesian Muslim youths' intention to use digital Zakat payments?	The pandemic has led to an increase in public donations, indicating the need for improved digital payment features and data security measures in Zakat management organisations.
Aurazo and Vega (2021)	Peru	- What are the determinants of digital payment use in Peru? - How does digital payment use vary across product categories and over time? - What are the implications for financial inclusion policies?	The use of digital payments in Peru is minimal. Utilisation is more prevalent among those aged 25 to 40, those possessing higher education, those with formal jobs, those with an urban domicile, those with an internet connection, and those with elevated household expenditure. The existence of financial institutions further enhances the acceptance of digital payments.
Berraies et al. (2017)	Tunisia	- In what manner do perceived values of mobile banking applications influence e-trust, e-satisfaction, and e-loyalty? - Does age moderate these relationships?	Perceived values (quality, price, emotional) of mobile banking apps predict e-trust. E-trust positively affects e-satisfaction and e-loyalty. Age moderates the relationship between perceived value and e-trust.
Beura et al. (2023)	India	What are the determinants of continuance intention towards digital payment, focusing on user experience and expectations?	Mobile expectancy confirmation explains continuance intention. Perceived usefulness, perceived experience, and satisfaction also contribute. Perceived experience moderates the confirmation–continuance relationship.
Chaveesuk et al. (2022)	Bangkok, Thailand	What factors influenced the continuous intention to use digital payments during COVID-19?	Ease of use, satisfaction, and social distancing impact digital payment adoption.

Table 3. Cont.

Authors (Year)	Country	Research Questions	Main Findings
Danisman and Tarazi (2020)	Europe	How does financial inclusion impact banking stability?	Financial inclusion, particularly through increased account ownership and digital payments, enhances banking system stability. The stabilising effect is strongest when targeting disadvantaged groups (young, undereducated, unemployed, and rural residents).
Das and Mahapatra (2020)	India	What influences consumer perception of bank payments?	Privacy, security, and convenience influence usage.
Daştan and Gürler (2016)	Turkey	What factors influence the adoption of mobile payment systems by consumers?	Trust, mobility, and attitudes positively influence MPS adoption, while usefulness and ease of use do not. Trust is positively related to reputation, while environmental risk negatively affects trust.
Dimitrova et al. (2021)	Sweden	What barriers prevent digital payment adoption?	Privacy, security, and access barriers affect digital payment adoption. For adopter–acceptors (young bank customers), privacy and access barriers hinder full adoption of digital payment methods.
Ebubedike et al. (2022)	Malaysia	What factors influence mobile payment adoption in Kuala Lumpur?	Trust, effort expectancy, and performance influence adoption.
Kamal et al. (2023)	Indonesia	- How do millennials perceive and use digital wallets vs. mobile banking? - What factors influence willingness to pay for transaction fees? - How do security, promotions, and integration impact consumer preferences?	Millennials prefer digital wallets over mobile banking due to promotions and usability.
C. Li et al. (2022)	China	How does heterogeneity (e.g., age, education, financial access) influence the relationship? How do big data-based digital payments impact household healthcare expenditure?	The impact of digital payments is stronger in households with high traditional financial accessibility, younger or middle-aged heads, and higher education levels.
Mavlutova et al. (2023)	EU and Baltic countries (Lithuania, Latvia, Estonia)	How does digital transformation drive financial sector sustainability?	Digital payments enhance financial inclusion and operational efficacy. There exists a positive correlation among the intensity of digital payments, financial inclusion, and operational efficiency in EU nations. Digital transformation improves customer satisfaction, reduces operational risks, and minimises environmental impact.
Niankara and Traoret (2023)	Global	- How did financial inclusion influence digital payments during the pandemic? - How did cross-country differences affect cashless payment preferences?	Financial inclusion significantly increased digital payments; gender gap in digital payment usage.
Niankara (2023)	Gulf Cooperation Council (GCC)	What role does financial inclusion play in digital payment adoption?	Financial inclusion indicators significantly influence digital payments.
Ocansey et al. (2024)	Ghana	How do mobile money and digital banking influence money velocity?	Mobile money, digital banking, and money velocity are interdependent.
Patil et al. (2020)	India	What factors drive mobile payment adoption in India?	Performance expectancy, grievance redressal, and social influence drive adoption.

Table 3. Cont.

Authors (Year)	Country	Research Questions	Main Findings
Patnaik et al. (2023)	India	- What factors influence digital payment adoption in India? - How do digital and mobile payments contribute to India's fintech revolution?	Trust, privacy, and financial literacy influence digital payment adoption; improving financial literacy is essential for broader acceptance.
Petrikova and Kocisova (2024)	Euro Area	- Which individual characteristics influence the use of digital payments in Euro Area countries? - Has there been a change in the use of digital payments after the coronavirus pandemic? - Is the level of digitalisation in the country crucial for increasing financial inclusion expressed through digital payments?	Higher income, education, and younger age groups increase digital payments; the digital access index influences adoption.
Poudel et al. (2023)	Nepal (Pokhara metropolitan city)	What factors influence the intention to adopt digital payment systems among the youth in Pokhara, Nepal?	Security and privacy, performance expectancy, and facilitating conditions significantly influence adoption intentions. Effort expectancy and social influence have no significant effect.
Purwanto et al. (2023)	Jakarta, Tangerang, South Tangerang, Indonesia	- What factors drive urban consumers to adopt digital payments? - What factors influence behavioural intentions toward e-money adoption among Generation X and Millennials?	Social influence and facilitating conditions drive adoption.
Santosa et al. (2021)	Indonesia	What factors influence the continuance intentions of baby boomers and Generation X towards digital payment use after the pandemic?	During the COVID-19 pandemic, Baby Boomers and Generation X adopted digital payments, with UTAUT2 constructs like performance expectancy and price value significantly impacting user satisfaction.
Seldal and Nyhus (2022)	Norway	How do demographic factors (e.g., age, gender, financial literacy) influence digital payment adoption and financial behaviour?	Mobile payment users are less financially vulnerable; women use digital payments more than men.
Sholihah and Ariyani (2023)	N/A	What factors influence Generation Z's intention to continue using digital payments in the post-COVID-19 era?	Perceived ease of use and satisfaction are significant predictors for continuance intention, while perceived usefulness is not.
Sivathanu (2019)	India	What factors influenced the actual usage (AU) of digital payment systems during India's demonetisation period? How does stickiness to cash affect the relationship between BI and AU?	Behavioural intention (BI) and innovation resistance (IR) affect the actual usage (AU) of digital payment systems. Stickiness to cash payments moderates the relationship between BI and AU.
Sutresna et al. (2023)	West Java, Indonesia	What factors influence the intention to use digital payments in rural communities during the COVID-19 pandemic?	Rural residents favour digital payments due to performance expectations and social influence, with perceived health risks like COVID-19 being less significant. Social influence significantly influenced adoption during the pandemic.
Tang et al. (2021)	China	What factors drive WeChat payment adoption?	Service quality, perceived risk, perceived security, perceived ease of use, social influence, and compatibility significantly influence consumers' intention to adopt WeChat as a digital payment platform. Age does not significantly influence adoption intentions.
Thoumrungroje and Suprawan (2024)	Thailand	What is the effect of technological self-efficacy and perceived values on mobile payment acceptance among various generations following COVID-19?	Technological self-efficacy influences m-payment intentions, with perceived values mediating for Gen B and X, and partially for Gen Y and Z, with younger generations less influenced.

Table 3. Cont.

Authors (Year)	Country	Research Questions	Main Findings
J. Zhang et al. (2019)	N/A	How does perceived security affect continuous mobile payment usage?	Perceived control, interface design, and conscientiousness impact security perceptions.
Zhong and Moon (2022)	China	What factors influence consumer adoption of contactless payment methods?	QR-code payment users are more satisfied than facial recognition users.
Zhu et al. (2023)	India	What factors influenced elderly users' intentions to adopt digital payments during the COVID-19 pandemic? How did motivation factors moderate these influences?	The study reveals that the TPB ¹ , perceived value, perceived risk, and COVID-19 influence elderly users' adoption of digital payments, with motivation factors like personal innovativeness and intergenerational support influencing these effects.

¹ TPB stands for Theory of Planned Behaviour.

Behavioural drivers, however, do not operate in isolation. They are often shaped by broader contextual and structural constraints, which are especially pronounced among older adults. The third cluster addresses this concern by shifting the focus from individual-level behavioural factors to systemic barriers, such as limited access, inadequate infrastructure, and socio-economic disparities—collectively referred to as the grey digital divide.

3.3. Cluster 3: The Grey Digital Divide: Structural Barriers to Digital Engagement Among Older Adults

This cluster brings together 17 studies (see Table 4) that investigate the persistent challenges that older adults face in accessing and utilising digital technologies. Although these studies do not exclusively focus on digital payments, they provide critical insights into the structural and socio-economic barriers shaping older individuals' broader digital engagement. Understanding these broader obstacles is essential to addressing RQ2 in particular, which explores the factors limiting the adoption of digital payment systems among elderly populations. Indeed, the reduced use of digital financial services by older adults cannot be fully explained without considering their limited access to the internet, lower levels of digital literacy, reduced motivation, and social or infrastructural constraints. The contributions in this cluster thus highlight how the grey digital divide—defined by gaps in skills, access, and empowerment among the elderly—is deeply intertwined with issues of income, education, cultural context, geographic disparities, and policy environments. Although the studies cover a wide range of digital inclusion topics, they collectively inform the understanding of why older populations remain underrepresented in the digital payment ecosystem.

A key insight emerging from the reviewed contributions is the central role of age in driving digital inequality. Older adults are systematically disadvantaged in accessing and effectively using digital tools, even in technologically advanced contexts. Research by Brandtzaeg et al. (2011) and Friemel (2016) illustrates that the elderly, compared to younger cohorts, display lower rates of digital engagement, with this disparity being heavily influenced by education levels, income, and private social support. Similarly, Hargittai et al. (2019) and Helsper and Reisdorf (2017) demonstrate that digital skills among older individuals in the United States, the United Kingdom, and Sweden are unevenly distributed along socio-economic lines, suggesting that lower education and income significantly exacerbate the risk of digital exclusion.

Table 4. Cluster 3: Key studies on age-related digital exclusion and structural barriers (alphabetical order).

Authors (Year)	Country	Research Questions	Main Findings
Audrin and Audrin (2022)	Global	- What place does digital literacy hold in the literature on education and learning? - How is digital literacy conceptualised in the educational context and what are the main research streams on the topic?	Key digital literacy factors for education: (1) Digital literacy; (2) Digital learning; (3) Twenty-first-century digital skills.
Brandtzaeg et al. (2011)	Europe (Norway, Sweden, Austria, the UK, and Spain)	- What are the different user types in Europe regarding internet usage? - How can we explain the different user types within, and across, different countries? - What is the relationship within and between countries, genders, age groups, types of households, and levels of access to technology with respect to different user types?	Identified five user types (Non-Users, Sporadic Users, Instrumental Users, Entertainment Users, Advanced Users) for digital divide analysis in Europe.
Brink (2024)	Luxembourg, Romania	How can digital inclusion for older adults be improved through training and system design?	- E-government systems unintentionally alienate older users due to complexity and assumptions about digital proficiency. - Peer-training and online skills classes are suggested solutions.
Chee (2024)	Unspecified	What barriers do older adults in senior care facilities face in adopting digital technology?	Older adults in senior care facilities struggle with digital technologies due to poor connectivity, functional impairments, and generational attitudes.
Friemel (2016)	Switzerland	- What proportions of groupings of seniors are using the internet with which frequency? - Which individual factors influence the likelihood of seniors' internet use? - Which social factors influence the likelihood of seniors' internet use? - Which reasons keep offliners from using the internet?	Individual and social variables influence the digital divide among seniors, with social networks having tremendous potential to overcome barriers such as physical restrictions and perceived complexities through focused support and benefit promotion.
Hargittai et al. (2019)	USA	How do socio-economic factors and available access points influence digital skills in older adults?	Socio-economic background and available access points affect digital skills among older Americans.
Helsper and Reisdorf (2017)	UK and Sweden	What motivates internet non-use among vulnerable groups?	Vulnerable groups represent a higher share of internet non-users, especially older adults.
Hunsaker and Hargittai (2018)	Developed nations	How does digital engagement affect well-being among older adults?	Digital engagement impacts health and well-being, and varies with age, income, and education.
Kaila (2023)	Vietnam	What factors hinder mobile phone adoption among ethnic minorities?	Education and socio-economic factors are barriers to mobile phone adoption among minorities.
H. Li and Kostka (2024)	China	How effective are government-led digital inclusion programmes for older adults in China?	Older Chinese adults lack digital understanding, which limits the effectiveness of government digital inclusion programmes. Outreach and training are needed.
Lythreathis et al. (2021)	Global	How are digital divides evolving across demographic lines?	Sociodemographic and economic factors drive the digital divide, shifting access types.

Table 4. Cont.

Authors (Year)	Country	Research Questions	Main Findings
Mohan and Lyons (2024)	Ireland	How does broadband access impact digital engagement among older adults?	High-speed broadband access is linked with increased internet use and online engagement among older adults.
Raihan et al. (2024)	Unspecified	What intersectional strategies can promote digital fairness among older populations?	Addressing the digital divide requires intersectional approaches, including affordable internet, culturally sensitive training, and community-led literacy programmes.
Rosenberg (2024)	Unspecified	How does internet use influence older adults' perception of digital technology in social interactions?	Online group involvement and internet use improve perceptions of technology's impact on social interactions.
Deursen and Van Dijk (2019)	The Netherlands	How do device disparities affect digital skills and outcomes?	Device-related disparities persist despite high internet access in the Netherlands.
Yang and Du (2020)	China	What are the main barriers to digital access among rural women?	Rural women in China face barriers due to low socio-economic capital, affecting digital access.
Yao et al. (2021)	China	How can policies mitigate pandemic-related digital exclusion among older adults?	The findings emphasise the need for policies to prevent pandemic-related digital exclusion in seniors.

Beyond age, these studies also emphasise the amplifying effects of socio-economic, cultural, and contextual barriers. Findings from Kaila (2023) and Yang and Du (2020) highlight that older adults from minority and rural backgrounds—such as in Vietnam and China—face compounded disadvantages due to limited educational opportunities, lower socio-economic capital, and restricted access to smart technologies. Deursen and Van Dijk (2019) further argue that even in environments with high levels of infrastructural availability, like the Netherlands, persistent disparities in digital skills reflect deeper structural inequalities that internet access alone cannot resolve. Furthermore, Brink (2024) critiques the design of e-government systems, pointing out that assuming high digital literacy levels unintentionally excludes older users unless specific support strategies are implemented.

Another significant dimension explored in this cluster is the link between digital engagement, health, and well-being. Research by Hunsaker and Hargittai (2018) shows that digital activities contribute positively to older adults' well-being and health. However, access to these benefits remains heavily mediated by socio-economic conditions. Studies by Rosenberg (2024) and Yao et al. (2021) highlight the heightened vulnerability of digitally excluded seniors to online risks, such as fraud or social isolation, particularly in crisis contexts like the COVID-19 pandemic.

Finally, several contributions emphasise the need for multidimensional strategies to promote digital inclusion among the elderly. Raihan et al. (2024) propose intersectional approaches that integrate affordable internet provision, culturally sensitive digital education, and community-based interventions to address the root causes of exclusion. Mohan and Lyons (2024) provide empirical evidence from Ireland, showing that access to high-speed broadband facilitates more frequent and meaningful online engagement among older users, although motivational and skills-related barriers persist. Similarly, Audrin and Audrin (2022) advocate for embedding digital literacy within broader educational policies, while Lythreitis et al. (2021) emphasise the importance of monitoring socio-economic trends that dynamically reshape the contours of digital inequality. Taken together, these findings portray the grey digital divide as a complex and evolving phenomenon where age interacts profoundly with socio-economic, cultural, and infrastructural factors. Addressing this

divide requires more than just expanding access; it necessitates integrated, context-sensitive strategies that simultaneously empower older adults with the skills, confidence, and motivation to participate fully in digital life—including, crucially, in the domain of digital financial services. Beyond individual digital skills and age-related factors, socio-economic and regional disparities significantly influence both access to and usage of digital payment systems. Lower-income individuals often encounter multiple layers of exclusion: limited access to smartphones, unreliable internet connections, and a lack of familiarity with app-based interfaces. These challenges are further compounded in rural or economically peripheral areas, where the decline of traditional banking infrastructure is not complemented by proportional investments in digital financial literacy or support mechanisms.

Several studies within this cluster highlight the uneven nature of digital readiness, showing that the mere presence of infrastructures does not adequately guarantee effective adoption. Individuals with lower levels of education or income frequently perceive digital payments as either insecure or irrelevant to their needs. Moreover, regional disparities often mirror broader patterns of economic marginalisation, resulting in entire communities being underserved by both traditional and digital financial services. These factors interact with age and technological familiarity in complex ways, creating cumulative barriers that disproportionately impact older adults in socio-economically disadvantaged contexts.

While structural barriers shape the external conditions for adoption, internal cognitive and neuropsychological factors also play a critical role, particularly among older adults. The final cluster explores emerging insights from neurofinance to shed light on how cognitive ageing influences financial decision-making, including digital payment behaviour.

3.4. Cluster 4: Brain Function

This cluster explores the emerging relationship between cognitive processes and payment behaviour, with a particular focus on older adults (Table 5).

Table 5. Cluster 4: Key studies on neuroscientific and cognitive perspectives on payment behaviour (alphabetical order).

Authors (Year)	Research Questions	Main Findings
Ceravolo et al. (2019)	How do colour and impulsivity modulate attention distribution while reading financial documents?	Eye movements during reading financial documents are influenced by colour and impulsivity, with colour playing a larger role.
A. Khan and Mubarik (2020)	How do different neurotransmitters influence financial decision-making and investment behaviour?	Developed an eight-dimensional neurotransmitter measurement scale to study their role in financial decisions.
Miendlarzewska et al. (2019)	How does neuroscience contribute to financial decision-making?	Neurofinance integrates psychology, neuroscience, and finance to understand financial decision-making and challenges classic finance theories.
Sudirjo et al. (2023)	What factors influence individuals' decisions to use multiple digital wallets simultaneously?	Convenience, utility, and sales promotions significantly influence the choice to use multiple digital wallets.

Neurofinance is an interdisciplinary field that combines insights from neuroscience, psychology, and behavioural economics to investigate how individuals make financial decisions. Unlike behavioural finance, which focuses on observed deviations from rational choice, neurofinance seeks to understand the underlying cognitive and neural mechanisms—such as attention, memory, emotional regulation, and reward processing—that drive financial behaviour. In the context of digital payment adoption, neurofinance offers a useful lens to explore how cognitive ageing influences the ways in which older adults perceive, trust,

and interact with digital financial tools. In the context of digital payment adoption, neurofinance provides a valuable framework for analysing how cognitive ageing affects user engagement, particularly in relation to interface design, learning capacity, and digital confidence.

Among the studies reviewed, only four contributions directly address payment behaviour or financial decision-making processes relevant to payment contexts. Most existing neuroeconomic research has concentrated on areas such as investments, credit evaluations, and financial market behaviour, underscoring the need to extend neuroscientific approaches to everyday financial transactions.

Cognitive functions such as memory, attention, impulsivity, and executive function play a fundamental role in shaping individuals' payment preferences and behaviour, especially in populations experiencing cognitive ageing. Age-related cognitive decline can manifest in various ways, such as reduced working memory, difficulty in managing multitasking, diminished inhibitory control, and slower decision-making. These changes increase the cognitive effort required to navigate digital interfaces—especially those that involve multi-step procedures, verification processes, or small-screen reading. As a result, even when older adults have access to digital payment tools, they may avoid using them due to the perceived complexity and mental fatigue associated with their use.

The contribution by Miendlarzewska et al. (2019) is particularly relevant in this context. By integrating insights from psychology, neuroscience, and finance, it demonstrates that emotional responses, cognitive biases, stress, and individual differences significantly influence financial decision-making. These mechanisms are particularly salient in digital contexts, where rapid interactions with interfaces and constant notifications can overwhelm users with lower cognitive resilience. In addition, A. Khan and Mubarik (2020) propose that neurotransmitters such as dopamine and serotonin modulate trust and impulsivity—two key dimensions that influence whether individuals perceive digital payments as secure and reliable or as risky and confusing.

Ceravolo et al. (2019) add a complementary perspective, showing how visual attention is modulated by design elements (e.g., colour) and personality traits such as impulsivity. Their findings suggest that digital payment interfaces—if poorly designed—can hinder comprehension and reduce confidence in completing a transaction. This is especially relevant for older adults, who may already be operating with reduced attentional capacity and who are disproportionately affected by unclear layouts, small fonts, and fast interaction flows.

Sudirjo et al. (2023) further support these insights by demonstrating that cognitive motivations, such as perceived convenience, reduced cognitive effort, and practical utility, drive the adoption of digital wallets. For older users, platforms that minimise cognitive friction and simplify the payment process are more likely to be adopted and retained over time. Their findings align with broader behavioural trends indicating that simplification and perceived ease of use significantly influence the transition toward digital financial ecosystems, particularly among individuals affected by cognitive decline.

The limited number of studies within this cluster highlights a notable gap in the current literature. While substantial progress has been made in documenting behavioural drivers and structural inequalities, the neurocognitive mechanisms that underpin how older adults engage with digital financial tools remain underexplored. Bridging this gap is essential not only for advancing theoretical understanding, but also for informing the development of inclusive technological solutions. Regulators, financial service providers, and developers should incorporate principles of cognitive ergonomics into the design process, by promoting usability testing with ageing users and adopting design standards that account for age-related changes in perception, memory, and attention. Aligning

financial innovation with neurocognitive inclusivity is essential to ensuring that the digital transition does not exacerbate age-related disparities in access and engagement.

According to the available evidence, this strand of the literature appears both underexplored and increasingly compelling. We believe that, by applying neuroeconomic approaches to the study of everyday payment, behaviour represents a highly promising frontier for future research. Investigating how cognitive ageing influences the acceptance and use of digital payment systems compared to cash payment systems could yield critical insights for designing more inclusive and cognitively adaptive financial technologies.

4. Discussion: Barriers, Digital Divide, and Strategies for Inclusion

The systematic review of the literature has identified several interconnected barriers that hinder the adoption of digital payment systems among senior citizens, directly addressing both RQ1 and RQ2. Technological challenges remain a major obstacle, with many older adults struggling to use digital payment applications that feature complex interfaces, requiring high cognitive effort to navigate. These technological barriers are compounded by age-related cognitive and physical limitations, such as memory decline, reduced vision, and decreased manual dexterity (Chee, 2024). In addition, security and privacy concerns introduce a substantial psychological barrier. Fears of fraud, personal data breaches, and a general mistrust towards digital systems are commonly reported by older users as key reasons for their resistance to the adoption (Dimitrova et al., 2021; Saha & Kiran, 2022). This combination of factors creates a sense of perceived vulnerability, which undermines users' willingness to adopt new payment technologies, even when, technically, access is available.

Socio-economic differences also exert a decisive influence in shaping digital payment behaviours among the elderly. Variations in income, education level, and broader financial inclusion significantly affect not only access to digital infrastructures, but also the ability to understand and confidently engage with digital financial services (Andaregie et al., 2024; Hargittai et al., 2019; Helsper & Reisdorf, 2017; Kaila, 2023; Lythreathis et al., 2021; Raihan et al., 2024). These findings reinforce the notion that adoption challenges are not merely technological or cognitive, but are deeply rooted in broader patterns of social and economic inequality.

The digital divide emerges as a structural factor that spans technological, skill-based, and motivational dimensions. Access-related divides—manifested in the limited availability of smartphones, broadband connectivity, and reliable internet services—are particularly pronounced for older adults in rural or underserved areas (Andaregie et al., 2024; Aurazo & Vega, 2021; Colline et al., 2022). Even when physical access is available, many elderly users are hindered by a skills divide, struggling with a lack of digital literacy and difficulty in acquiring new digital competences (Aurazo & Vega, 2021; Deursen & Van Dijk, 2019; Hargittai et al., 2019). However, the motivational divide appears equally critical. Older adults often express a low perceived usefulness of digital payment technologies and resistance to changing well-established payment habits, even when technical barriers are reduced (Ahmad et al., 2020; Beura et al., 2023; Sholihah & Ariyani, 2023; Zhong & Moon, 2022). This suggests that simply improving infrastructure and skills may not be sufficient, unless accompanied by efforts to reshape attitudes and expectations towards digital financial tools.

The literature also outlines several strategic pathways to facilitate greater inclusion. Improving digital literacy through targeted educational programmes emerges as a necessary step, aiming not only to teach technical skills, but also to build confidence and trust in digital systems. Moreover, the design of digital payment technologies must evolve to be more age-friendly, leveraging intuitive navigation, larger fonts, and even voice-activated systems to accommodate the cognitive and physical needs of elderly users. In parallel, community support mechanisms such as peer mentoring and localised training sessions

can play a key role in fostering adoption by creating trusting, supportive environments for learning and experimentation.

In conclusion, the findings show that elderly individuals' engagement with digital payment systems is influenced by a complex interaction of technological, cognitive, motivational, and socio-economic factors. Addressing these barriers through multidimensional strategies—such as technological redesign, targeted education, policy incentives, and community engagement—is essential for bridging the digital gap and promoting equitable access to financial innovations.

To support the synthesis of findings, Table 6 summarises the key barriers identified in the literature and links them to the corresponding research questions. The evidence is categorised across technological, cognitive, social, and infrastructural domains, offering a structured view of how these factors inhibit or shape digital payment adoption among older adults. Each entry highlights the underlying issue, references supporting authors, and outlines the practical strategies proposed in the reviewed studies. By consolidating the core insights from all clusters, this table serves as a bridge between the detailed literature review and the broader implications for policy and future research.

Table 6. Mapping insights from the literature to RQ1 and RQ2: key findings and suggested interventions.

Research Question	Category	Key Issues	Supporting Authors	Proposed Strategies
RQ1	Technological Barriers	Complex interfaces, unfriendly design, low usability	Daştan and Gürler (2016), Dimitrova et al. (2021), J. Zhang et al. (2019), Sivathanu (2019), Sholihah and Ariyani (2023), Beura et al. (2023), Tang et al. (2021)	Age-friendly interfaces, voice assistants, simplified UI ¹ , inclusive UX ² design
	Trust, Risk, and Privacy	Security/privacy concerns, fear of fraud, low trust	Kamal et al. (2023), Zhong and Moon (2022), Berraies et al. (2017), Ebubedike et al. (2022), J. Zhang et al. (2019), Tang et al. (2021)	Stronger data protection standards, transparent communication, fraud detection tools
	Cognitive and Physical Limits	Memory decline, dexterity, eyesight, cognitive load	Santosa et al. (2021), Zhu et al. (2023), Thourmrunroje and Suprawan (2024), Ceravolo et al. (2019)	Cognitive-aware design, larger fonts/buttons, tailored onboarding
	Social Support and Influence	Family help, peer encouragement, intergenerational support	Zhu et al. (2023), Santosa et al. (2021), Poudel et al. (2023), Al Arif et al. (2023), Sutresna et al. (2023), Sholihah and Ariyani (2023)	Peer mentoring, community-based support groups
RQ1/RQ2	Socio-economic Factors	Education, income, employment, financial literacy	Aurazo and Vega (2021), Hargittai et al. (2019), Petrikova and Kocisova (2024), Niankara and Traoret (2023), Patnaik et al. (2023), Seldal and Nyhus (2022), Beura et al. (2023), Lythreatis et al. (2021), Kaila (2023)	Subsidised access to tech, digital and financial literacy programmes
RQ2	Access Divide	No broadband, smartphone, or stable connectivity	Dimitrova et al. (2021), Niankara (2023), Petrikova and Kocisova (2024), Aurazo and Vega (2021), Deursen and Van Dijk (2019), Mohan and Lyons (2024)	Public Wi-Fi, rural broadband rollout, device donation programmes
	Skills Divide	Lack of digital literacy, inability to learn new technologies, low training capacity	Deursen and Van Dijk (2019), Santosa et al. (2021)	Targeted training, experiential learning, user testing with seniors
	Motivational Divide	Low perceived usefulness, inertia, resistance to changes	Beura et al. (2023), Sholihah and Ariyani (2023), Zhong and Moon (2022), Zhu et al. (2023), Sivathanu (2019), Sholihah and Ariyani (2023)	Highlight real-world benefits, gamified learning, social norm reinforcement

¹ UI stands for user interfaces; ² UX refers to user experiences.

Before concluding, it is worth acknowledging some limitations of both the reviewed evidence and the review process itself. The studies examined vary considerably in terms of geographic focus, methodology, and target populations—many are limited to specific national contexts or lack long-term perspectives. Although the review followed a structured

and transparent protocol, the exclusion of non-English literature and grey sources may have left out valuable insights. That said, the results provide useful guidance for both policy and practice: they highlight the urgent need to rethink digital payment ecosystems with an age-inclusive lens and open up promising directions for future research—particularly around cognitive ageing and the design of more supportive technologies.

5. Conclusions

This systematic literature review set out to explore the relationship between ageing and digital payment adoption by uncovering the complex interplay of behavioural, demographic, and structural factors that shape older adults' engagement with financial technologies. As digital payments become the default mode of transaction in many societies, ensuring that ageing populations are not excluded is both a social imperative and a technological challenge.

Our findings suggest that age itself is not a barrier, but rather a lens through which various vulnerabilities—such as low digital literacy, reduced cognitive agility, and socio-economic inequality—are magnified. The evidence shows that older adults are not unwilling to adopt digital financial tools; rather, their engagement is often hindered by inaccessible design, perceived risk, and a lack of tailored support. These barriers are compounded by broader divides in access, skills, and motivation, creating a stratified digital landscape in which elderly individuals often remain marginalised.

By organising the literature into four thematic clusters, this study highlights both the progress made and the gaps that remain. While behavioural models such as the TAM and UTAUT have provided a solid foundation for understanding user intentions, they often overlook the lived realities of ageing—realities marked by changing physical, emotional, and social dynamics. Similarly, while some efforts have been made to document the grey digital divide, fewer studies take a systemic view of how age-related exclusion emerges at the intersection of policy, technology, and human cognition.

What emerges clearly is that inclusive digital finance is not only a matter of infrastructure or access, but of empathy in design, foresight in policymaking, and sustained investment in digital capacity building. Age-friendly interfaces, intergenerational support networks, and community-based digital education programmes are not optional add-ons, but essential components of an equitable digital ecosystem.

In sum, ageing in a digital society requires more than technological adaptation—it calls for a rethinking of how we define usability, trust, and inclusion in financial innovation. Sustained investment in building digital capacity must be informed by rigorous, user-centred research. Future studies could explore the following questions:

- How do specific cognitive factors (e.g., memory retention, attentional control, decision fatigue) influence the usability of and trust in digital payment platforms among users aged 65 and over?
- What role do interface complexity and visual design features play in shaping digital payment behaviour across different cognitive ageing profiles?
- To what extent can intergenerational learning environments or peer-support interventions mitigate cognitive barriers to adoption?

These research directions could be pursued using mixed-methods designs that combine neuropsychological assessments (e.g., working memory tasks, cognitive load measures) with usability testing, eye-tracking experiments, or longitudinal interviews. Such approaches would help to bridge the gap between behavioural insights and practical design implications for inclusive financial technology.

In light of these findings, future research should not only explore the long-term impact of educational and policy interventions, but also embrace interdisciplinary approaches that account for cognitive, emotional, and social factors influencing digital engagement.

Among the most promising research frontiers, the emerging strand of neurofinance holds particular potential to shed light on how cognitive ageing shapes payment behaviour, offering new insights into decision-making processes and helping to inform the design of cognitively adaptive financial technologies for older users. Bridging the grey digital divide is not solely a matter of technological innovation; it is also a question of social inclusion and justice. Ensuring equitable access to financial technologies across all generations is a necessary condition for building truly inclusive digital societies.

Future research would benefit from more longitudinal, comparative, and interdisciplinary approaches, especially those that combine insights from economics, psychology, gerontology, and human–computer interaction. Only then can we ensure that digital transformation lives up to its promise: improving lives across all ages, without leaving anyone behind.

The findings of this review also carry significant practical and policy implications. Financial service providers and digital platform designers are encouraged to adopt age-sensitive usability standards that account for cognitive and emotional challenges that are commonly experienced by older adults. Policymakers should avoid one-size-fits-all digital inclusion strategies, and instead develop tailored interventions that account for local infrastructure deficiencies, income inequalities, and the distinct digital habits of different generational cohorts. Furthermore, the review highlights the value of participatory design and intergenerational learning programmes as effective tools for building trust in digital finance. Collectively, these implications advocate for a shift from purely access-oriented models of inclusion towards more human-centred, equity-driven approaches to digital payment innovation.

Building on these insights, we identify three policy priorities directly linked to the barriers outlined in this review. First, governments and regulatory agencies should promote the development of digital payment platforms that incorporate rigorous usability testing with older adults, ensuring accessibility for individuals experiencing cognitive decline or sensory impairments. Second, targeted interventions are imperative in rural and low-income areas where the reduction of physical banking infrastructure has not been compensated by investments in digital education programmes or infrastructure. Potential measures include developing mobile support units, establishing community-based digital finance advisors, and funding publicly accessible help desks. Third, policy frameworks should incentivize both formal and informal intergenerational mentoring initiatives that empower younger users to support elderly family members or neighbours in managing digital financial tasks. These actionable strategies aim to translate the study's findings into measurable steps toward a more inclusive and equitable digital payment ecosystem.

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Appendix A

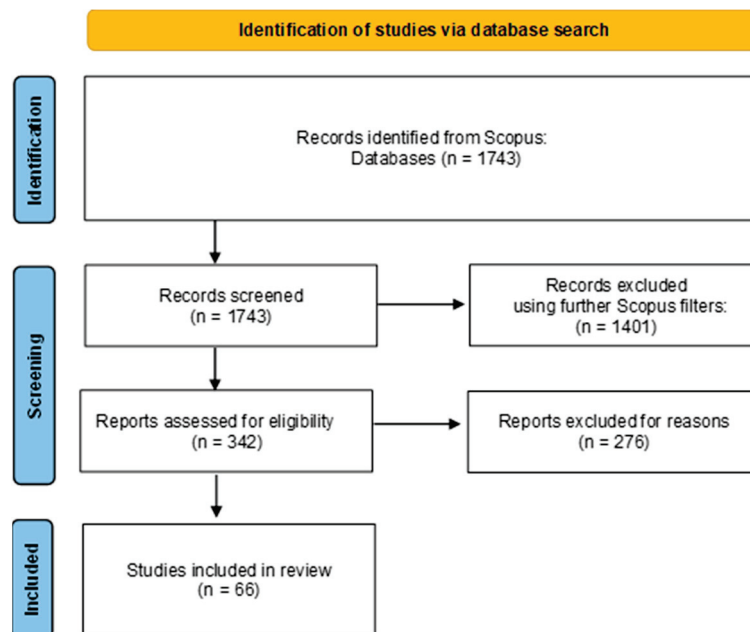


Figure A1. The PRISMA 2020 flow diagram for the selection of the included studies.

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Review

Mapping the Knowledge Landscape of Money Laundering for Terrorism Financing: A Bibliometric Analysis

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Abstract: This study employs a bibliometric analysis of emerging trends in money laundering for terrorism financing (ML/TF) to provide direction for future research. The authors used VOSviewer and analyzed 2577 published documents retrieved from the SCOPUS database using the PRISMA methodology. The findings reveal a growing research interest in understanding the complex interplay between money laundering and terrorism financing. This research emphasizes the significance of ML/TF for economic stability, as understanding terrorism financing mechanisms allows authorities to trace and block funds going to terrorist groups, which is crucial for national security. Critical insights for policymakers underscore the need for robust legislative frameworks, effective Financial Intelligence Units (FIUs), and international collaboration to combat these global threats. This analysis offers a foundation for future research, mapping the evolving knowledge landscape in ML/TF.

Keywords: bibliometric analysis; co-occurrence; VOSviewer; financial intelligence unit; financial action task force; anti-money laundering; counterterrorism financing; cryptocurrencies

1. Introduction

A robust and transparent financial system contributes significantly to the global fight against money laundering for terrorist financing. Consequently, research into the vulnerabilities and countermeasures within the banking sector has been gaining the interest of researchers across the globe. Money laundering for the purpose of financing terrorism (ML/TF) poses a significant threat to global security and financial stability. Criminal enterprises and terrorist organizations take advantage of financial systems to obscure the origins of their money and fund their operations. Addressing ML/TF requires a comprehensive strategy that incorporates robust legislative measures, efficient Financial Intelligence Units (FIUs), and collaborative efforts on an international level.

With this background, this study aims to provide readers with a brief outline of the literature on money laundering for terrorism financing. It focuses on emerging trends, publication statuses, and leading authors, organizations, and countries contributing to this field of study.

Money laundering and terrorism financing are critical issues that intersect with global governance, democracy, and criminality. Various studies highlight the complexities of these issues across different regions and legal systems. For instance, international governance organizations like the Financial Action Task Force (FATF) play a pivotal role in setting anti-money laundering (AML) and counterterrorism financing (CTF) standards, urging member states to comply with international regulations (Kalokoh 2024). Despite the widespread adoption of these standards, many countries continue to face significant challenges in implementation. In Bosnia and Herzegovina, for example, money laundering is governed by criminal laws at multiple levels—state, entity, and district—indicating the complexity of managing compliance across different jurisdictions. While preventive

measures are outlined in national laws, assessments reveal practical deficiencies in terms of enforcement and the adaptation of regulations to current laundering methods (Katica 2024). Similar challenges exist globally, where the effectiveness of regulatory frameworks varies, particularly in regions with high levels of criminality and political instability. Several scholars have explored the relationship between democratic governance and the ability to combat financial crimes. According to Nizzero (2023), International Relations theory offers insights into how global political dynamics affect the coordination of AML and CTF efforts. The research in this field emphasizes that international cooperation is essential for addressing transnational crime, yet the success of these efforts often depends on individual countries' internal stability and governance structures. Criminologists contribute to this conversation by analyzing how criminal networks exploit legal loopholes and technological advancements. Hybrid threats, which blend traditional crime with cybercrime and terrorism, present emerging challenges to the financial system's stability. Korauš et al. (2024) suggest that a more integrated approach is needed, combining criminological and international relations perspectives to effectively address these hybrid threats. Another emerging concern is the role of legal professionals in AML/CTF frameworks. The FATF mandates that lawyers, notaries, and similar professionals assess and mitigate money laundering and terrorism financing risks within their practices. However, these requirements have sparked debate, particularly regarding client confidentiality, with some arguing that these measures infringe on attorney–client privilege (Goldbarsht and Benson 2023). This tension between regulatory compliance and professional ethics continues to be a significant concern across jurisdictions. Additionally, digital financial tools such as crowdfunding have become attractive funding techniques for legitimate and illicit activities. Teichmann et al. (2022) warn that while crowdfunding can accelerate innovation and project funding, it is also a high-risk avenue in terms of money laundering, fraud, and terrorism financing. Indonesia's efforts to strengthen its AML/CTF measures, particularly in light of its FATF membership, are an example of how countries adapt to these emerging risks. Ginting et al. (2024) note that while joining FATF has bolstered Indonesia's global economic reputation, challenges like weak cash declaration rules and a limited supervisory capacity remain (Table 1).

Table 1. Earlier bibliometric studies on money laundering and terrorism financing.

Sr. No.	Authors	Title	Year
1	(Tiwari et al. 2024)	"Trade-based money laundering: a systematic literature review"	2024
2	(Khelil et al. 2023)	"The economic consequences of money laundering: a review of the empirical literature"	2023
3	(Ahuja et al. 2023)	"Money Laundering: A Bibliometric Review of Three Decades from 1990 to 2021"	2023
4	(Saxena and Kumar 2023)	"Bibliometric analysis of Journal of Money Laundering Control: emerging trends and a way forward"	2023
5	(Davidescu et al. 2023)	"Mapping the Field. A Text Analysis of Money Laundering Research Publications"	2023
6	(Isolauri and Ameer 2022)	"Money laundering as a transnational business phenomenon: a systematic review and future agenda"	2022
7	(Tiwari et al. 2020)	"A review of money laundering literature: the state of research in key areas"	2020
8	(Al-Suwaidi and Nobanee 2020)	"Anti-money laundering and anti-terrorism financing: a survey of the existing literature and a future research agenda"	2020
9	(Alsuwailam and Saudagar 2020)	"Anti-money laundering systems: a systematic literature review."	2020

Source: Compiled by the author from SCOPUS.

This article investigates the interconnected issues of money laundering and terrorist financing (ML/TF), emphasizing the necessity of a comprehensive strategy that includes

robust legislation, effective Financial Intelligence Units (FIUs), and international collaboration. By employing bibliometric analysis of the existing literature, it sheds light on the current research landscape, identifying key trends, authors, and organizations contributing to the field. This study aims to inform policymakers and law enforcement about the complex relationships between ML and TF, with the aim of ultimately enhancing strategies to disrupt criminal financial networks.

The bibliometric analysis uncovered important patterns in terms of the co-occurrence of keywords, authorship networks, and citation trends in the literature on money laundering and terrorist financing (ML/TF). This article highlights emerging research trends and influential contributors. This study will help researchers contribute to more effectively in the future in order to advance knowledge on the issue of money laundering and terrorist financing.

2. Materials and Methods

In the present study, the VOSviewer tool (van Eck and Waltman 2017) was employed to investigate the emerging trends related to money laundering for terrorist financing. VOSviewer version 1.6.20 (www.vosviewer.com) is a bibliometric software that utilizes a dataset of literature samples as its input, constructs a knowledge map, and generates visualization maps (Huang et al. 2022). Based on electronic bibliographic data, the visualization process can be performed using various analytical options, including co-authorship, co-occurrence, citation analysis, bibliographic coupling, and co-citation (Deveci 2023). Visualization methods serve as invaluable resources in research as they aid in comprehending intricate data and uncovering insights that may not be readily apparent through fundamental data analysis alone (Wagner Filho et al. 2018). Bibliometric methods, often referred to as bibliometric analysis, have become well-established scientific practices and are crucial in evaluating research, especially in scientific and applied disciplines. These methods are increasingly being employed to examine different facets of science and play a significant role in ranking institutions and universities globally. With a substantial body of research now available, it is feasible to use bibliometric analysis to study bibliometric methods themselves (Ellegaard and Wallin 2015).

2.1. Research Questions

1. What is the current status of publications on money laundering and terrorist financing?
2. What are the emerging trends in terms of publishing citations for money laundering for terrorist financing?
3. What are the leading authors, and which are the leading contributing organisations and countries, contributing to money laundering for terrorist financing?

2.2. Searching & Retrieving Data

SCOPUS, Web of Science, Google Scholar, etc., are some of the available databases that can be searched for the documents for the bibliometric analysis. The SCOPUS database provided us with more search results than the others (Moosa et al. 2021). The SCOPUS database has a large number and variety of publications. Further, in recent times, Scopus has earned a reputation as a comprehensive bibliographic data source, and it has proven to be reliable and, in some ways, even better than WoS. Due to this, this study used the SCOPUS database to search and retrieve the data for analysis.

The search was performed on 2 July 2024 using the keywords “Money Laundering” and “Terrorism Financing”, and also by adding OR Boolean searches—“FATF” and “Anti-money Laundering”—to yield a total of 4638 results. The preferred results were used in the systematic reviews (PRISMA) (Moosa et al. 2021) for the identification, screening, and selection of the final data for the analysis (Figure 1).

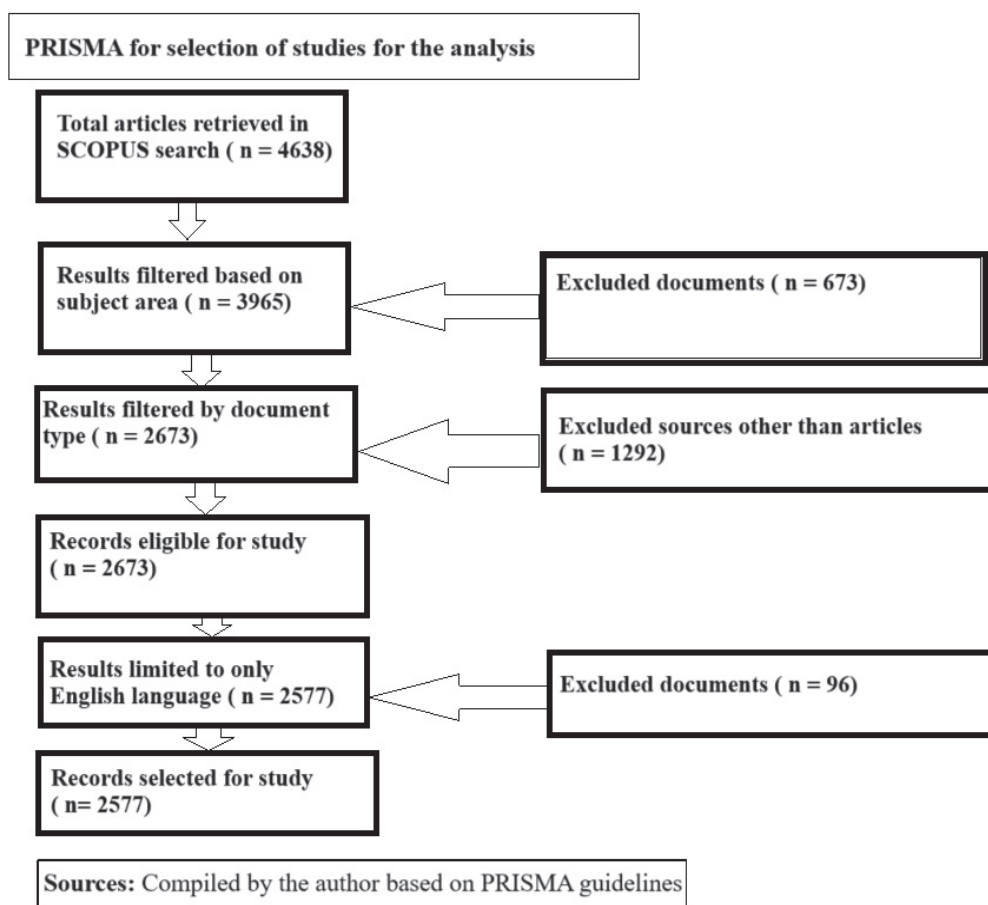


Figure 1. PRISMA is used for the selection of studies for the analysis. **Source:** Compiled by the author based on PRISMA guidelines.

The data file containing the 2577 documents was exported from the SCOPUS database as a .csv file and a BibTex file. The data could then be used for visualization purposes. In the study, we used the VOSviewer tool for the analysis (van Eck and Waltman 2017). Biblioshiny (an R tool for comprehensive Science Mapping Analysis) was utilized for the analysis (Aria and Cuccurullo 2017). Biblioshiny contains the most extensive set of techniques and is suitable for practitioners through Bibliometrix, an R package version 4.4.1 (Moral-Muñoz et al. 2020).

TITLE ("Money Laundering" OR "Terrorism Financing" OR "FATF" OR "Anti-money Laundering" OR "Terrorist Financing" OR "Financial Intelligence Units" OR "Financial Intelligence Unit" OR "Financial Action Task Force" OR "Financing of terrorism" OR "Financial Intelligence" OR "Counter-terrorism Financing" OR "Anti-money Laundering" OR "counter Terrorism Financing" OR "Counterterrorism" OR "Counter terrorism") AND (LIMIT-TO (SUBJAREA, "SOC") OR LIMIT-TO (SUBJAREA, "ECON") OR LIMIT-TO (SUBJAREA, "BUSI") OR LIMIT-TO (SUBJAREA, "MULT")) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "re")) AND (LIMIT-TO (LANGUAGE, "English"))).

During the initial stage of the process, we obtained descriptive results. For this, electronic data files containing the descriptive values of 2577 documents from the search results in the Scopus database were stored in the computer. The files were then arranged in the Excel electronic file, and the descriptive results were obtained in the next stage; visualization approaches were analyzed to obtain the evaluative results (Deveci 2023). VOSviewer was used, giving us a platform with methods and features that could be used in the analysis and the visualization process. VOSviewer is a software tool for constructing and visualizing bibliometric networks (Pires and Rafael 2022; van Eck and Waltman 2017) and was used in this study to construct and view bibliometric maps. VOSviewer can display maps con-

constructed using any suitable mapping technique, and the program can be applied not only to display maps, constructed using the VOS mapping technique, but also to display maps constructed using techniques such as multidimensional scaling (van Eck and Waltman 2009). VOSviewer runs on a large number of hardware and operating system platforms and can be started directly from the Internet (van Eck and Waltman 2009). VOSviewer is a bibliometric software that samples pieces of literature data as inputs, draws a knowledge map, and creates visualization maps (Huang et al. 2022). The visualization approaches based on the electronic bibliographic data can be carried out using different analysis options, such as co-authorship, co-occurrence, citation analysis, bibliographic coupling, and co-citation (Deveci 2023). Further, there are various analysis options, such as the author, organization, country, and source. Then, based on the analysis unit, the output is visualized using data mapping techniques such as network visualization, overlay visualization, and density visualization (Deveci 2023). The paper provides a comprehensive data analysis method, utilizing co-occurrence, co-authorship, and citation mapping approaches derived from bibliographic data.

2.3. Evaluative Parameters

The evaluative parameters include keyword co-occurrence, co-authorship, and citation analysis findings.

- **Keyword co-occurrence:** This refers to the frequency with which two or more keywords appear together in a set of academic documents or publications. It helps to identify the relationships between concepts and topics in a research area by analyzing how often particular keywords are used together. The more frequently keywords co-occur, the stronger the connection between those research themes, revealing trends and key topics within the field.
- **Co-authorship:** This analysis examines the collaboration patterns between authors, organizations, or countries based on the shared authorship of publications. By studying co-authorship networks, one can understand the structure of academic collaboration, identify influential researchers or institutions, and observe how knowledge is being exchanged and co-produced across different entities in a field.
- **Citation Analysis:** This method evaluates the impact or influence of academic papers by examining how often they are cited by other researchers. Citation analysis can track the intellectual influence of specific papers, authors, or institutions. It helps in identifying key contributions to a field, highly cited works, and the flow of knowledge over time across different research areas.

The table below provides comprehensive details of the mapping and visualization approaches based on the bibliographic data under consideration.

Table 2 provides a detailed overview of the different types of analyses, units, counting methods, and limitations used in bibliometric evaluations, particularly focusing on co-occurrence, co-authorship, and citation mapping. Table 2 shows that for co-occurrence, the unit of analysis is author keywords, and fractional counting is employed based on the occurrences of keywords, with a threshold of five occurrences. In co-authorship analysis, authors, organizations, and countries are the units, with fractional counting measuring the total link strength. For citation analysis, documents, sources, authors, organizations, and countries are evaluated, focusing on citation counts or total link strength. In this context, weights such as the occurrences and total link strength determine the strength of connections in the network. Visualization types like network visualization (NV) are used to represent relationships between entities, providing insight into collaborative and citation networks across various levels of analysis.

Table 2. Types, Units, and Limitations of Analysis Considered in Evaluative Results.

Type of Analysis	Unit of Analysis	Counting Method	Weights	Threshold	Visualization
Co-occurrence	Author keywords	Fractional counting	Occurrences	MNO of a keyword = 5	NV
Co-authorship	Authors	Fractional counting	Total link strength	MND of an author = 1, MNC of an author = 0	NV
	Organizations	Fractional counting	Total link strength	MND of an organization = 1, MNC of an organization = 0	NV
	Countries	Fractional counting	Total link strength	MND of a country = 1, MNC of a country = 0	NV
	Documents	Ignored	Citations	MNC of a document = 2	NV
	Sources	Ignored	Total link strength	MND of a source = 1, MNC of a source = 1	NV
	Authors	Ignored	Total link strength	MND of an author = 1, MNC of an author = 1	NV
Citation	Organizations	Ignored	Total link strength	MND of an organization = 1, MNC of an organization = 1	NV
	Countries	Ignored	Total link strength	MND of a country = 1, MNC of a country = 1	NV

Source: compiled by the author.

3. Results

The bibliometric analysis, conducted on 2577 documents from the Scopus database, revealed significant trends in money laundering for terrorism financing (ML/TF). The co-occurrence keyword analysis highlighted “money laundering” as the most frequent term, followed by “terrorism”, “counterterrorism”, and “anti-money laundering”, underscoring the primary research focus. The citation analysis identified key contributions to the field, with the United Kingdom, the United States, and Australia emerging as the most cited countries, reflecting their prominence in ML/TF research. The top-cited journals include the “*Journal of Money Laundering*” and “*Crime Law and Social Change*”, which are critical in disseminating research findings in this domain.

Additionally, the co-authorship analysis revealed solid collaborative networks, particularly among researchers from the United Kingdom and the United States. This study also indicated that regulatory and compliance issues are gaining increased attention, especially in evolving financial systems. These findings underscore the importance of international cooperation and interdisciplinary research in combating ML/TF while highlighting areas where further investigation is required, particularly in the intersection between money laundering and terrorism financing.

The journals shown in Figure 2 were chosen based on their relevance to critical research areas surrounding money laundering, terrorism financing, and financial crimes. These journals focus on issues directly related to anti-money laundering efforts, counterterrorism financing, and the broader nexus of economic crime. The selection also reflects the increasing publication output of these journals over time, as demonstrated by the cumulative occurrences in the figure, indicating their growing prominence in academic and policy discussions on these crucial topics. This trend highlights the journals’ significant contributions to understanding vulnerabilities and countermeasures within the global financial system.

The bibliometric analysis shows that the United Kingdom, with a substantial total of 4317 citations, as illustrated in Figure 3, was the most cited country. This indicates that the UK holds a significant position in the realm of research. Together, the United States and Australia accounted for more than 4663 citations, with Australia showcasing notable productivity in Asia and highlighting its considerable research contributions in that

area. Furthermore, the Netherlands and Switzerland are noted, with 775 and 589 citations, respectively. This provides a thorough summary of the five most cited countries.

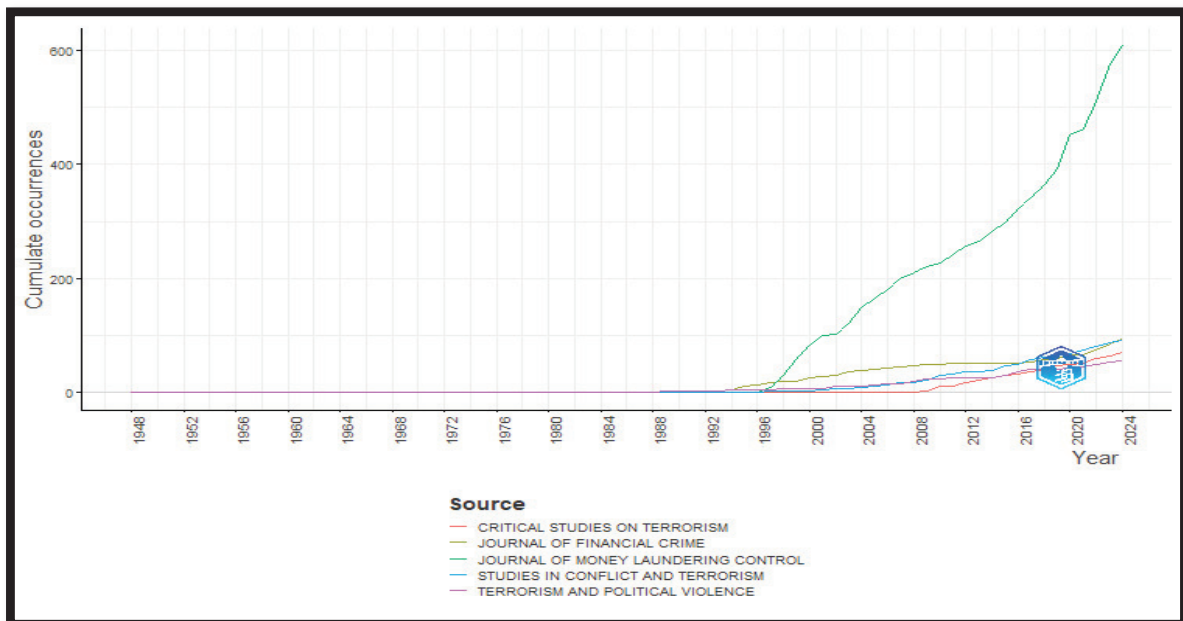


Figure 2. Annual production over time. Source: compiled by the author using the SCOPUS database.



Figure 3. Most cited countries. Source: compiled by the author from the SCOPUS database.

3.1. Co-Occurrence Keyword Analysis

The network visualization results of 219 of 3788 keywords that meet the criteria in terms of author keyword co-occurrence, with at least 5 occurrences of a keyword (Deveci 2023), are given in Figure 4.

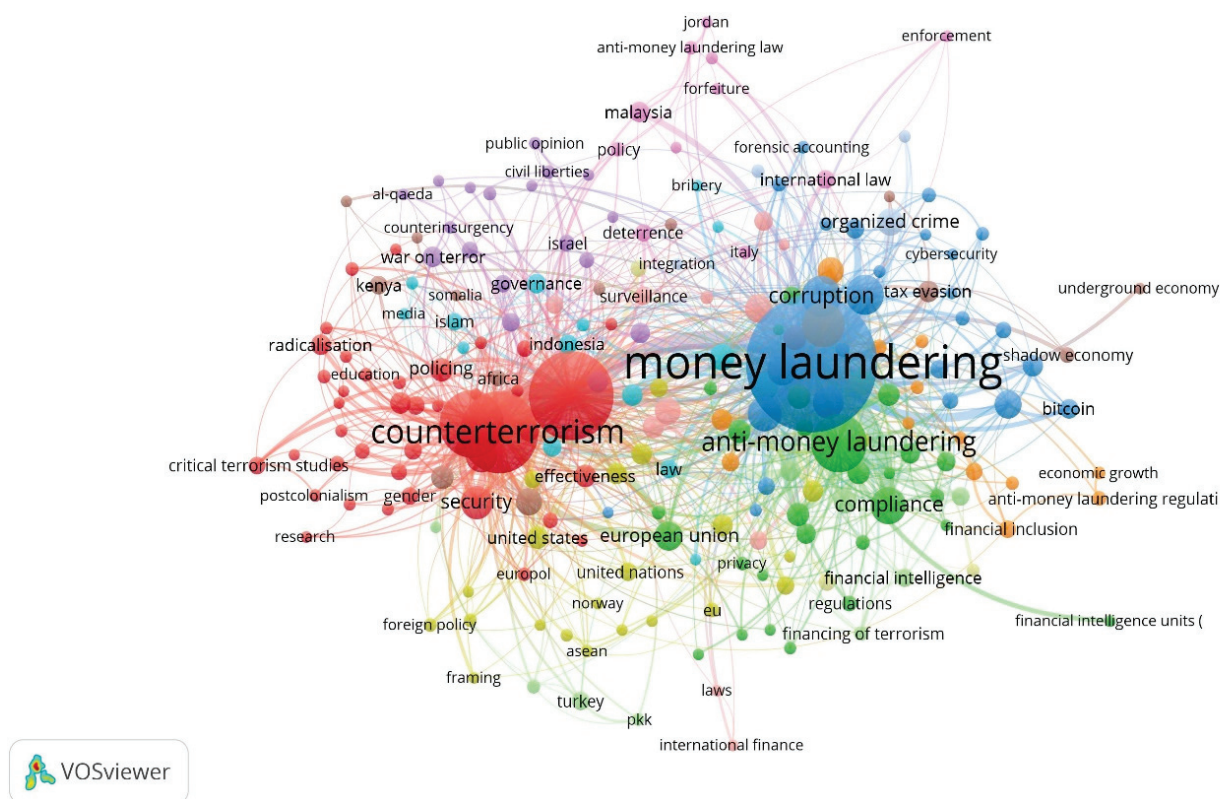


Figure 4. The co-occurrence of keywords. Source: compiled by the author from the SCOPUS database.

Out of the top 219 keywords, the top 10 keywords with the highest co-occurrence were money laundering (frequency of occurrence (FO) = 663), terrorism (FO = 273), counterterrorism (FO = 234), anti-money laundering (FO = 121), regulation (FO = 70), corruption (FO = 59), terrorist financing (FO = 58), compliance (FO = 48), security (FO = 39). Among these keywords, the 5 keywords with the highest total link strength were money laundering [total link strength (TLS) = 541], terrorism (TLS = 247), counterterrorism (TLS = 198), anti-money laundering (TLS = 98) and regulation (TLS = 69) (Deveci 2023).

3.2. Co-Authorship Analysis

The analysis of co-authorship among the authors yielded 1000 results, and Figure 5 displays the highest link strength for each of the 1000 authors' co-authorship connections (Deveci 2023).

The top 10 authors with the highest total link strength of co-authorship were, respectively, Mohamed Norazida (TLS = 11), Falker Marie-Christen (TLS = 11), Omar Normah (TLS = 10), Unger Brigitte (TLS = 8), Salehi Mahdi (TLS = 8), Masciandaro Donato (TLS = 8), Kaunert Christian (TLS = 7), Ofoeda Isaac (TLS = 5) (Ofoeda et al. 2020), Kuzmenko Olha (TLS = 4), Akartuna Eray Arda (TLS = 4) and Aish Kinza (TLS = 4).

The analysis of organizations' co-authorship produced 554 results. Figure 6 displays the highest total link strength for each of the 554 organizations' co-authorship links.

The top 10 organizations with the highest total link strength of co-authorship were, respectively, Teichmann International (Schweiz) AG (TLS = 5); the Accounting Research Institute, University Technology Mara, Shah Alam (TLS = 5); the School of Law, University Utara (TLS = 3); the Faculty of Law, University Kebangsaan (TLS = 3); the Association of

German Public Banks (TLS = 3); Bocconi University (TLS = 3); the University of Gujarat (TLS = 3); Prince Sultan University (TLS = 2); the Financial Intelligence Unit (TLS = 2); the University of Birmingham (TLS = 2); and the European University Institute (TLS = 2).

Countries were analyzed for co-authorship, yielding 140 results. Figure 7 displays the highest total link strength for each country's co-authorship connections.

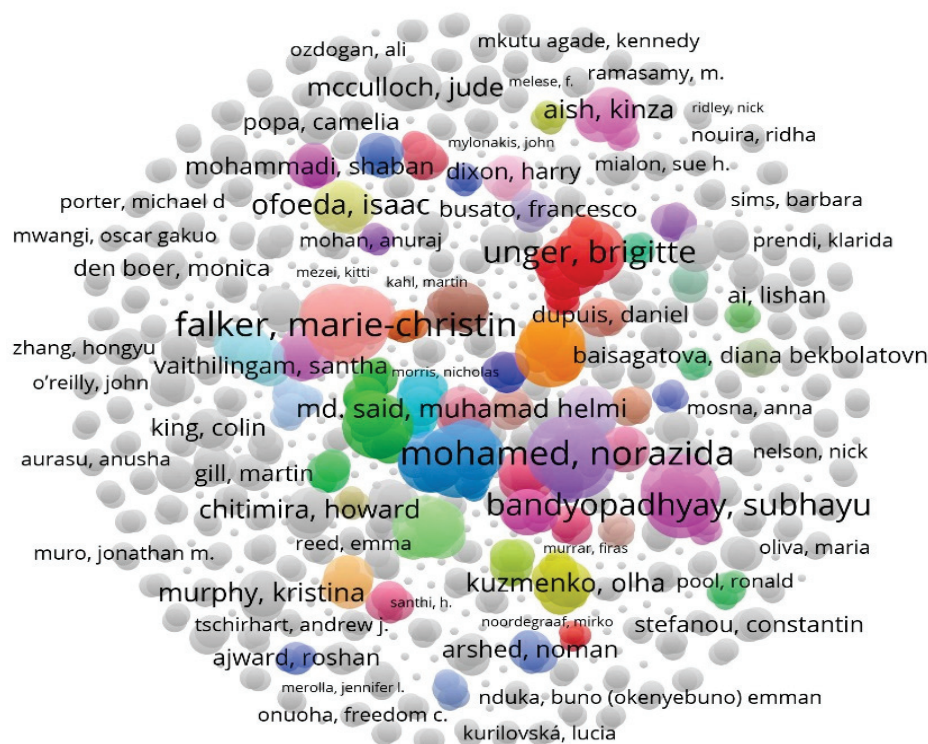


Figure 5. The total link strength of co-authorship links for authors. Source: compiled by the author from the SCOPUS database.

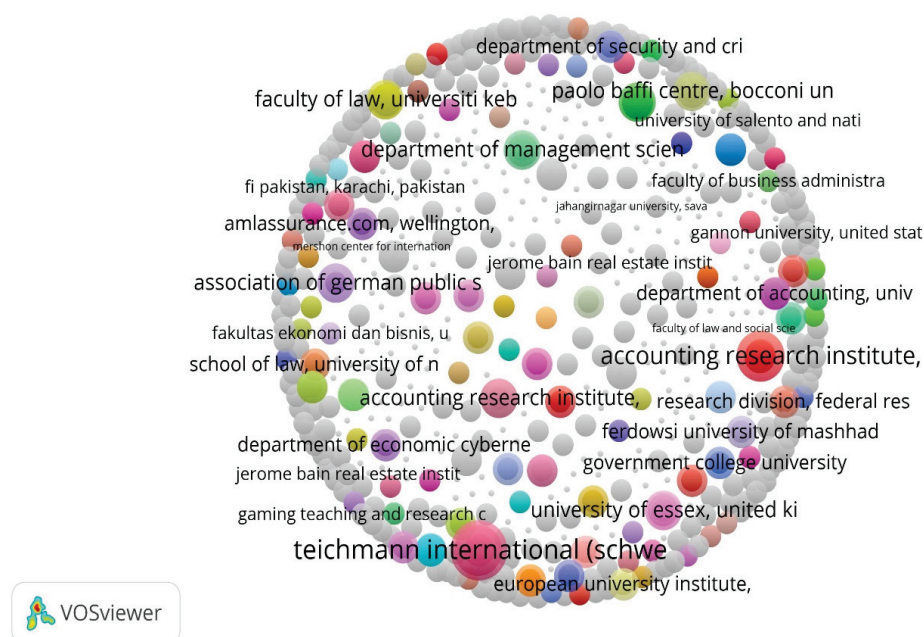


Figure 6. The total link strength of co-authorship links for organizations. Source: compiled by the author from the SCOPUS database.

The top 10 countries with the highest total link strength of co-authorship were, respectively, the United Kingdom (TLS = 104), the United States (TLS = 77), Australia (TLS = 50), Netherlands (TLS = 28), Malaysia (TLS = 23), China (TLS = 16), Canada (TLS = 15), Indonesia (TLS = 14), Switzerland (TLS = 9), India (TLS = 8). The United Kingdom, with the highest total link strength, has the strongest connection with the United States and Australia.

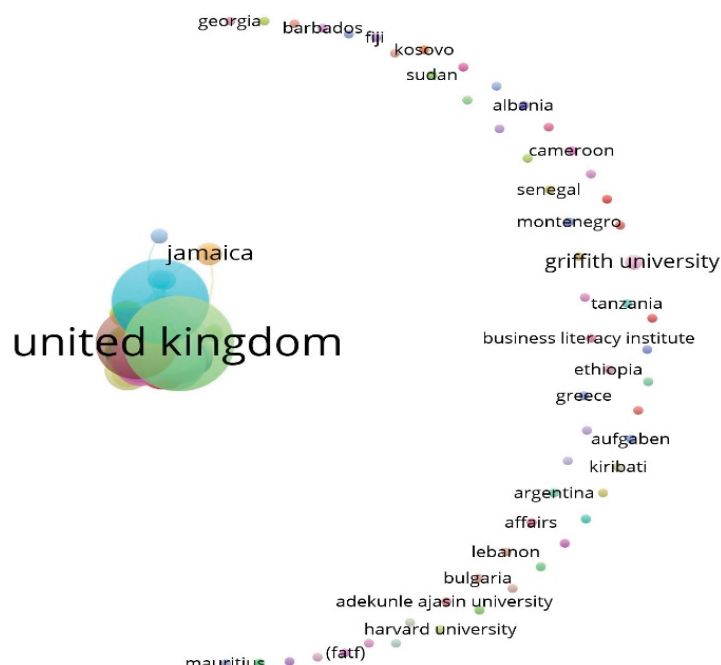


Figure 7. The total link strength of co-Authorship links for countries. Source: compiled by the author from the SCOPUS database.

3.3. Citation Analysis

The network visualization of the citation links, calculated for each of the 940 documents that meet the threshold value out of 1000 documents in the citation analysis results in terms of documents is given (Deveci 2023) in Figure 8.

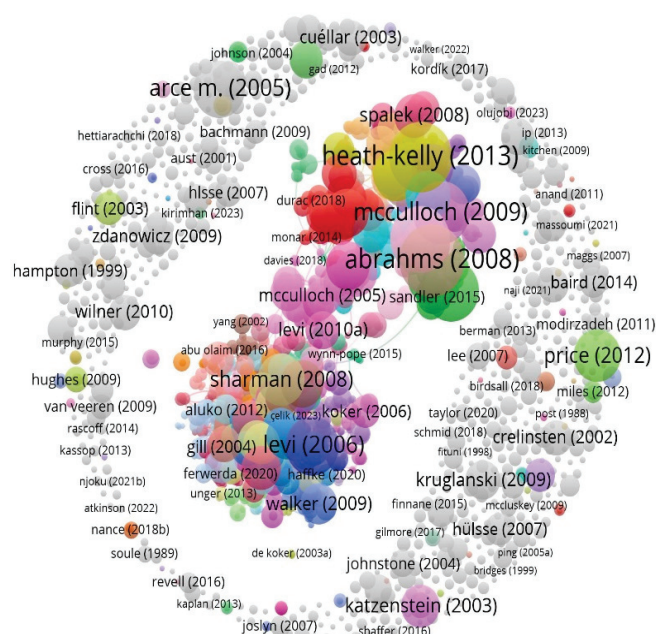


Figure 8. Highest citations. Source: compiled by the author from the SCOPUS database.

The top 10 highly cited documents are as follows, with Abrahms (2008) leading the list with an impressive number of citations (NC = 293), followed by Heath-Kelly (NC = 281) (Heath-Kelly 2012), Tyler (NC = 251) (Tyler et al. 2010); McCulloch (NC = 226) (McCulloch and Pickering 2009), Bueno de Mesquita (NC = 219) (Bueno de Mesquita and Dickson 2007), Lum (NC = 201) (Lum et al. 2006), Levi (NC = 201) (Levi and Reuter 2006), Koschade (NC = 144) (Koschade 2007), Hoffman (NC = 135) (Hoffman and Shelby 2017), and Boer (NC = 133) (Boer et al. 2007). In addition, the top 10 documents with the highest citation link were, respectively, Abrahms (2008), Heath-Kelly (2012), Tyler et al. (2010), McCulloch and Pickering (2009), Bueno de Mesquita and Dickson (2007), Lum et al. (2006), Levi and Reuter (2006), Koschade (2007), Hoffman and Shelby (2017), and Boer et al. (2007). Moreover, the documents with the most citations were given in a reference list (Deveci 2023).

Total link strength is an essential metric in bibliometric analysis that measures the degree of connectivity between entities, such as sources, authors, organizations, and countries, within a research field. These evaluations are crucial for several reasons:

- Total link strength according to sources: This evaluates the overall connections between different academic journals or sources. It indicates how frequently journals cite each other, helping to identify influential publications and core journals in a specific research domain. Understanding these relationships provides insights into the most important and central sources contributing to knowledge in the field.
- Total link strength to authors: This assesses the citation connections between individual authors, showing which researchers are most interconnected based on their work. It helps to identify leading authors and their influence on the research community. A high total link strength can signify the authors who are central to the dissemination of ideas, collaborations, and the development of new knowledge in a particular area.
- Total link strength to organizations: This measures how institutions or research organizations are connected through their published works and citations. It highlights the collaborative networks of institutions and can reveal the most influential research organizations. This analysis is essential for understanding the distribution of knowledge production and the key organizations driving research in specific fields.
- Total link strength to countries: This evaluates the global influence of countries by examining how often papers from different countries cite one another. It reflects the international collaboration and the impact of research at a national level. Countries with a high total link strength are often key players in global research, contributing significantly to the development of knowledge and international research partnerships.

3.4. Total Link Strength According to Sources

A total of 760 sources (journal, congress, etc.) were assessed. The total link strength of the citation links of the 430 sources meeting the criteria from the 760 sources is given (Deveci 2023) in Figure 9.

The top five sources with the highest number of citations were, respectively, the *Journal of Money Laundering* (NC = 1169), *Crime, Law and Social Change* (NC = 170), the *Journal of Financial Regulation and Compliance* (NC = 153), *Studies in Conflict and Terrorism* (NC = 148), and *Terrorism and Political Violence* (NC = 100). Additionally, the top five sources with the highest total link strength of citation links were the *Journal of Money Laundering*; *Crime, Law and Social Change*; the *Journal of Financial Regulation and Compliance*; *Studies in Conflict and Terrorism*; and *Terrorism and Political Violence*.

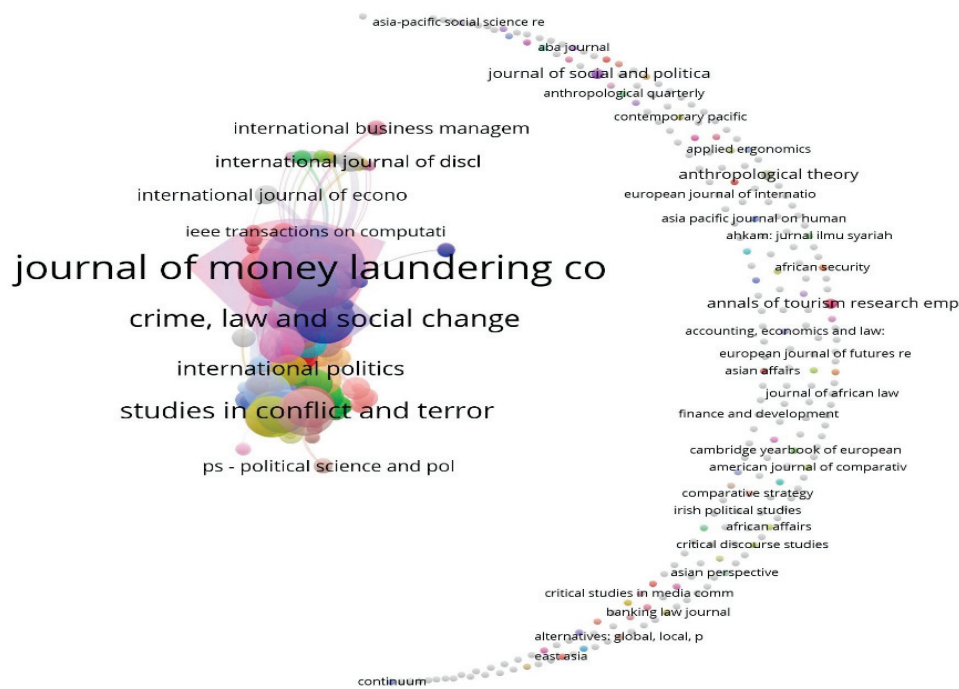


Figure 9. Top cited sources. Source: compiled by the author from the SCOPUS database.

3.5. Total Link Strength to Authors

As a result of the citation analysis, a total of 2000 authors were reached and the total link strength of citation links of the 1692 authors out of 2000 who met the criteria is given (Deveci 2023) in Figure 10.

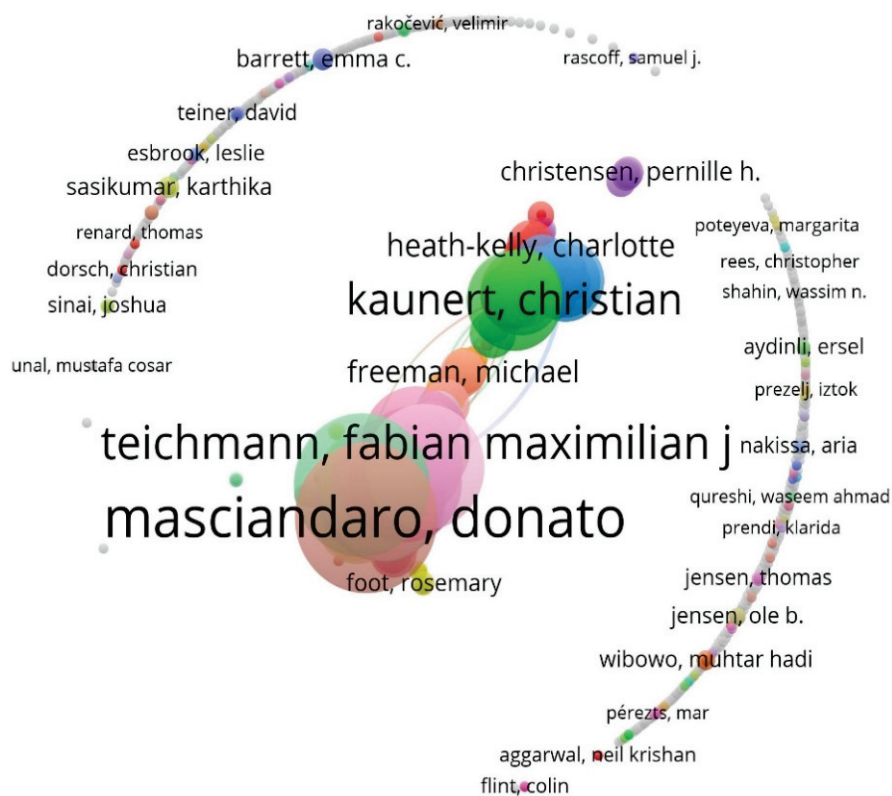


Figure 10. Top cited authors. Source: compiled by the author from the SCOPUS database.

The top 10 authors who have received the highest number of citations are as follows: Masciandaro Donato (NC = 349), Levi Michael (NC = 229), Teichmann Fabian Maximilian Johannes (NC = 196), Mohammed Norazida (NC = 180), Unger Brigitte (NC = 180), Salehi Mahdi (NC = 164), Ofoeda Isaac (NC = 144), Ferwerda Jonas (NC = 143), Kaunert Christian (NC = 139), and Naheem Mohammed Ahmad (NC = 129). Furthermore, the following is a list of the top 10 authors with the highest total link strength of citation links: Masciandaro Donato, Levi Michael, Teichmann Fabian Maximilian Johannes, Mohammed Norazida, Unger Brigitte, Salehi Mahdi, Ofoeda Isaac, Ferwerda Jonas, Kaunert Christian, and Naheem Mohammed Ahmad.

A total of 1500 organizations were identified through the organization citation analysis. Figure 11 presents the total link strength of citation links for 1477 organizations that met the specified criteria out of the total 1500 identified organizations.

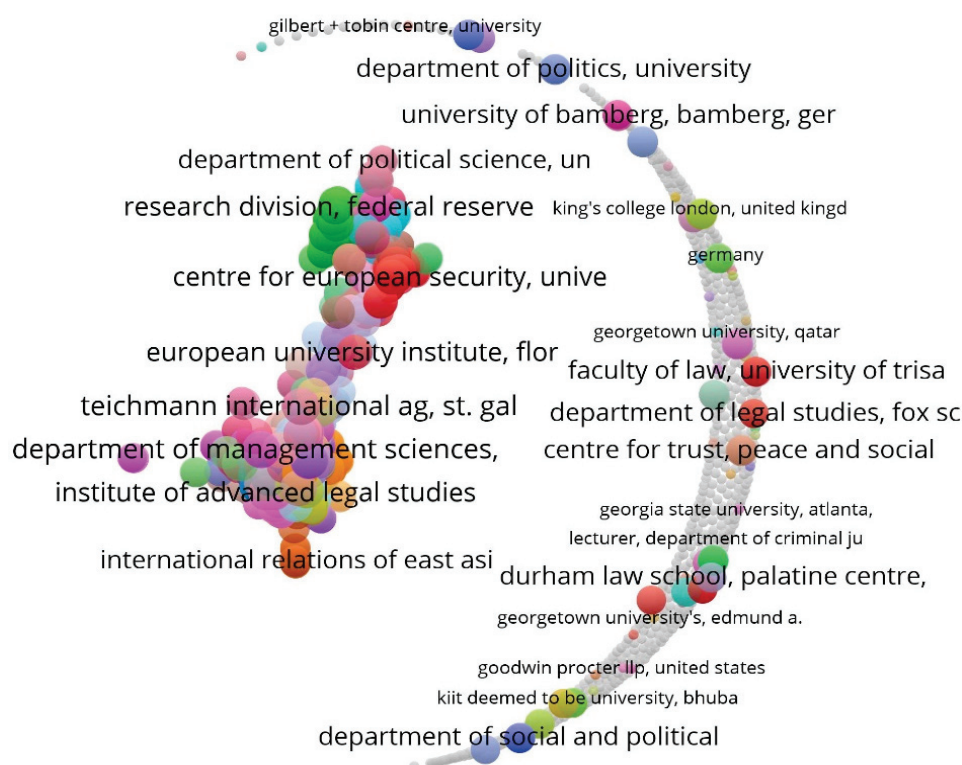


Figure 11. Top cited organizations. Source: compiled by the author from the SCOPUS database.

3.6. Total Link Strength to Organizations

The top 10 organizations with the highest number of citations were, respectively, the Institute of Finance Management, Tanzania (NC = 222); Teichmann International Ag, St. Gallen, Switzerland (NC = 210); Teichmann International Schweiz, Switzerland (NC = 129); the Department of Economics and Administrative Sciences, Iran (NC = 122); the Department of Management and Administrative Sciences, Gujarat (NC = 84); the Department of Finance, Ghana (NC = 85); the Department of Accounting, Ghana (NC = 70); the Accounting Research Institute, Malaysia (NC = 58); Bocconi University, Italy (NC = 51); and Southwest Jiaotong University, China (NC = 48). In addition, the top ten organizations with the highest total link strength regarding citation links were identified as the Institute of Finance Management, Tanzania; Teichmann International Ag, St. Gallen, Switzerland; Teichmann International Schweiz, Switzerland; the Department of Economics and Administrative Sciences, Iran; the Department of Management and Administrative Sciences, Gujarat; the Department of Finance, Ghana; the Department of Accounting, Ghana; the Accounting Research Institute, Malaysia; Bocconi University, Italy; and Southwest Jiaotong University, China.

3.7. Total Link Strength to Countries

A total of 140 countries were identified via citation analysis by country. The total link strength of citation links of 108 countries meeting the criteria from 140 countries is given in Figure 12 (Deveci 2023).

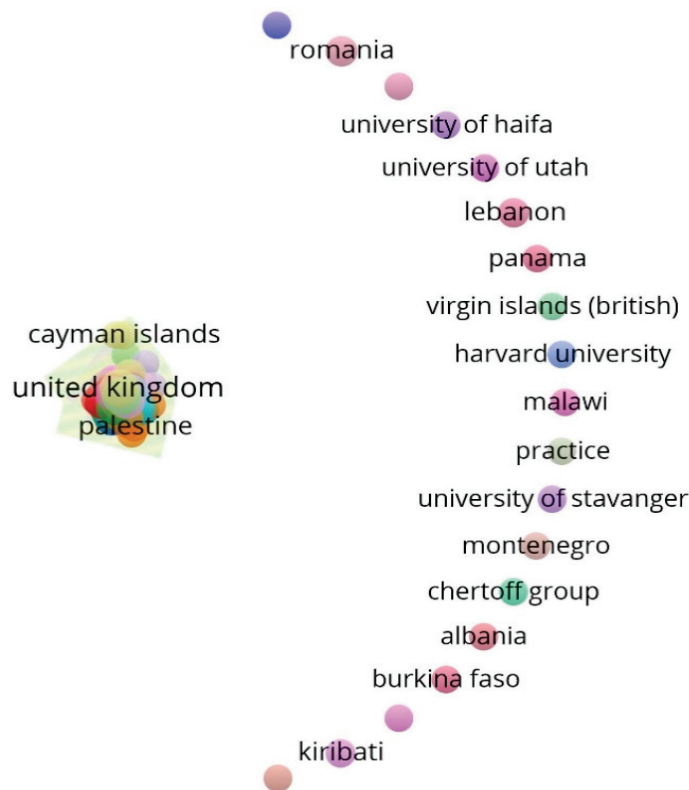


Figure 12. Top cited countries. Source: compiled by the author from the SCOPUS database.

The following list comprises the top 10 countries with the highest citation counts: the United Kingdom (NC = 1242), the United States (NC = 731), Australia (NC = 670), Italy (NC = 412), Malaysia (NC = 364), Pakistan (NC = 225), Canada (NC = 262), China (NC = 187), Iran (NC = 182), and New Zealand (NC = 120). Furthermore, the top 10 countries with the highest total link strength of citation links were the United Kingdom, the United States, Australia, Italy, Malaysia, Pakistan, Canada, China, Iran, and New Zealand.

4. Discussion

This bibliometric analysis of 2577 research articles retrieved from the Scopus database revealed several key findings regarding the research landscape on money laundering (ML) and terrorist financing (TF).

4.1. Focus Areas

- Thematic analysis using the co-occurrence of keywords identified “money laundering” as the most frequent term, followed by “terrorism”, “counterterrorism”, “anti-money laundering”, and “regulation.” This highlights the primary focuses of understanding the nature of ML and developing strategies to combat it.
- Citation analysis revealed that the most cited documents dealt with the broader themes of terrorism and counterterrorism, suggesting a potential gap in research specifically focused on the intersection of ML and TF.

4.2. Authorship and Collaboration:

- The analysis of co-authorship revealed the top 10 authors and institutions with the highest total link strength (Deveci 2023). These data are valuable for identifying leading researchers and potential collaborators within the domain.
- The nations with the highest total link strength among the top 10 include the United Kingdom, the United States, and Australia, reflecting a strong research emphasis in developed countries.

4.3. Sources and Citations

- The “*Journal of Money Laundering*” emerged as the publication with the most citations, followed by “*Crime, Law and Social Change*” and the “*Journal of Financial Regulation and Compliance*.” These findings suggest that these journals serve as important platforms for sharing research on money laundering (ML) and terrorist financing (TF).
- Among the top 10 most cited authors were Masciandaro Donato, Levi Michael, and Teichmann Fabian Maximilian Johannes. These scholars have notably advanced the field.
- The results indicate that research on ML and TF is becoming more interdisciplinary, establishing links between financial crimes, terrorism studies, and regulatory frameworks. While prominent researchers and institutions have been identified, there remains a need for further investigation into the effectiveness of the prevailing strategies aimed at combating ML and TF activities.

4.4. Emerging Trends in Money Laundering for Terror Financing

4.4.1. Increased Focus on Network Analysis

The use of the co-occurrence analysis of keywords suggests a shift towards studying money laundering and terror financing as interconnected networks. This emphasizes the significance of comprehending the connections between actors, methods, and vulnerabilities within the more extensive financial system.

4.4.2. Evolving Techniques and Actors

The analysis suggests an increasing amount of research is focused on specific techniques, such as trade-based money laundering. Furthermore, delving into the co-authorship analysis could potentially uncover valuable information about the participation of non-state actors or individuals in terror financing endeavors.

4.4.3. Regulatory and Compliance Landscape

The increasing usage of keywords such as “regulation” and “compliance” indicates a rising curiosity among researchers regarding the effectiveness of current anti-money laundering/counterterrorist financing (AML/CTF) regulations. This corresponds with modifying regulatory frameworks to tackle new and evolving risks.

4.4.4. Technological Advancements and Vulnerabilities

The analysis does not directly address keywords associated with new technologies; however, it could be beneficial to investigate how cryptocurrencies, virtual assets, and online platforms are being misused for money laundering and terrorism financing.

4.4.5. Heightened Focus on Specific Areas

Although money laundering and terrorism financing remain central topics, the analysis reveals a growing focus on particular aspects of these issues. Terms such as “counterterrorism”, “regulation”, and “compliance” indicate a trend towards stronger measures to combat these activities.

4.4.6. Collaboration and Knowledge Exchange

The co-authorship analysis indicates active cooperation among researchers from various countries and institutions (e.g., universities, Financial Intelligence Units). This reflects a global initiative to comprehend and combat money laundering and terrorism financing. The involvement of leading countries such as the UK, the US, and Australia further underscores this international collaboration.

4.4.7. Key Sources and Researchers

The citation analysis identifies significant sources and influential researchers in this field. Journals like *"The Journal of Money Laundering"* and *"Studies in Conflict and Terrorism"* appear to be crucial platforms for research on this subject (Weinberg and Eubank 2008). Additionally, prominent researchers such as (Masciandaro 2013), (Levi and Reuter 2006), and (Teichmann and Falker 2020) are emerging as thought leaders in this area.

5. Conclusions

This bibliometric analysis offers an extensive summary of the research landscape surrounding money laundering and terrorist financing. This study has explored co-occurrence patterns, authorship dynamics, and citation networks, highlighting significant research themes, prominent scholars, and essential publications within the discipline.

The prominence of "money laundering" as a central keyword brings to light its continued significance as a research focus. However, the relatively lower frequency of terms directly linked to terrorist financing suggests a potential gap in research dedicated to this specific intersection. This shows the need for further exploration of the evolving relationship between these two criminal activities.

The analysis reveals a concentration of research in developed countries, particularly the United Kingdom, the United States, and Australia. To enhance the global perspective on ML and TF, future research should prioritize collaborations with scholars from diverse geographical contexts, especially regions known as financial crime hotspots.

This bibliometric analysis of 2577 documents on money laundering (ML) and terrorist financing (TF) highlights some of the well-established results from this research area and some findings that are new. The prominent focus on such key terms as 'money laundering,' 'terrorism,' and 'anti-money laundering' is in harmony with other scholars, who call upon nations to establish adequate measures to mitigate these concerns. It also supports previous studies, seeing the UK, the USA, and Australia as the three dominant countries in this area of study, which indicates the extent of these countries' supplementary research output in this area. This study concludes that anti-financial crime measures and compliance culture are also supportive of the studies that have placed a premium on such aspects when dealing with the challenges of money laundering and terrorist finance. However, this study also brings out new findings, particularly concerning the emerging phenomenon of analyzing social networks. This perspective aimed to describe money laundering as well as terrorist financing together with their activities as networks, representing a departure from the challenges seen with the older barriers. This act of putting things into the right perspective depicts the systems being used that many prior studies may not have focused on sufficiently. The concern about the effectiveness of the anti-money laundering, anti-terrorism measures demonstrates that there is an appreciation of the threat posed by the evolution of financial landscapes, such as via crypto-currencies and online platforms—topics that have received limited exploration in earlier research. Overall, while this study aligns with foundational concepts in the literature, it introduces fresh perspectives on the complexities and interconnectedness of ML and TF. The findings underscore the necessity for interdisciplinary collaboration and continued research to address the evolving challenges in this critical area.

To enhance the global perspective on ML and TF, future research should prioritize collaborations with scholars from diverse geographical contexts, especially regions known as financial crime hotspots.

Furthermore, this study identifies the need for deeper investigation into the effectiveness of existing anti-money laundering and counterterrorism-financing measures. The practical implications of research findings can be examined by policymakers and practitioners so that they can develop more robust strategies to combat these transnational crimes.

6. Future Scope of Research

Further research is needed on the use of cryptocurrencies in money laundering and terrorist financing. Additionally, more research is required on how machine learning can aid in identifying money laundering and terrorist financing. Future research should also explore the gaps in anti-money laundering and counterterrorism financing and how these policies can be implemented in vulnerable countries.

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Review

Research on Price Discovery in Financial Securities: Trends and Directions for Future Research

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Abstract: The futures contracts were introduced to act as hedging instruments and ensure the price discovery (referred to as PD hereafter) mechanism for the underlying securities. If the price movement of a futures contract leads the price movement of the underlying securities in the spot market, this confirms the existence of price discovery in the market. This study undertakes an in-depth analysis of past research in order to find research trends and directions for the future in the field of price discovery. The bibliometric analysis technique is used to analyse the existing literature. The study considers the 1431 documents collected from the Scopus database for the period of 1982–2021 to conduct the descriptive and network analysis of search results. The study identifies three key clusters, i.e., the foundation of the price discovery process (Cluster 1), the econometric tools and techniques to assess the price discovery process (Cluster 2), and price discovery under different market conditions and constraints (Cluster 3). After an in-depth content analysis of these clusters, the study provides suggestions for future research in the field of price discovery. The study is the first of its type to conduct an in-depth analysis of the literature of price discovery since inception, and provides directions for future research in the field.

Keywords: price discovery; bibliometric analysis; network analysis; VOS viewer; lead–lag relationship

1. Introduction

Futures contracts, as part of derivative products, are the financial instruments that allow a trader to enter a contract where the contract will be made for a future date while the price, quantity, quality, and delivery mechanism will be fixed at the time of entering the contract. The first derivatives exchange in the United States was established in 1848, followed by futures contracts on the Chicago Mercantile Exchange (CME) in 1972 and interest rate futures on the Chicago Board of Trade (CBT) in 1975 (Pauletto and Steve 2012). The two key objectives for the introduction of futures contracts were to act as a hedging instrument and ensure a price discovery mechanism for the underlying securities. The futures contracts enable traders to diversify their risk exposure with their current or future investments. These contracts are made for a future date, and the price of the same is available while entering into the contract. This indicates that the price of a future contract should reflect the expectations of different types of traders about the price of underlying securities in the future, and these contracts should serve as the important information criteria that derive the price of underlying securities in the spot market. If the price movement of a futures contract derives the price movement of the underlying securities in the spot market, this is considered the existence of price discovery (PD) in the market (Silber 1981).

Since the inception of these contracts, futures contracts on different securities, such as equities, currencies, commodities, interest rates, and cryptocurrencies, have been launched in different economies across the world. The trading volume of the derivatives market is significantly higher than that of the spot market, and as a result, the futures prices reflect the expectations of the investors more efficiently than the spot prices. This confirms that the price of a futures contract should lead to the price movement of the underlying security in the spot market, and this leads to the PD in the market.

Researchers have made significant attempts to assess the existence of PD among different asset classes. During the early phase of the existence of the PD discipline, a researcher tried to develop a framework to assess the PD mechanism. Hasbrouck (1995) introduced the “information sharing approach” and argued that for the same underlying security the prices should be similar in different markets where it is traded. Considering the sample of DOW 30 stocks, the study found the existence of PD in the US equity market. Gonzalo and Granger (1995) proposed a different econometric technique to assess PD. The authors suggested using the error correction mechanism when the variables have the same order of integration, that is, $I(1)$. Fleming et al. (1996) studied the role of trading costs on the PD mechanism among the spot and derivatives markets and found that new information is reflected quickly among those securities that have low trading costs compared to those with high trading costs. The study also found that the cost of trading is lower with index-based securities than with individual stocks. Tse (1999) extended the literature by assessing the volatility spillover along with the PD mechanism in the US equity market. The study applied the bivariate EGARCH model to assess whether there is evidence of volatility spillover among the futures and spot indexes of the DJIA index. The results supported the bi-directional information flow, where the spillover from future-to-spot was higher than that from spot-to-future markets. Baillie et al. (2002) tried to develop the PD mechanism using the common factors of previous studies by Hasbrouck (1995) and Gonzalo and Granger (1995). The study found that these two popular PD models are related and lead to similar inferences when the error terms do not have problems with serial correlations. The subsequent studies by Hasbrouck (2003), Andersen et al. (2007), and Brogaard et al. (2014) on PD try to use the different data frequencies to assess the information sharing among the futures and spot markets. Hasbrouck (2003) used the intraday prices of the index futures and exchange-traded funds (ETFs) of the S&P 500 to assess the PD among the two markets and found the existence of PD among the futures and ETFs prices. Andersen et al. (2007) assessed the PD using the high-frequency data of three different markets, such as equities, debt, and forex, in three different economies: the USA, Germany, and Britain. Brogaard et al. (2014) assessed the PD mechanism among NASDAQ- and NYSE-listed firms by looking at the role of high-frequency traders. The study found that with the existence of high-frequency traders, the overall efficiency of information dissemination in pricing improves.

In the existing literature, numerous attempts have been made in the past to assess the existence of PD mechanisms in different markets. Most of these studies were empirical in nature and tried to assess whether price discovery exists in different asset classes across different economies. Some studies also tried to assess the role of volatility in the PD process among different underlying securities. Most of the existing literature is focused on the empirical examination of PD, while a detailed review of the discipline is still missing. The discipline has been in existence for the past four decades, and, to the best of our knowledge, no attempt has been made by the researchers to conduct an in-depth analysis of the existing literature on PD. Thus, it has become important to assess the past trends of the research publications on PD by conducting a comprehensive, in-depth analysis of the literature using the bibliometric method. These trends will be helpful for future researchers to select prominent authors and documents when they plan to contribute to the PD discipline. These trends will also enable the researchers to identify quality research work published in the domain, research trends, contributions by the most relevant researchers, contributions across geographies and institutions, and the connectedness among these aspects. In view of this, the aim of the present study tries to address the following research questions:

- RQ1. What is the growth of publications on price discovery?
 RQ2: Who are the most prominent authors and documents on price discovery?
 RQ3: Who are the prominent contributors to price discovery?
 RQ4. What are the collaboration patterns among the researchers on price discovery?
 RQ5. What are existing and current research themes and topics on price discovery?
 RQ6. What are the future research directions for research on price discovery?

2. Data and Methodology

This section provides a description of the sampling method, data collection, and analysis methods adopted to conduct the study.

2.1. Data and Sample

The bibliographic data collected from the Scopus Database indicates that the first paper on price discovery (PD) was published in 1982 and that a total of 1879 publications had been added to the body of knowledge on the topic by 2021 (refer to Figure 1). The investigation ultimately found a total of 1431 publications for this study after filtering the results to include only pertinent articles and reviews written in English. The study of these selected publications is provided in the following sections, considering several bibliometric characteristics associated with price discovery.

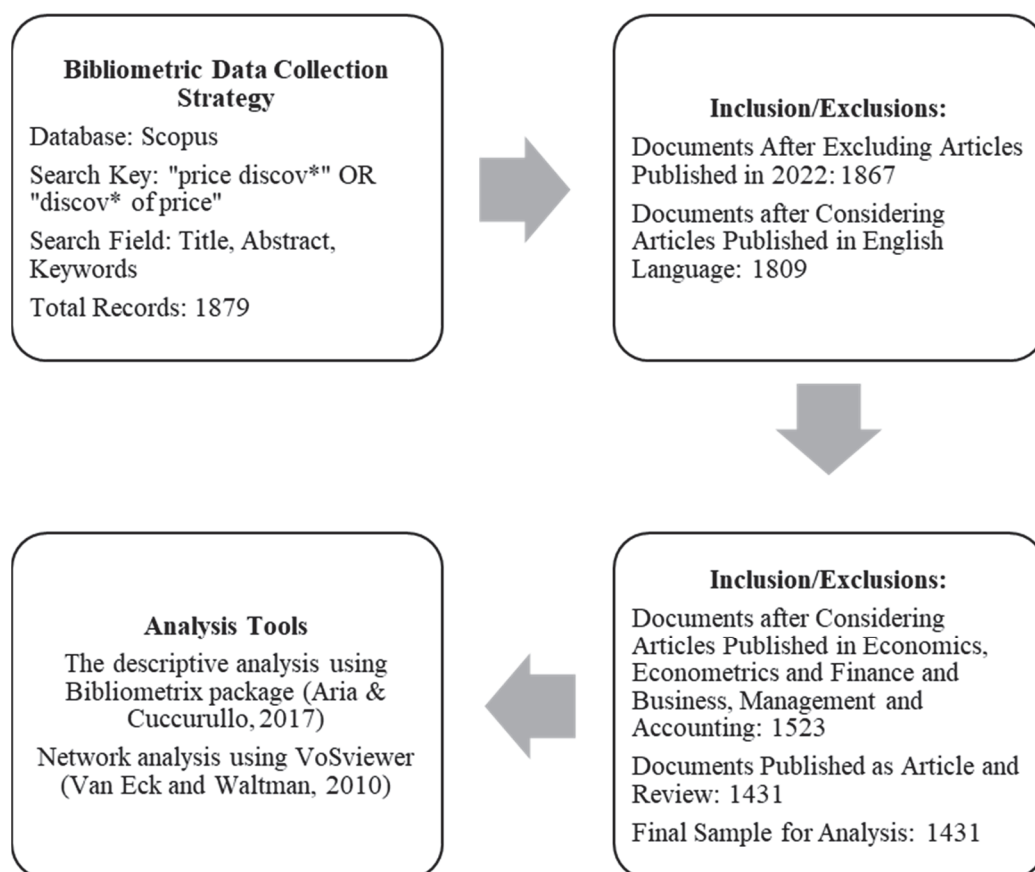


Figure 1. Description of sample selection and analysis method.

2.2. Bibliometric Methods and Their Use in Finance, Accounting and Related Fields

In recent years, there has been a significant increase in the use of bibliometric methods to conduct in-depth analyses of the literature in various disciplines, using a large pool of previously published studies. Pritchard (1969) defined bibliometrics as “the application of mathematics and statistical methods to books and other media of communication”. Other researchers suggest the following: “The discipline of bibliometric methods has evolved

with the recommendations to use “bibliometric citations” (Broadus 1987), “co-citations” (Small 1973), “co-occurrences” (Koseoglu 2016), and “co-authorship” (Cheng et al. 2018). The researchers have used bibliometric methods to understand the intellectual structure and research trends in different fields (Podsakoff et al. 2008).

The application of bibliometric methods has become popular in recent years, and the business, finance, and accounting disciplines are no exceptions to this. Zheng et al. (2020) applied the scientometric methods in the construction industry to assess the research trends, while Ye et al. (2015) used social network analysis to understand the knowledge flow of the patent citation data.

The use of bibliometric methods in the financial and accounting disciplines has also increased significantly over the past few years, in the cases of green finance (Zhang et al. 2019), productivity in finance (Chung and Cox 1990), option pricing (Sharma et al. 2023), supply chain finance (Xu et al. 2018), Islamic banking and finance (Biancone et al. 2020), renewal energy finance (Elie et al. 2021), sustainable finance (Bui et al. 2020), and artificial intelligence and machine learning in finance (Goodell et al. 2021).

3. Results and Discussion

The results of the bibliometric analysis, including both descriptive analyses using the Bibliometrix package (Aria and Cuccurullo 2017) and network analysis (van Eck and Waltman 2010), are summarised and presented below.

3.1. Publication Productivity of Price Discovery Research (RQ1)

Out of the 1431 total publications examined in the field of price discovery, 1373 are conceptual and empirical papers and 58 are reviews. The first article in this field was “Price Trends at Livestock Auctions,” written by Steven T. Buccola and published in 1982. From Table 1, in the first two decades (1982–2001) of price discovery research, only 10% of total papers were published, while in the first three decades (1982–2011), only 37% of papers were published. A total of 63% of the total publications were published in only one decade, i.e., the fourth decade (2012–2021). The recent five years (2017–2021) have produced 36% of the field’s publications, and it has been extremely productive. The year 2021 saw 145 publications, which is the most ever. Overall, there has been an increasing trend in the growth of publications on price discovery research (refer to Figure 2).

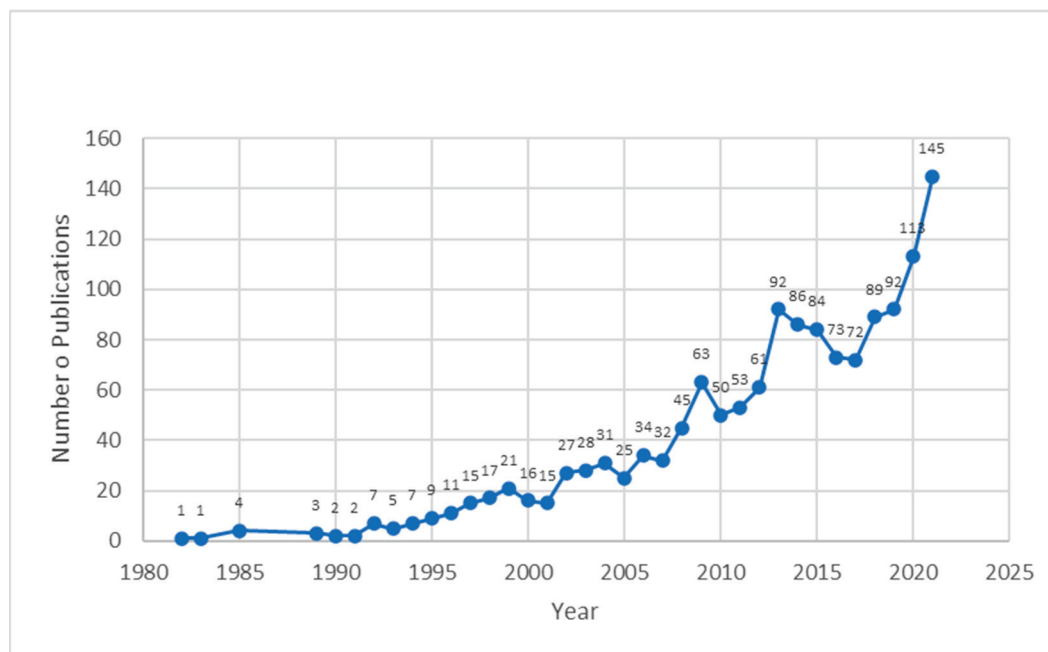


Figure 2. Article publications on PD across the years.

Table 1. Publication trends of PD research.

Year	Number of Publications	Percentage	Cumulative Percentage	Total Citations
1982	1	0.1%	0.1%	18
1983	1	0.1%	0.2%	9
1984	0	0.0%	0.2%	0
1985	4	0.3%	0.4%	19
1986	0	0.0%	0.4%	0
1987	0	0.0%	0.4%	0
1988	0	0.0%	0.4%	0
1989	3	0.2%	0.7%	84
1990	2	0.1%	0.8%	43
1991	2	0.1%	0.9%	128
1992	7	0.5%	1.4%	135
1993	5	0.3%	1.8%	87
1994	7	0.5%	2.3%	324
1995	9	0.6%	2.9%	1140
1996	11	0.8%	3.7%	529
1997	15	1.0%	4.7%	1025
1998	17	1.2%	5.9%	305
1999	21	1.5%	7.4%	905
2000	16	1.1%	8.5%	432
2001	15	1.0%	9.5%	1102
2002	27	1.9%	11.4%	1439
2003	28	2.0%	13.4%	2525
2004	31	2.2%	15.5%	1244
2005	25	1.7%	17.3%	1388
2006	34	2.4%	19.7%	940
2007	32	2.2%	21.9%	1299
2008	45	3.1%	25.0%	972
2009	63	4.4%	29.5%	1329
2010	50	3.5%	32.9%	1670
2011	53	3.7%	36.6%	1523
2012	61	4.3%	40.9%	1004
2013	92	6.4%	47.3%	1772
2014	86	6.0%	53.3%	1927
2015	84	5.9%	59.2%	1185
2016	73	5.1%	64.3%	613
2017	72	5.0%	69.4%	655
2018	89	6.2%	75.6%	845
2019	92	6.4%	82.0%	547
2020	113	7.9%	89.9%	414
2021	145	10.1%	100.0%	107

3.2. Publication Impact of Price Discovery Research (RQ2)

To understand the impact of published research, the citations received by the article are used as key criteria (Baker et al. 2020; Kumar et al. 2021). As per the study of global citations, most citations were received by J. Hasbrouck's (1995) article, "One Security, Many Markets: Determining the Contributions to Price Discovery," followed by Hendershott et al.'s (2011) article, "Does Algorithmic Trading Improve Liquidity?" and Andersen et al.'s (2003) article, "Micro Effects of Macro Announcements: Real-Time Price Discovery in Foreign Exchange" (refer to Table 2). The focus of the studies that received the most global citations was to provide early empirical evidence on the existence of PD in different market conditions and using different data models.

Table 2. Global citations.

Authors	Year	Article Title	Journal	Total Citations
Hasbrouck, J.	1995	“One Security, Many Markets: Determining the Contributions to Price Discovery”	<i>The Journal of Finance</i>	752
Hendershott, T., Jones, C.M., Menkveld, A.J.	2011	“Does Algorithmic Trading Improve Liquidity?”	<i>The Journal of Finance</i>	605
Andersen, T.G., Bollerslev, T., Diebold, F.X., Vega, C.	2003	“Micro Effects of Macro Announcements: Real-Time Price Discovery in Foreign Exchange”	<i>American Economic Review</i>	592
Blanco, R., Brennan, S., Marsh, I.W.	2005	“An Empirical Analysis of the Dynamic Relation between Investment-Grade Bonds and Credit Default Swaps”	<i>The Journal of Finance</i>	536
Andersen, T.G., Bollerslev, T., Diebold, F.X., Claravogad	2007	“Real-time price discovery in global stock, bond and foreign exchange markets”	<i>Journal of International Economics</i>	476
Hasbrouck, J., Seppi, D.J.	2001	“Common factors in prices, order flows, and liquidity”	<i>Journal of Financial Economics</i>	435
Madhavan, A., Richardson, M., Roomans, M.	1997	“Why Do Security Prices Change? A Transaction-Level Analysis of NYSE Stocks”	<i>The Review of Financial Studies</i>	426
Brogaard, J., Hendershott, T., Riordan, R.	2014	“High-Frequency Trading and Price Discovery”	<i>The Review of Financial Studies</i>	390
Chakravarty, S., Gulen, H., Mayhew, S.	2004	“Informed Trading in Stock and Option Markets”	<i>The Journal of Finance</i>	334
Longstaff, F.A.	2010	“The subprime credit crisis and contagion in financial markets”	<i>Journal of Financial Economics</i>	313

While discussing local citations, most citations were received by J. Hasbrouck’s (1995) article, “One Security, Many Markets: Determining the Contributions to Price Discovery,” followed by Baillie et al.’s (2002) article, “Price discovery and common factor models,” and B. Lehmann’s (2002) article, “Some desiderata for the measurement of price discovery across markets” (refer to Table 3). The focus of the studies cited the most in local citations was on providing different statistical and empirical models to test the PD process in different asset classes.

The study uses Bradford’s law (Bradford 1934) in the price discovery discipline to understand the concentration and dispersion factors of publication patterns and the most productive nucleus. According to the law, a small nucleus of journals covers a larger proportion of publications in the discipline, whereas a larger nucleus of journals covers a smaller proportion (Alvarado 2016). Bradford’s Law divides publications into three zones: Core, Zone 1, and Zone 2. Zone 1 and Zone 2 have n and n^2 times the number of core journals, respectively. The Core, Zone 1, and Zone 2 ratios are $1:n:n^2$.

According to the findings of the analysis, a core nucleus of 15 (4.3% of total) journals caters to 478 (33.4%) publications. Zone 1 contains 55 (15.6% of total) journals covering 485 (33.9%) publications, while Zone 2 contains 282 (80.1% of total) journals covering only 468 (32.7%) publications (refer to Figure 3 and Table 4). This demonstrates a concentration of publications in the Core and an unequal distribution of publications across journals. Price discovery research is best served by a small number of journals, which publish a large proportion of the studies in the field.

Table 3. Local citations.

Authors	Year	Title	Journal	Local Citations
Hasbrouck, J.	1995	“One Security, Many Markets: Determining the Contributions to Price Discovery”	<i>The Journal of Finance</i>	363
Baillie, R.T., Booth, G.G., Tse, Y., Zobotina, T.	2002	“Price discovery and common factor models”	<i>Journal of Financial Markets</i>	191
Lehmann, B.	2002	“Some desiderata for the measurement of price discovery across markets”	<i>Journal of Financial Markets</i>	91
Harris, F.H.D., Mcinish, T.H., Wood, R.A.	2002	“Security price adjustment across exchanges: an investigation of common factor components for Dow stocks”	<i>Journal of Financial Markets</i>	90
Hasbrouck, J.	2003	“Intraday Price Formation in U.S. Equity Index Markets”	<i>The Journal of Finance</i>	89
Yan, B., Zivot, E.	2010	“A structural analysis of price discovery measures”	<i>Journal of Financial Markets</i>	82
Chakravarty, S., Gulen, H., Mayhew, S.	2004	“Informed Trading in Stock and Option Markets”	<i>The Journal of Finance</i>	78
Jong, F.D.	2002	“Measures of contributions to price discovery: a comparison”	<i>Journal of Financial Markets</i>	72
Booth, G.G., So, R.W., Tse, Y.	1999	“Price discovery in the German equity index derivatives markets”	<i>The Journal of Futures Markets</i>	71
Eun, C.S., Sabherwal, S.	2003	“Cross-Border Listings and Price Discovery: Evidence from U.S.-Listed Canadian Stocks”	<i>The Journal of Finance</i>	70

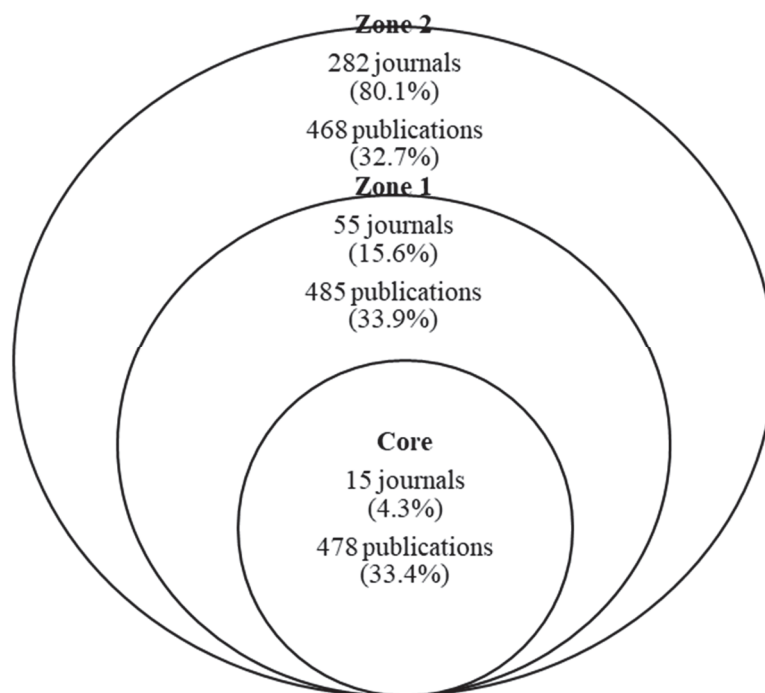


Figure 3. Dispersion of PD research in Bradford Rings.

Table 4. Publication dispersion zones of PD research under Bradford's Law.

Nucleus	Journals		Publications		Ratio (1:n:n ²)
	N	%	n	%	
Core	15	4.3%	478	33.4%	1
Zone 1	55	15.6%	485	33.9%	3.66
Zone 2	282	80.1%	468	32.7%	13.44
Total	352	100.0%	1431	100%	

3.3. Most Prominent Journals for Price Discovery Research (RQ3)

The reputation of a journal within its field has an impact on the citation power of the publications in that journal. In the case of price discovery, scholars have published in journals across different disciplines (e.g., derivatives markets, banking and finance, financial markets, economics, and international money and finance). The journal-wise distribution of publications (refer to Table 5) indicates that the *Journal of Futures Markets* is the most highly preferred destination for scholars to publish their research on price discovery (101 publications, or nearly 7% of the total 1431 papers). The *Journal of Financial Markets* (44 publications, or about 3% of the total) and the *Journal of Banking and Finance* (37 publications, or about 2.6% of the total), along with the *Journal of Financial Economics* (15 publications), are also popular choices. Surprisingly, the top 10 journals only account for 22% of the total number of publications examined in this field. In terms of citations and identifying the most prominent source, the *Journal of Finance* comes at the top, followed by the *Journal of Futures Markets*. The *Journal of Futures Markets* ranks first in terms of impact as measured by the h-index, followed by the *Journal of Financial Markets*. The *Journal of Futures Markets* remains at the top of the table, followed by the *Journal of Financial Markets* when the impact is measured in terms of the g-index.

Table 5. Most relevant source and impact.

Journal	NP	TC	h-Index	g-Index	m-Index	Start YP
<i>Journal of Futures Markets</i>	101	2828	28	50	0.824	1989
<i>Journal of Financial Markets</i>	44	1972	22	44	0.917	1999
<i>Journal of Banking and Finance</i>	37	1269	17	35	0.586	1994
<i>Journal of Financial Economics</i>	25	1658	17	25	0.773	2001
<i>Journal of Empirical Finance</i>	24	578	13	24	0.619	2002
<i>Journal of Finance</i>	21	4039	20	21	0.769	1997
<i>Energy Economics</i>	20	438	13	20	0.406	1991
<i>Journal of Financial and Quantitative Analysis</i>	18	696	12	18	0.429	1995
<i>Review of Financial Studies</i>	14	1794	13	14	0.5	1997
<i>Journal of International Money and Finance</i>	14	456	12	14	0.4	1993

Notes: NP = Number of publications. TC = Total citations. Start YP = Starting year of publishing price discovery research. h-index = Publications with citations greater than/equal to h. g-index = g number of articles with g² citations. M-index = h-index per year since first publication.

3.4. Most Prominent Authors Contributing to Price Discovery Research (RQ3)

A total of 2461 authors have contributed to price discovery research. Out of this total, 1950 authors (79.2%) have published only one publication, while 308 authors (12.5%) have published two publications. A total of 31 authors (1.2%) have contributed more than five publications, whereas only 2 authors have contributed more than ten publications to the field (refer to Table 6). This shows that only a few scholars have made a significant contribution to price discovery research, which is still in the early stages.

Table 6. Author productivity of PD research.

Documents Written	N. of Authors	Proportion of Authors
1	1950	79.30%
2	308	12.53%
3	105	4.27%
4	49	1.99%
5	18	0.73%
6	14	0.57%
7	7	0.28%
8	3	0.12%
9	3	0.12%
15	1	0.04%
27	1	0.04%

Out of the 2461 authors of price discovery research, the most productive author is Tse Y., who has contributed 27 publications since 1995, received 1197 citations, and has an h-index of 15 (Table 7). Following Tse Y. are Wang J. (15 publications) and Hendershott T. (9 publications), who have received 1524 and 1563 citations, respectively. Since no author in the field has an h-index above 20, it can be concluded that no author has a decisive influence on price discovery research, and the field can still be considered to be in the precursor stage of research.

Table 7. Author impact on PD research.

Author	h-Index	g-Index	m-Index	TC	NP	Start YP
Tse Y	15	27	0.536	1197	27	1995
Wang J	7	12	0.241	152	15	1994
Hendershott T	8	9	0.4	1563	9	2003
Mcinish Th	7	9	0.292	295	9	1999
Chen Y L	5	9	0.357	191	9	2009
Frijns B	6	8	0.429	127	8	2009
Lien D	6	8	0.3	174	8	2003
Schwartz R A	5	8	0.185	176	8	1996
Corbet S	7	7	1.4	181	7	2018
Gau Y F	5	7	0.357	181	7	2009

Notes: NP = Number of publications. TC = Total citations. Start YP = Starting year of publishing price discovery research. h-index = Publications with citations greater than/equals to h. g-index = g number of articles with g² citations. M-index = h-index per year since first publication.

Table 8 depicts the statistics of the top 10 contributing universities and institutions in price discovery research in the world, which contributed 194 publications (about 13.56% of total publications during this study period). The analysis of the affiliation reveals that the highest number of publications in the area of price discovery are from Australia, which contributes 66 articles (about 4.6%), followed by the United States, which also contributes 66 articles (about 4.6% of total publications during this study period). The university that has contributed the most to price discovery research is Auckland University of Technology in New Zealand, with 29 articles, followed by Deakin University and the University of Sydney in Australia, with 25 and 22 publications, respectively.

Table 8. Most relevant affiliations for PD research.

Affiliation	Country	Articles
Auckland University of Technology	New Zealand	29
Deakin University	Australia	25
University of Sydney	Australia	22
Oklahoma State University	United States	19
University of Technology Sydney	Australia	19
University of Delhi	India	18
California State University	United States	17
International Islamic University Malaysia	Malaysia	15
Kansas State University	United States	15
University of Memphis	United States	15

3.5. Co-Authorship Network of Countries (RQ4)

The co-authorship network of countries involved in price discovery research was analysed using VOS Viewer. The analysis reveals the major co-authorship networks within price discovery research. The USA is at the centre of the first major country collaboration network (purple), collaborating with China, Hong Kong, South Korea, and Canada (Figure 4). The second major country collaboration network (green) is driven by the United Kingdom, which collaborates with Sweden, Spain, Norway, Italy, Israel, and Greece. Australia is at the centre of the third major country collaboration network (blue), collaborating with Vietnam, Turkey, South Africa, and Latvia. India is at the centre of the fourth major country collaboration network (red), collaborating with France, Taiwan, Malaysia, the Netherlands, and Japan. Based on a close examination, the distribution of publications on price discovery research by nation reveals that the USA ($n = 361$, or 25.2% of all publications during this study period) has contributed the most publications, followed by China ($n = 142$, 9.9%), the United Kingdom ($n = 90$, 6.3%), Australia ($n = 84$, 5.9%), and India ($n = 83$, 5.8%) (refer to Table 9).

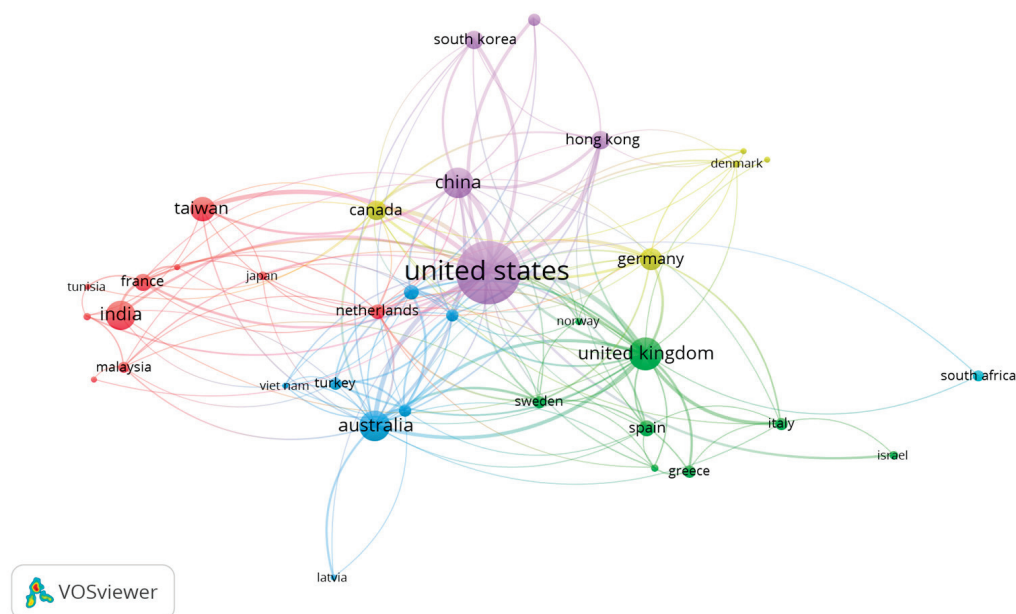
**Figure 4.** Co-authorship network among countries for PD research.

Table 9. Most relevant countries for PD research.

Country	Articles
USA	361
China	142
United Kingdom	90
Australia	84
India	83
Germany	41
Korea	33
Canada	30
New Zealand	29
Spain	24

3.6. Author Collaboration in PD Research (RQ4)

The following Table 10 shows the collaboration of the authors on PD research. The researchers Sifat I. M. and Mohamad A. have collaborated on six publications, followed by the co-authorship of five publications by Chen Y. L., Gau Y. F., Frijns B., and Tourani R. A.

Table 10. Bibliographic coupling of authors for PD research.

Author 1	Author 2	Number of Articles Co-Authored
Sifat I. M.	Mohamad A.	6
Chen Y. L.	Gau Y. F.	5
Frijns B.	Tourani R. A.	5
Akyildirim E.	Corbet S.	4
Adrangi B.	Chatrath A.	3
Ante L.	Fiedler I.	3
Avino D.	Lazar E.	3
Beekes W.	Brown P.	3
Buckle M.	Chen J.	3
Dimpfl T.	Peter F. J.	3

3.7. Bibliographic Coupling of Authors' Affiliated Countries (RQ4)

Figure 5 presents the bibliographic coupling of authors' affiliated countries, in which we set the coupling threshold of at least five publications as criteria. The United States is at the centre of this figure. Among the series of bibliographic couples, the coupling strengths of the USA and China, the USA and Australia, the USA and the United Kingdom, the USA and Hong Kong, the USA and Canada, the United Kingdom and Australia, and the United Kingdom and Italy are the strongest. These couplings are consistent with the findings in Table 8, which show that the country's most commonly affiliated authors are from the United States and Australia.

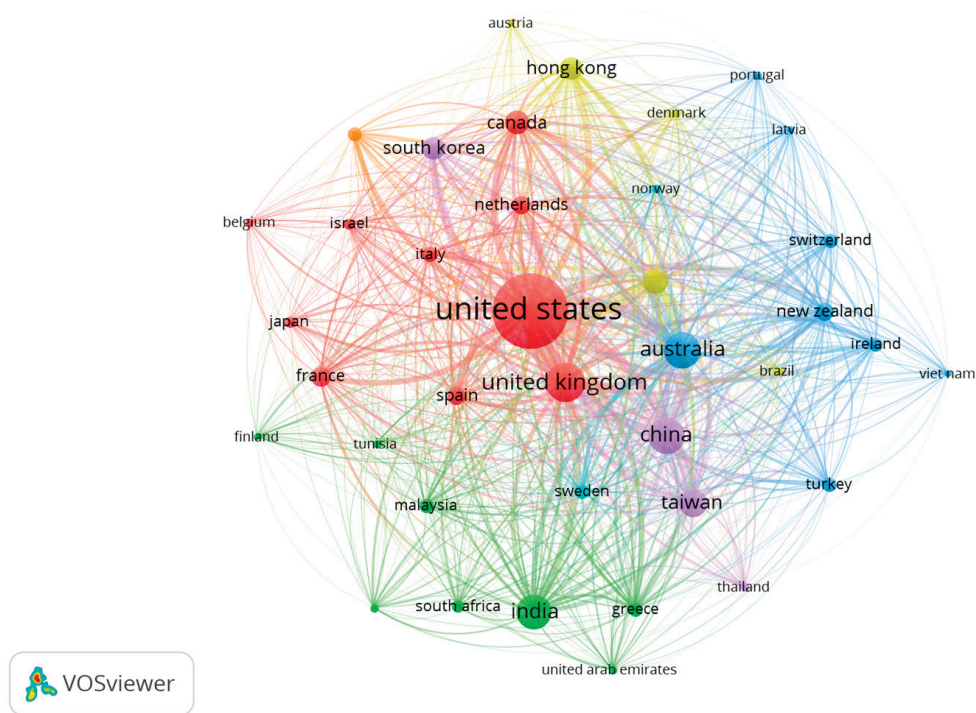


Figure 5. Bibliographic coupling of author–country for PD research.

3.8. Co-Occurrence of Author-Specified Keywords in Price Discovery Research Area (RQ5)

Figure 6 shows the frequency of author-specified keywords in the area of price discovery research, with the most common topics appearing at least five times in the publications between 1982 and 2021. The most frequent themes during 1982–2021 were price discovery, market efficiency, information asymmetry, market microstructure, volatility, futures, volatility spillover, etc.

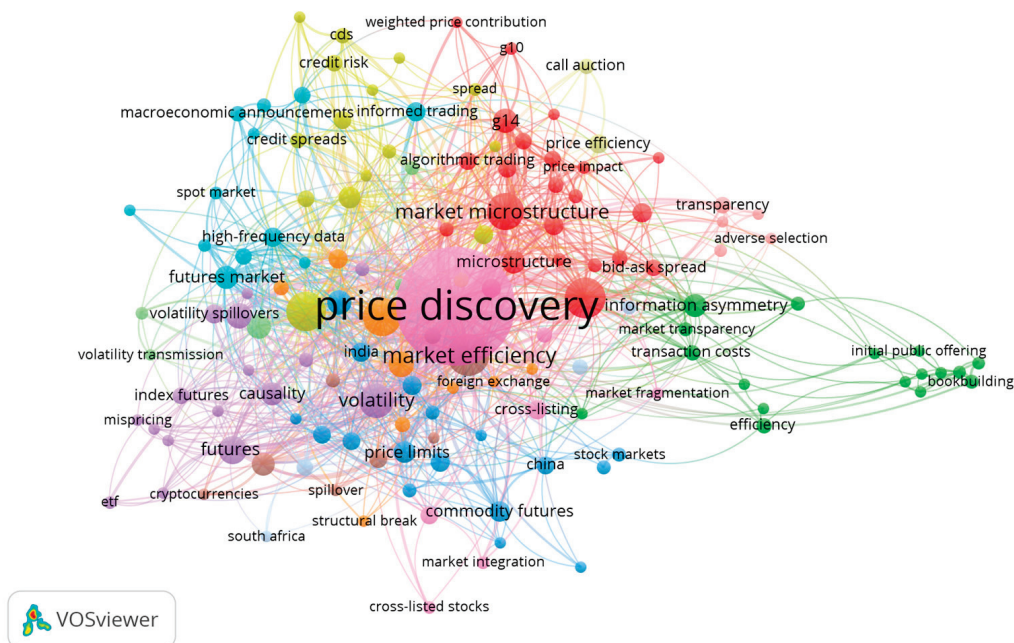


Figure 6. Co-occurrence of author-specified keywords for PD Research.

3.9. Co-Citation Network and Clustering of Articles (RQ5)

The literature also suggests that if two documents are being cited together, there is a possibility that these are falling into the same discipline of research (Hjørland 2013) or sharing similar contents (Small 1973). In the co-citation network of articles published in the field of PD, the data were presented as nodes and edges. The documents referred to were represented by nodes, while the links were shown by edges. The density of the edges, which is the link between nodes in one cluster that is on the higher side of the cluster compared to the nodes in other clusters, can be used as a parameter to divide nodes in a network into clusters (Mingers and Leydesdorff 2015). For a better understanding of the dispersion of the co-citation network, we classified it into three clusters. In each cluster, the top nine papers were selected by considering their page rank. The detailed analysis of each cluster is presented and summarised below (Figure 7).

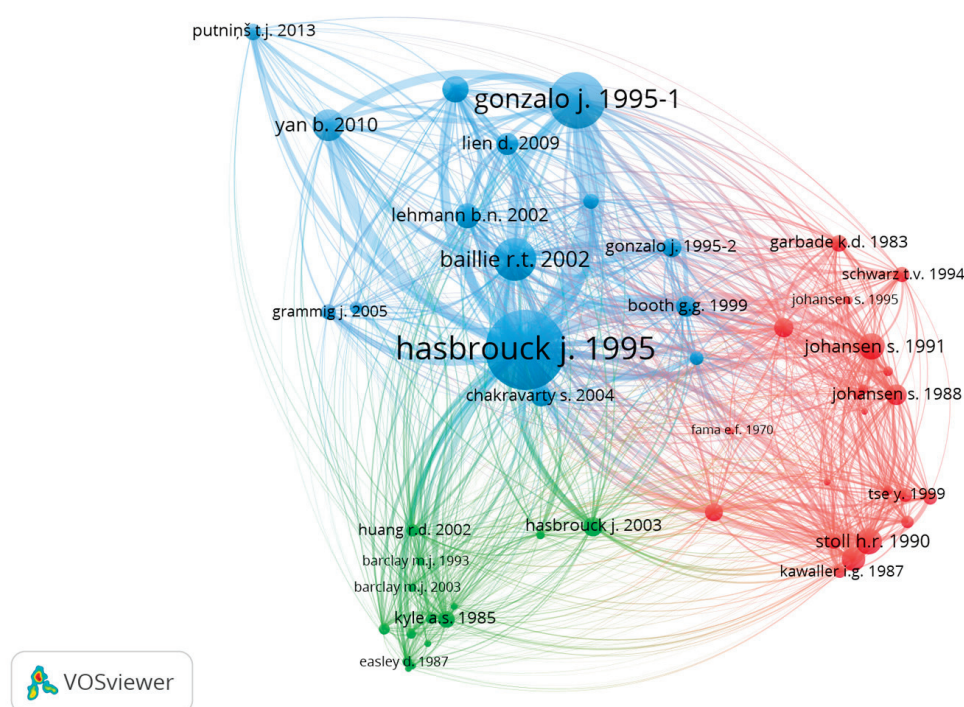


Figure 7. Clustering of Articles on PD using Co-citation Network.

Cluster 1: The study's first cluster serves as the foundation for the price discovery process. The cluster considers the study that laid down the theory to identify the price discovery process. The articles in this cluster provide a mechanism for evaluating the price discovery process under various market conditions. The foundation of the cluster was laid down by Garbade and Silber (1983), who explored whether the new information received in the market is first reflected in the futures of the security or in the spot prices of the underlying security in the market. The study by Hasbrouck (1995) dominates this cluster and justifies the logic of price discovery in closely-linked homogenous securities. This approach is considered an information-sharing approach in the existing literature on PD. The studies by Gonzalo and Granger (1995) and Baillie et al. (2002) suggested the use of the common method approach to test the price discovery process. Baillie et al. (2002) also tried to compare the factors proposed by Hasbrouck (1995) and Gonzalo and Granger (1995) and found that the common factors proposed by these two studies are related to each other. Later, Lien and Shrestha (2009) attempted to provide a modified information-sharing approach that did not rely on the upper and lower bounds of prices in the way that Hasbrouck's (1995) information-sharing approach did (refer to Table 11).

Cluster 2: According to co-citation analysis, cluster 2 is dominated by studies that suggest econometric tools and techniques to assess the price discovery process. The cluster considers studies by Johansen and Juselius (1990) and Johansen (1988), which advocate the use of a co-integrating equation to assess the long-run relationship between two non-stationary variables. Dickey and Fuller (1979) provide an econometric method for testing the stationarity of time series variables in another study. Before testing the long-term co-integrating relationship, it is important to assess whether the time series variables are stationary in nature. The same can be done after using the Dickey and Fuller (1979) unit root test method. Engle and Granger (1987) further suggested the use of the error-correction method after co-integration to see the long-run causality between the time series variables (refer to Table 11).

Cluster 3: Cluster 3 of the study considers the empirical studies that try to test the PD under different market conditions and asset classes. Cluster 3 is named “Price discovery under different market conditions and constraints” and is dominated by the study conducted by Kyle (1985). The study considers insider trading as a continuous action to test the information-sharing component in the price of the securities. Easley and O’Hara (1987) tried to explore the role of trade size and price of the underlying security to assess the PD, while Glosten and Milgrom (1985) used the bid–ask spread and transaction prices to assess the PD under “Specialized Markets that have heterogeneously informed traders.” Amihud and Mendelson (1989) tried to assess the price discovery under different market microstructures in the Japanese market, and Hasbrouck (2003) tried to test the PD after considering the intraday prices in the US market. The other studies in the cluster also tried to explore the existence of PD in different markets and asset classes (refer to Table 11).

More specifically, in the case of equities, the existence of price discovery between the spot and future markets was assessed in the US market (Cornell and French 1983), in the Germany context (Booth et al. 1999), in the case of BRICS (Sharma et al. 2020), and in the Vietnam context (Rajput et al. 2012; Nhung et al. 2019). The researchers considered different data frequencies, sample periods, and empirical methodologies to assess the robustness of the existence of the PD process in these markers. In the US market, the study conducted by Cornell and French (1983) considered the daily closing data, while Kawaller et al. (1987) considered the intraday data to assess the same. Similar attempts were made in the case of commodities, currencies, and cryptocurrencies as asset classes. Considering the sample of eight commodities, Beck (1994) confirmed the existence of PD, while Yang et al. (2001) analysed the role of storage requirements for the commodities and assessed the existence of PD. The study discovered that PD exists for both types of commodities, including storable and non-storable commodities. In the case of other types of commodities such as energy (Shrestha 2014), metals, and agricultural commodities (Chinn and Coibion 2014; Dimpfl et al. 2017), the researchers have presented empirical evidence supporting the existence of PD. The researchers have made efforts to empirically test the price discovery in the currency market (Chen and Gau 2010; Osler et al. 2011; Rosenberg and Traub 2009; Kumar 2018; Sharma and Chotia 2019; Fassas et al. 2020; Akyildirim et al. 2020). Chen and Gau (2010) used the USD and Euro and Yen, Kumar (2018) considered the USD and INR, ZAR, and BRL, and Sharma and Chotia (2019) used the INR and USD, EURO, GBP, and JPY. In the case of cryptocurrency, mainly bitcoin (Karkkainen 2018; Sharma et al. 2022), Fassas et al. (2020) confirmed the existence of PD using the daily closing data, while the same was confirmed by Akyildirim et al. (2020) using the high-frequency data.

Table 11. Clustering of articles on PD research.

Authors	Year	Title	Journal	Cluster	PageRank
Cluster 1: Foundation of price discovery process					
Hasbrouck, J.	1995	“One Security, Many Markets: Determining the Contributions to Price Discovery”	<i>The Journal of Finance</i>	1	0.0850
Gonzalo, J., Granger, C.	1995	“Estimation of Common Long-Memory Components in Cointegrated Systems”	<i>Journal of Business & Economic Statistics</i>	1	0.0521
Baillie, R.T., Booth, G.G., Tse, Y., Zobotina, T.	2002	“Price discovery and common factor models”	<i>Journal of Financial Markets</i>	1	0.0431
Yana, B., Zivot, E.	2010	“A structural analysis of price discovery measures”	<i>Journal of Financial Markets</i>	1	0.0316
Chakravarty, S., Gulen, H., Mayhew, S.	2004	“Informed Trading in Stock and Option Markets”	<i>The Journal of Finance</i>	1	0.0218
Lehmann, B.	2002	“Some desiderata for the measurement of price discovery across markets”	<i>Journal of Financial Markets</i>	1	0.0273
Jong, F.D.	2002	“Measures of contributions to price discovery: a comparison”	<i>Journal of Financial Markets</i>	1	0.0279
Garbade, K.D., Silber, W.L.	1983	“Price Movements and Price Discovery in Futures and Cash Markets”	<i>The Review of Economics And Statistics</i>	1	0.0172
Booth, G.G., So, R.W., Tse, Y.	1999	“Price Discovery in the German Equity Index Derivatives Markets”	<i>The Journal of Futures Markets</i>	1	0.0233
Lien, D., Shrestha, K.	2009	“A New Information Share Measure”	<i>The Journal of Futures Markets</i>	1	0.0232
Cluster 2: Econometric tools and techniques to assess price discovery process					
Johansen, S.	1991	“Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models”	<i>Econometrica</i>	2	0.0333
Johansen, S.	1988	“Statistical Analysis of Cointegration Vectors”	<i>Journal of Economic Dynamics And Control</i>	2	0.0279
Stoll, H.R., Whaley, R.E.	1990	“The Dynamics of Stock Index and Stock Index Futures Returns”	<i>The Journal of Financial And Quantitative Analysis</i>	2	0.0345
Engle, R.F., Granger, C.W.J.	1987	“Co-Integration and Error Correction: Representation, Estimation, and Testing”	<i>Econometrica</i>	2	0.0223
Chan, K.	1992	“A Further Analysis of the Lead–Lag Relationship Between the Cash Market and Stock Index Futures Market”	<i>The Review of Financial Studies</i>	2	0.0300
Fleming, J., Ostdiek, B., Whaley, R.E.	1996	“Trading Costs and The Relative Rates of Price Discovery in Stock, Futures, And Option Markets”	<i>The Journal of Futures Markets</i>	2	0.0204
Schwarz, T.V., Szakmary, A.C.	1994	“Price Discovery in Petroleum Markets: Arbitrage, Cointegration, and the Time Interval of Analysis”	<i>The Journal of Futures Markets</i>	2	0.0171
Tse, Y.	1999	“Price Discovery and Volatility Spillovers in the DJIA Index and Futures Markets”	<i>The Journal of Futures Markets</i>	2	0.0180
Dickey, D.A., Fuller, W.A.	1979	“Distribution of the Estimators for Autoregressive Time Series with a Unit Root”	<i>Journal of The American Statistical Association</i>	2	0.0154
Wahab, M., Lashgari, M.	1993	“Price Dynamics and Error Correction in Stock Index and Stock Index Futures Markets: A Cointegration Approach”	<i>The Journal of Futures Markets</i>	2	0.0201
Cluster 3: Price discovery under different market conditions and constraints					
Kyle, A.S.	1985	“Continuous Auctions and Insider Trading”	<i>Econometrica</i>	3	0.0227
Hasbrouck, J.	1991	“Measuring the Information Content of Stock Trades”	<i>The Journal of Finance</i>	3	0.0146
Hasbrouck, J.,	2003	“Intraday Price Formation in U.S. Equity Index Markets”	<i>The Journal of Finance</i>	3	0.0150
Easley, D., O'Hara, M.	1987	“Price, Trade Size, And Information in Securities Markets”	<i>Journal of Financial Economics</i>	3	0.0163
Glosten, L.R., Milgrom, P.R.	1985	“Bid, Ask And Transaction Prices in A Specialist Market with Heterogeneously Informed Traders”	<i>Journal of Financial Economics</i>	3	0.0141
Admati, A. R., Pfleiderer, P.	1988	“A Theory of Intraday Patterns: Volume and Price Variability”	<i>The Review of Financial Studies</i>	3	0.0113
Huang, R.D., Stoll, H.R.	2002	“Tick Size, Bid-Ask Spreads, and Market Structure”	<i>The Journal of Financial and Quantitative Analysis</i>	3	0.0124
Amihud Y., Mendelson, H.	1989	“Market Microstructure and Price Discovery on The Tokyo Stock Exchange”	<i>Japan and The World Economy</i>	3	0.0072
Barclay M.J., Hendershott, T.	2003	“Price Discovery and Trading After Hours”	<i>The Review of Financial Studies</i>	3	0.0117
Barclay M.J., Warner, J.B.	1993	“Stealth trading and volatility. Which trades move prices?”	<i>Journal of Financial Economics</i>	3	0.0113

4. Directions for Future Research (RQ6)

In view of the in-depth analysis of the literature published and the clustering of the existing themes of the studies published in the PD discipline, the directions for future research in the PD discipline are presented below.

1. Information quality plays a significant role in affecting the price discovery process in different asset classes. With the rising role of social media and other technology platforms, access to information has become very easy for end investors. This may also lead to a rise in the spread of both correct and misleading information to end investors on a real-time basis, and that may affect the price discovery discipline in different markets (Wu et al. 2022). This makes it important for the researchers to analyse the role of information quality through social media in affecting the price discovery mechanism across different asset classes and markets.
2. There is substantial evidence reported in the existing literature to assess the price discovery mechanism across different securities listed on different secondary markets, but the literature on the same in the case of over-the-counter (OTC) traded securities is limited. The volume traded in OTC markets is comparable to that traded on formal secondary exchanges (Lu and Zhan 2022). The researchers should try to explore the existence of price discovery in the OTC market.
3. The literature shows that some attempts have been made to assess the price discovery mechanism in the case of cryptocurrencies (an emerging asset class), but the same is limited to some of the more popular cryptocurrencies, including Bitcoin. A comprehensive analysis of the price discovery mechanism across different cryptocurrencies has yet to be presented in the literature, and thus becomes the focus of future research.
4. The major portion of the existing literature is focused on assessing the price discovery using the futures contracts as a measure of the information for future dates and seeing its impact on the price movement of the spot prices of the underlying securities. The options contracts are also made for a future date, and the option chain formed by the investors while investing in the options at different strike prices can also serve as a significant predictor for the price discovery mechanism across different asset classes. In the existing literature, not much focus has been given to options contracts to study the price discovery mechanism, and this is becoming a significant research gap for future researchers.

5. Conclusions

The analysis of the study presented above shows that the last decade (2012–2021) has witnessed the majority of the contribution (63%) in the price discovery discipline. Out of the total number of publications in the PD discipline, a small number of journals are preferred for price discovery research, publishing a large proportion of studies from the field. Some of these journals include *The Journal of Finance* and *The Journal of Futures Markets*. The focus of the most-cited studies using both global and location citation measures has been to provide empirical evidence on the existence of PD in different market conditions and using different data models. The study shows that only a few scholars have made a significant contribution to price discovery research, which is still in the early stages. Tse Y. and Wang J. are the most prominent authors, with 27 and 15 publications, respectively. The most frequent themes during 1982–2021 were price discovery, market efficiency, information asymmetry, market microstructure, volatility, futures, volatility spillover, etc.

From the cluster analysis, it is evident that the existing literature on PD can be divided into three clusters, where cluster 1 of the study provides the foundation of the price discovery process. Cluster 2 is dominated by the studies that suggest the econometric tools and techniques to assess the price discovery process, and cluster 3 of the study considers the empirical studies that try to test the PD under different market conditions and asset classes.

Considering this, the study suggests the directions for future research, including exploring the role of information quality through social media in affecting the price discovery mechanism across different asset classes and markets; conducting empirical studies to

explore the existence of the price discovery mechanism in the OTC market; conducting a comprehensive analysis of the price discovery mechanism across different cryptocurrencies; and considering options contracts to assess the price discovery mechanism across different asset classes and markets.

The study carries implications for researchers and professionals dealing in the field of risk management. The testing of price discovery mechanisms in different asset classes and markets allows the professional to assess whether the futures markets are acting efficiently compared to the spot market. The introduction of futures contracts is intended to provide instruments for hedging, and if the futures contracts are acting efficiently the overall risk management for different types of investors across different asset classes can be carried out efficiently. This also enables the professional to make accurate predictions about spot market movements and to trade in the market accordingly.

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Article

Unveiling the Path to Mobile Payment Adoption: Insights from Thai Consumers

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Abstract: Mobile payment, replacing traditional methods like cash and cards, offers users convenience and accessibility, benefiting individuals, businesses, and governments. However, most research on mobile payment adoption has primarily focused on developed countries, leaving a gap in understanding the adoption factors in developing nations. This study addresses this gap by investigating the determinants of mobile payment adoption in Thailand, an emerging economy experiencing significant smartphone adoption and e-commerce growth. Through a quantitative approach and a survey of 475 Thai consumers, this research applies an extended Unified Theory of Acceptance and Use of Technology (UTAUT) model as a theoretical foundation to examine Thai consumers' mobile payment adoption. Data analysis using SPSS 28.0 and AMOS 28.0 identifies key factors influencing Thai consumers to adopt mobile payment. By offering a comprehensive research model and considering evolving smartphone technology, this study aims to guide policymakers and stakeholders in promoting mobile payment adoption, ultimately enhancing Thailand's economic development and tourism industry.

Keywords: mobile payment; the unified theory of acceptance and use of technology (UTAUT); intention to use mobile payment; attitude toward mobile payment; Thailand

1. Introduction

In the era of the 4.0 Industrial Revolution, advancements in information and communications technology, along with wireless Internet, have integrated functionalities into smartphones, making them indispensable in daily life worldwide (Arniati 2023; Nguyen et al. 2023). This evolution has significantly influenced the growth of e-commerce and mobile commerce (Changchit et al. 2023b; Loh et al. 2023). Mobile commerce, encompassing various services like mobile advertising, mobile games, and mobile payment, has become a cornerstone of modern transactions (Changchit et al. 2023b).

Mobile payment, particularly, serves as a crucial platform supporting other mobile commerce applications (Tew et al. 2022). Defined as the use of wireless Internet-connected devices to conduct financial transactions, mobile payment enables convenient, anytime, and anywhere purchases and services (Bailey et al. 2022). The concept of a cashless society has garnered growing interest due to the widespread adoption of cashless transactions and the increasing circulation of digital currency (Chang et al. 2024). It is gradually replacing traditional forms of payment, offering benefits such as expanded consumer reach for businesses and improved convenience for consumers (Belanche et al. 2022).

The growth of mobile payment extends beyond developed countries, with significant adoption in developing and newly emerging economies (Chang et al. 2023). Southeast Asia, for instance, has seen a rapid increase in mobile payment transactions, driven by modernizing telecommunications infrastructure and increasing smartphone penetration (Arniati 2023).

Despite the growing importance of mobile payments, research has predominantly focused on developed countries, leaving a gap in the understanding of the adoption factors

in developing or newly emerging countries (Bui et al. 2022). The emphasis on developed countries in previous studies may be attributed to their advanced telecommunications infrastructure and higher income levels. This study aims to fill this gap by examining the factors influencing mobile payment intention in Thailand, a newly emerging economy with a high smartphone adoption rate and a booming tourism industry (Chinnapakjarusiri et al. 2024).

This research aims to propose a comprehensive model to understand mobile payment adoption factors, considering the evolving landscape of mobile payment and its implications for developing economies like Thailand. The findings are expected to inform policymakers and businesses on strategies to promote mobile payment, potentially attracting more international business and tourism to Thailand.

Overall, this paper contributes to the understanding of mobile payment adoption in emerging economies and provides insights that can drive its further growth and development. The subsequent sections of this paper detail the characteristics of mobile payment, the adoption landscape in Thailand, the research methodology, results, and implications for theory and practice, followed by conclusions, limitations, and future research directions.

2. Literature Review

2.1. Previous Studies on Mobile Payment

Mobile payment is considered as an evolutionary form of online payment (Hanafiah et al. 2024). Mobile payment is conducted via a mobile network (Ghosh 2024). In other words, mobile payment is regarded as a process in which at least one stage of a financial transaction is performed through a handheld mobile device connected to the wireless Internet, for example, a smartphone, tablet, or personal digital assistant, capable of processing a financial transaction through a mobile network (Chang et al. 2024).

Revolutionary advances in information and communications technology, along with wireless Internet, are fundamentally transforming the mobile payment sector (Mollick et al. 2023). Mobile payment is predicted to become the most popular payment method in the future, superseding traditional forms such as cash, checks, debit cards, and credit cards (Changchit et al. 2023b).

Numerous studies have been conducted to identify the factors influencing the intention to use mobile payment (Ling et al. 2024; Wen et al. 2023). These studies draw on theories/models of behaviors, attitudes, and technology acceptance (Momani 2020). The theory of reasoned action (TRA) by Fishbein and Ajzen (1975) explains individual behaviors, focusing on attitudes toward the behavioral and subjective norms. The theory of planned behavior (TPB) by Ajzen (1991) suggests that beliefs can determine intended and actual behaviors.

The technology acceptance model (TAM) by Davis et al. (1989) examines information technology acceptance, with perceived ease of use and usefulness as key variables. Some studies augment these with factors like perceived trust, transaction convenience, speed, security, privacy, and perceived compatibility, influencing mobile commerce intentions (Mollick et al. 2023).

A study by Sun et al. (2020) emphasizes perceived compatibility, portability, and subjective norms, while Handarkho (2021) focuses on behavioral beliefs, social influences, and personal characteristics. Phan et al. (2020) and Belanche et al. (2022) highlight similar factors, with Singh (2020) adding social influences and performance expectancy. Chen and Lai (2023) note that perceived risk and cost hinder mobile payment intention.

Most research on mobile payment has been on developed countries, with limited studies in Southeast Asia and even fewer in Thailand despite its high smartphone adoption rate. Prior studies often consider factors in isolation. Therefore, a comprehensive and systematic research model that integrates various factors is needed to enhance the explanatory power of mobile payment intention, especially given the evolving technological landscape in newly emerging countries like Thailand. This study addresses these gaps.

2.2. Current Situation on Mobile Payment in Thailand

Thailand is a newly emerging country with a population of 71 million people (Worldometers 2023). The country boasts enormous potential for economic growth and development, situated in a strategic position in Southeast Asia that attracts significant foreign direct investment. As a result, more multinational companies and their supply chains are establishing business operations in Thailand.

The success of the Thai economy can be attributed to economic reform and transformation policies, which aim to attract foreign companies to establish manufacturing and processing plants in the country. Additionally, Thailand's tourism industry is flourishing, supported by its beautiful landscapes and the hospitality of its people (Chinnapakjarusiri et al. 2024). The country's Internet infrastructure and information and telecommunications technology are also increasingly modernized, with over 90% of the population using smartphones (Boonsiritomachai and Sud-On 2023) and approximately 49% participating in e-commerce.

Thailand's e-commerce sales hit \$31 billion in 2023, accounting for about 10% of the country's total retail sales of consumer goods (Vu and Nguyen 2024). Thailand is seen as having significant potential to further develop mobile payment. Popular forms of mobile payment in the world are present in Thailand. Statistics show that within the next 5 years, the growth rate of mobile payment in Thailand will reach an average of 7.51% a year (Ponsree 2024).

Despite the benefits of mobile payment, it is surprising that not all Thai citizens use mobile payment. This could be due to approximately 48 percent of the Thai population living in rural areas in Thailand that have limited telecommunications infrastructure (Telecom Review 2024; Worldometers 2024). Previous studies have identified factors that influence mobile payment usage. However, these studies are mostly conducted in developed countries. A notable feature of these studies is that they examine factors in isolation and discretely, not as constituent components of an integrated research model. Furthermore, the evolution of mobile payment requires adding new factors to the research model to increase its explanatory power for intention to use mobile payment. These factors include perceived security, perceived privacy, perceived compatibility, and technology competency.

Given the fact that Thailand can be a representative of developing or newly emerging countries, it is necessary to choose a comprehensive research model to examine intention to use mobile payment. The model chosen in this study is the Unified Theory of Acceptance and Use of Technology (UTAUT). The reason for choosing this model is that it is built on the outstanding features of other technology acceptance theories and models. To increase its explanatory power for the intention to use mobile payment, variables added to the UTAUT include technology competency, perceived compatibility, perceived privacy, perceived security, and attitude toward mobile payment.

Thailand is increasingly attracting foreign direct investment, multinational companies and their supply chains are moving to Thailand, and Thailand's tourism industry has potential for further growth. In addition, the Thai government is working to improve the telecommunications infrastructure in the rural parts of Thailand (Telecom Review 2024), opening even more opportunities to expand mobile payment in Thailand. Therefore, identifying factors that influence intention to use mobile payment in Thailand will help Thailand develop strategies and policies to promote the acceptance and use of mobile payment, which, in turn, further support economic growth and development in Thailand.

3. Theoretical Background, Research Model, and Hypotheses

Based on the review of outstanding features of technology acceptance models and theories, Venkatesh (2022) developed the Unified Theory of Acceptance and Use of Technology (UTAUT). Four basic factors make up the UTAUT, including performance expectancy, effort expectancy, social influence, and facilitating conditions. The UTAUT has been used in many studies on the acceptance of a new technology in different contexts.

Consistent with studies using the UTAUT, this study also focuses on four basic factors: performance expectancy, effort expectancy, social influence, and facilitating conditions to examine the intention to use mobile payment in Thailand. It is worth noting that mobile payment is an evolutionary form of online payment. In the mobile payment environment, transactions and exchanges are conducted anytime and anywhere. As a form of technology use in payment, an individual's technology competence plays an important role in influencing the intention to use mobile payment.

Perceived compatibility is also an important factor, because individuals will be willing to participate in activities that are compatible with their lifestyle and social image. In the mobile payment environment, transactions and exchanges take place without limitations of space and time, so risks related to privacy and security are considered higher than in other payment contexts. Therefore, perceived privacy, perceived security, perceived compatibility, technology competency, and attitude toward mobile payment, from a study by Changchit et al. (2023a), were integrated into the UTAUT. These factors are expected to influence the intention to use mobile payment. This is consistent with the studies of Changchit et al. (2023a). Figure 1 shows the integrated research model utilized to examine consumers' intentions to use mobile payment in Thailand.

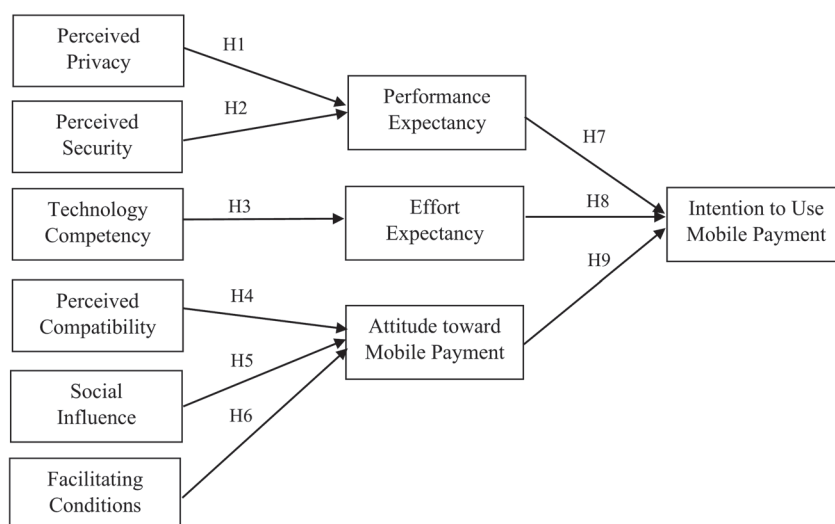


Figure 1. Research models and hypotheses.

3.1. Perceived Privacy and Security

Accepting and using a new technology involves risks (Bland et al. 2024; Katini et al. 2023). Since mobile payment can be conducted anywhere and anytime, consumers face difficulties in evaluating its reliability (Abraham Sleiman et al. 2023). In other words, consumers are concerned about security and privacy issues. If consumers are assured that their personal and financial information is respected, not used for illegal purposes, and not transferred to third parties without their consent, their expectations about the outcomes of using mobile payment will be enhanced. Empirical studies also show that perceived privacy and perceived security are positively related to performance expectancy (Changchit et al. 2023b). Consistent with these studies, the following hypotheses are proposed:

H1. *A positive relationship exists between perceived privacy and performance expectancy.*

H2. *A positive relationship exists between perceived security and performance expectancy.*

3.2. Technology Competency

Technology competency is seen as the degree to which consumers can use technologies in different contexts (Alzeaiden et al. 2024). Consumers with high technology competency seem to be motivated and encouraged to use technologies to complete tasks at work, at

home, or in social interactions and communications (Ling et al. 2024). Consumers with high levels of technology competency will feel it is easy to learn how to use mobile payment (Changchit et al. 2024). Furthermore, in the context of mobile payment, consumers with good technology competency tend to be confident that using mobile payment does not require significant efforts in terms of time and cost (Al-Okaily et al. 2024). Consistent with previous studies, the following hypothesis is proposed:

H3. *A positive relationship exists between technology competency and effort expectancy.*

3.3. Perceived Compatibility

Perceived compatibility in the mobile payment environment can be understood as the extent to which the characteristics of mobile payment align with the intrinsic characteristics of mobile payment consumers (Ayoungman et al. 2021). These intrinsic characteristics may include lifestyles, values, social images, or experiences (Changchit et al. 2024). The intrinsic characteristics of consumers are considered crucial in determining their preference for mobile payment over other forms of payment. Empirical studies in the contexts of online banking, online payment, e-commerce, and m-commerce have demonstrated that perceived compatibility significantly influences attitudes toward the use of technology or innovation (Pushpa et al. 2022). Thus, the following hypothesis is proposed:

H4. *A positive relationship exists between perceived compatibility and attitude toward mobile payment.*

3.4. Social Influence

Social influence is understood as the extent to which consumers perceive that individuals significant to them, such as friends, co-workers, or family members, believe they should or should not adopt a technology or innovation (Venkatesh et al. 2012). It is worth noting that in many situations, the attitudes and behaviors of these individuals influence consumers' attitudes toward technology adoption (Geng et al. 2023). In the context of mobile payment, if social influence is substantial, consumers' attitudes toward mobile payment adoption will be positively influenced. Consistent with previous studies, the following hypothesis is proposed:

H5. *A positive relationship exists between social influence and attitudes toward mobile payment.*

3.5. Facilitating Conditions

Facilitating conditions are the degree to which a consumer believes that the technological, organizational, and human infrastructures exist to support the adoption or use of a technology or innovation (Chawla and Joshi 2023). These enabling conditions include technological, organizational, and human factors or attributes that act to remove the barriers related to the acceptance or use of a technology or innovation (Man et al. 2022). Consistent with previous studies (e.g., Man et al. 2022; Roh et al. 2023), the following hypothesis is proposed:

H6. *A positive relationship exists between facilitating conditions and attitudes towards mobile payment.*

3.6. Performance Expectancy

Performance expectancy demonstrates the usefulness of a technology or innovation (Purohit et al. 2022). The expected benefits generated by using a technology can influence the intention to use that technology. Consumers' perception that using mobile payment can bring convenience and benefits will lead to the intention to use or accept mobile payment (Widyanto et al. 2020). Consistent with previous studies, the following hypothesis is proposed:

H7. *A positive relationship exists between performance expectancy and the intention to use mobile payment.*

3.7. Effort Expectancy

Effort expectancy is understood as the degree to which using a technology is difficult or easy (Wei et al. 2021). Effort expectancy serves as an important factor influencing technology acceptance (Saprikis et al. 2022). In the mobile payment environment, if consumers perceive that it is simple to use mobile payment or that using mobile payment does not require significant efforts, they will tend to use mobile payment. Consistent with previous studies, the following hypothesis is proposed:

H8. *A positive relationship exists between effort expectancy and the intention to use mobile payment.*

3.8. Attitude toward Mobile Payment

In the e-commerce or mobile commerce environment, a technology is considered successful if consumers are able and willing to accept and use that technology (Upadhyay et al. 2022). Consumers with positive attitudes are more likely to accept technology than other consumers (Lu and Ahn 2023). In the context of mobile payment, consumers will have a positive attitude towards mobile payment if they can achieve their goals or expected benefits from using mobile payment (Changchit et al. 2023b). Positive attitudes will boost the intention to use mobile payment. Consistent with previous studies, the following hypothesis is proposed:

H9. *A positive relationship exists between attitude toward mobile payment and the intention to use mobile payment.*

4. Research Methodology

4.1. Measurement Instrument

The survey instrument for this study was developed based on an adaptation of the UTAUT scales developed by Venkatesh (2022) and a study by Changchit et al. (2023a). The questionnaire includes scales, namely the intention to use mobile payment, performance expectancy, effort expectancy, attitude towards mobile payment, perceived privacy, perceived security, technology competency, perceived compatibility, social influence, and facilitating conditions.

A mobile payment expert, fluent in both English and Thai, translated the questionnaire into Thai. Another mobile payment expert, proficient in both English and Thai, back-translated the Thai version into English to evaluate the level of consistency between the Thai and English versions. Two mobile payment researchers fluent in both Thai and English independently reviewed the Thai and English versions of the survey. The results indicated that both the Thai and English versions were consistent and accurate. Evaluations to validate the appropriateness and reliability of the items constituting the scales in the measurement model were performed.

The survey questionnaire consists of two parts: The first part aimed to collect data on consumers' perceptions about mobile payment and their intention to use mobile payment. The second part aimed to collect demographic information. To enhance the reliability and validity of the questionnaire, three professors and ten mobile payment consumers filled out the questionnaire and provided feedback. Some adjustments were made based on the feedback to improve the questionnaire.

Appendix A summarizes the constructs and measurement items designed to assess consumer perception levels about mobile payment and their intention to use mobile payment. All items use a 5-level Likert scale (1 = strongly disagree and 5 = strongly agree).

4.2. Data Collection and Subjects' Demographics

Questionnaires were developed using Google Forms and distributed online via Facebook pages, using a snowball method for data collection. The survey began with a qualifying question asking if the potential participant was a Thai citizen currently living in Thailand and at least 18 years old. If the potential participant did not meet these criteria, they were thanked for their willingness to participate but informed that they did not qualify, as only participants with Thai citizenship living in Thailand were being studied. Four hundred and seventy-five (475) subjects qualified and participated in this study. Each question was set with validation to require a response, ensuring that all surveys were fully completed. According to Hair et al. (2009), the sample size should be at least ten times the number of variables; thus, the sample size for this study is considered sufficient and appropriate. The demographics of the respondents are shown in Table 1.

Table 1. Subjects' demographics (n = 475).

Gender					
Male: 166 (34.95%)			Female: 309 (65.05%)		
Age (in years)					
18–25	26–35	36–45	46–55	56–65	
371 (78.11%)	65 (13.68%)	18 (3.79%)	15 (3.16%)	6 (1.26%)	
Employment					
Full time: 127 (26.74%)		Part time: 39 (8.21%)		Not employed: 309 (65.05%)	
Online orders last month					
0	1–2	3–5	6–9	>10	
49 (10.32%)	93 (19.58%)	152 (32%)	65 (13.68%)	116 (24.42%)	
Online orders last year					
0	1–2	3–5	6–9	10–20	>20
0 (0%)	27 (5.68%)	37 (7.79%)	57 (12%)	102 (21.47%)	252 (53.05%)
Having credit or debit card					
Yes: 398 (83.79%)		No: 77 (16.21%)			

5. Data Analysis

SPSS 28.0 and AMOS 28.0 were used to analyze the data. This section describes the data analysis.

5.1. Reliability Test

A reliability test was conducted to assess the internal consistency of the survey instrument's constructs. The reliability of each construct in the research model was calculated, and the results are presented in Table 2. All reliability test results exceed the recommended value of 0.70 (Nunnally 1978), indicating that the internal consistency of the constructs is satisfactory.

Table 2. Reliability test *.

Constructs	Measurement Items	Cronbach's α
Performance expectancy	PE2, PE3, PE4, PE5	0.840
Effort expectancy	EE1, EE2, EE3, EE4	0.857
Perceived privacy	PP1, PP2, PP3, PP4, PP5	0.952
Perceive security	PS1, PS2, PS3, PS4, PS5	0.901

Table 2. *Cont.*

Constructs	Measurement Items	Cronbach's α
Perceived compatibility	PC1, PC2, PC3, PC4	0.891
Social influence	SI1, SI3, SI4	0.851
Technology competency	TC1, TC3, TC5	0.824
Facilitating conditions	FC1, FC2, FC3, FC5	0.869
Attitude toward mobile payment	ATT1, ATT2, ATT3, ATT4	0.872

* Items with factor loadings <0.6 were removed.

5.2. KMO and Bartlett's Test

The Kaiser–Meyer–Olkin (KMO) and Bartlett's tests were conducted to assess the unidimensionality of the scales (refer to Table 3). The sphericity test yielded a significant p -value of 0.000. Additionally, the sampling adequacy was confirmed by a value of 0.959.

Table 3. KMO and Bartlett's Test.

KMO and Bartlett's Test		
KMO Sampling Adequacy Measurement.		0.959
Sphericity test	Approx. Chi-square	13,980.765
	Degree of freedom	741
	Significance	0.000

5.3. Common Method Bias

Harman's single-factor test was employed to verify the absence of common method bias in the model. The analysis was performed using SPSS, conducting an unrotated, single-factor constraint factor analysis. As depicted in Table 4, the highest variance explained by one factor was 41.896%, suggesting that there are no significant concerns regarding common method bias.

Table 4. Total variance explained.

Total Variance Explained						
Components	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	16.339	41.896	41.896	16.339	41.896	41.896
2	4.472	11.466	53.362	4.472	11.466	53.362
3	1.733	4.442	57.805	1.733	4.442	57.805
4	1.427	3.658	61.463	1.427	3.658	61.463
5	1.341	3.437	64.900	1.341	3.437	64.900
6	1.053	2.701	67.601	1.053	2.701	67.601
7	1.014	2.601	70.201	1.014	2.601	70.201
8	0.949	2.432	72.634	0.949	2.432	72.634
9	0.775	1.987	74.621	0.775	1.987	74.621
10	0.689	1.767	76.388			
11	0.546	1.400	77.788			
12	0.524	1.344	79.131			
13	0.491	1.259	80.391			
14	0.478	1.226	81.617			
15	0.453	1.161	82.777			
16	0.442	1.133	83.910			
17	0.423	1.084	84.994			
18	0.398	1.021	86.015			
19	0.379	0.971	86.986			
20	0.371	0.952	87.938			

Table 4. Cont.

Total Variance Explained						
Components	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
21	0.361	0.926	88.864			
22	0.348	0.892	89.755			
23	0.344	0.883	90.639			
24	0.320	0.821	91.460			
25	0.310	0.796	92.256			
26	0.300	0.770	93.026			
27	0.298	0.765	93.791			
28	0.272	0.697	94.488			
29	0.259	0.664	95.153			
30	0.240	0.615	95.768			
31	0.232	0.595	96.364			
32	0.224	0.576	96.939			
33	0.210	0.539	97.478			
34	0.200	0.513	97.991			
35	0.195	0.501	98.492			
36	0.178	0.456	98.948			
37	0.151	0.387	99.335			
38	0.137	0.351	99.686			
39	0.123	0.314	100.000			

5.4. Analysis of Factor Loadings

To assess the convergent validity of the factors, factor loadings were examined to ensure that each survey item loaded appropriately onto its corresponding factor (refer to Table 5). The findings indicate that the thirty-nine survey items loaded onto ten factors, explaining 74.621% of the total variance. Items with factor loadings below the recommended threshold of 0.6 (Hair et al. 2009) were eliminated during the data analysis process.

Table 5. Factor analysis *.

Constructs	Component									
	1	2	3	4	5	6	7	8	9	10
PE2	0.067	0.036	0.209	0.647	0.394	0.125	0.087	0.047	−0.014	0.275
PE3	0.032	0.044	0.182	0.793	0.161	0.128	0.162	0.113	0.083	−0.027
PE4	0.036	0.106	0.243	0.754	−0.053	0.075	0.186	0.120	0.144	0.033
PE5	0.051	0.015	0.149	0.681	0.137	0.243	0.210	0.066	0.123	0.337
EE1	0.236	0.100	0.061	0.173	0.200	0.728	0.131	0.094	0.199	0.123
EE2	0.142	0.185	0.075	0.026	0.044	0.794	0.139	0.113	0.153	0.085
EE3	0.088	0.248	0.170	0.274	0.167	0.671	0.099	0.156	0.116	0.117
EE4	0.183	0.157	0.294	0.163	0.251	0.648	0.077	0.132	0.136	0.103
PP1	0.821	0.291	0.058	0.040	0.126	0.127	0.056	0.142	0.054	−0.002
PP2	0.884	0.200	0.087	0.023	0.039	0.118	0.040	0.117	0.061	0.054
PP3	0.867	0.225	0.012	0.046	0.065	0.084	0.093	0.120	0.070	0.135
PP4	0.876	0.236	0.101	0.058	0.083	0.100	0.104	0.107	0.043	0.048
PP5	0.776	0.314	0.120	0.032	0.058	0.127	0.160	0.099	0.097	0.038
PS1	0.329	0.705	0.038	0.042	0.161	0.201	0.126	0.194	0.047	0.098
PS2	0.395	0.712	0.132	0.072	0.185	0.136	0.069	0.081	0.130	0.081
PS3	0.398	0.719	0.001	0.003	0.001	0.183	0.051	0.071	0.122	0.072
PS4	0.439	0.665	0.082	0.095	0.075	0.107	0.041	0.166	0.108	0.050
PS5	0.430	0.674	0.078	0.087	0.114	0.144	0.195	0.084	0.065	0.125
PC1	0.215	0.120	0.261	0.256	0.273	0.196	0.613	0.132	0.148	0.207
PC2	0.188	0.081	0.219	0.201	0.251	0.156	0.677	0.132	0.159	0.243
PC3	0.078	0.175	0.228	0.248	0.110	0.079	0.677	0.216	0.155	0.116
PC4	0.165	0.115	0.275	0.228	0.242	0.194	0.663	0.174	0.151	0.245

Table 5. Cont.

Constructs	Component									
	1	2	3	4	5	6	7	8	9	10
SI1	0.170	0.119	0.116	0.164	0.209	0.177	0.152	0.677	0.213	0.176
SI3	0.203	0.175	0.104	0.087	0.095	0.085	0.180	0.806	0.123	0.121
SI4	0.222	0.147	0.162	0.109	0.122	0.179	0.119	0.776	0.131	0.136
TC1	0.055	0.206	0.083	0.050	0.259	0.276	0.132	0.139	0.731	−0.002
TC3	0.086	0.105	0.181	0.091	0.200	0.176	0.126	0.143	0.766	0.116
TC5	0.158	0.046	0.158	0.199	0.130	0.099	0.152	0.161	0.737	0.224
FC1	0.112	0.220	0.217	0.123	0.689	0.184	0.154	0.165	0.175	0.163
FC2	0.101	0.180	0.203	0.130	0.627	0.237	0.224	0.108	0.323	−0.030
FC3	0.080	0.100	0.195	0.177	0.679	0.165	0.237	0.118	0.216	0.173
FC5	0.150	0.042	0.424	0.123	0.658	0.113	0.131	0.157	0.151	0.160
ATT1	0.150	0.046	0.689	0.173	0.306	0.171	0.290	0.101	0.143	0.106
ATT2	0.100	0.003	0.705	0.247	0.298	0.141	0.196	0.114	0.150	0.161
ATT3	0.092	0.057	0.679	0.360	0.171	0.038	0.121	0.101	0.138	0.151
ATT4	0.055	0.171	0.681	0.190	0.141	0.220	0.225	0.139	0.099	0.186
INT3	0.113	0.208	0.322	0.157	0.210	0.141	0.260	0.232	0.152	0.629
INT4	0.152	0.131	0.237	0.188	0.199	0.207	0.291	0.232	0.192	0.673
INT5	0.098	0.154	0.251	0.219	0.147	0.184	0.295	0.228	0.155	0.622

* Rotation method: varimax with Kaiser normalization. The items with factor loadings less than 0.6 were removed from data analysis.

5.5. Multicollinearity Test

To address the potential adverse effects of multicollinearity, an assessment was conducted within the research model (Cenfetelli and Bassellier 2009). As shown in Table 6 below, the Variance Inflation Factor (VIF) ranged from 1.799 to 2.828, all below the threshold of 10. This indicates that multicollinearity is not a significant concern in this dataset.

Table 6. Multicollinearity test.

Coefficients ^a							
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	−0.304	0.186		−1.630	0.104		
PE	0.099	0.050	0.074	1.972	0.049	0.507	1.974
EE	0.067	0.039	0.066	1.736	0.083	0.498	2.009
PP	−0.048	0.033	−0.059	−1.454	0.147	0.442	2.264
PS	0.082	0.039	0.092	2.138	0.033	0.388	2.578
PC	0.375	0.047	0.364	8.050	<0.001	0.354	2.828
SI	0.188	0.035	0.192	5.335	<0.001	0.556	1.799
TC	0.041	0.039	0.039	1.052	0.293	0.529	1.891
FC	0.047	0.051	0.041	0.924	0.356	0.371	2.698
ATT	0.221	0.053	0.186	4.169	<0.001	0.363	2.753

^a Dependent variable: INT.

5.6. Structural Equation Model (SEM)

SPSS AMOS 28.0 was utilized to analyze the research model. Seven structural equation modeling (SEM) fit measures were evaluated to determine the overall goodness of fit of the model. All goodness of fit indices were found to be within acceptable ranges (refer to Table 7), suggesting that the model exhibited a strong fit with the data (Bentler and Bonett 1980; Hu and Bentler 1999; Tucker and Lewis 1973).

Table 7. Fit indices for the models.

Indices of Fit	Value Recommended	Model Value
df/Chi-square	≤ 3.00	2.289
Goodness of fit	≥ 0.90	0.993
Adjusted goodness of fit	≥ 0.80	0.949
Root mean square error of approximation	≤ 0.06	0.052
Comparative fit index	≥ 0.93	0.996
Tucker-Lewis index	≥ 0.90	0.980
Normed fit index	≥ 0.90	0.994

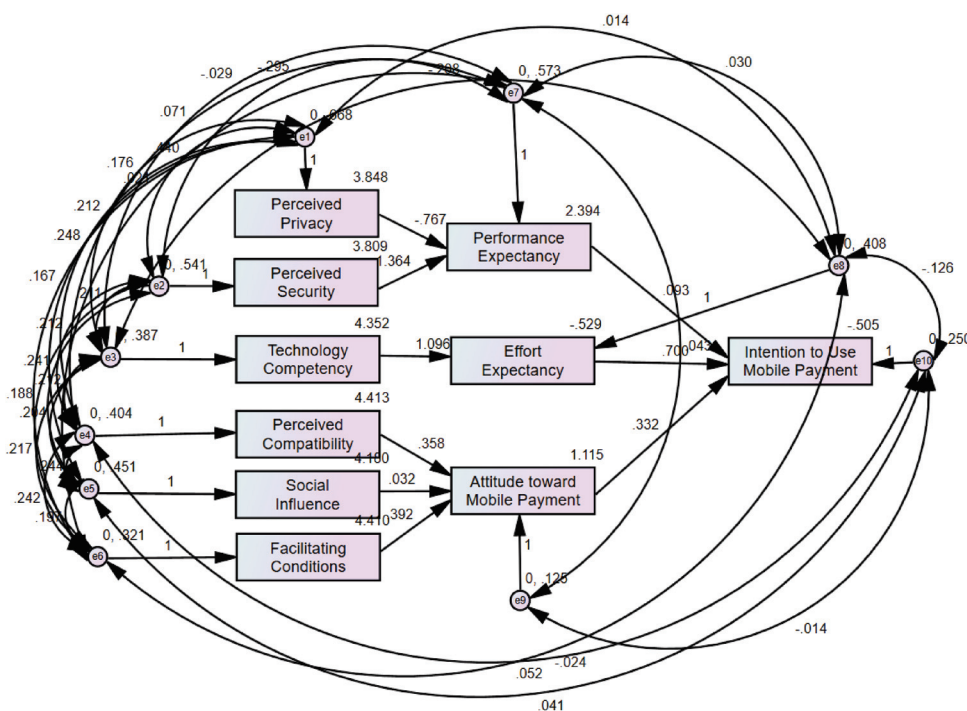
5.7. Hypothesis Testing

Table 8 provides the results of the hypothesis testing. Figure 2 illustrates the properties of the causal paths, including standardized path coefficients.

Table 8. Hypothesis testing.

H#	Hypothesis Testing			Standardized Estimate (β)	Critical Ratio	p-Value
1	Perceived privacy	→	Performance expectancy	−0.767	−4.233	***
2	Perceived security	→	Performance expectancy	1.364	5.093	***
3	Technology competency	→	Effort expectancy	1.096	14.130	***
4	Perceived compatibility	→	Attitude toward mobile payment	0.358	9.726	***
5	Social influence	→	Attitude toward mobile payment	0.032	1.074	0.283
6	Facilitating conditions	→	Attitude toward mobile payment	0.392	9.895	***
7	Performance expectancy	→	Intention to use mobile payment	0.093	1.052	0.293
8	Effort expectancy	→	Intention to use mobile payment	0.700	4.423	***
9	Attitude toward mobile payment	→	Intention to use mobile payment	0.332	1.599	0.110

*** indicates significance level <0.001 .

**Figure 2.** Path analysis of structure equation model.

6. Results and Discussion

The research model proposed in this study received partial support, with the data validating six out of nine hypotheses. Specifically, H1, which posited a significant relationship between perceived privacy and performance expectancy, was supported ($\beta = -0.767$, p -value < 0.001). Contrary to the expected positive relationship, a negative correlation was found, consistent with Alanzi et al. (2023). While this aligns with the significance noted by Abd-Alrazaq et al. (2020), it contrasts with their positive correlations, possibly due to Thai consumers perceiving that enhanced privacy protections in mobile payment systems may detract from system performance.

The findings corroborate H2, providing evidence for a positive relationship between perceived security and performance expectancy ($\beta = 1.364$, $p < 0.001$). Given the direct linkage of mobile payments to consumers' banking or credit card accounts, the security of these transactions emerges as a crucial part of the anticipated performance from mobile payment technologies. The likelihood of consumers attributing a higher performance to mobile payment technology increases when they perceive their financial information as safeguarded. The significant finding for H2 agree with the results reported in mobile payment studies by Katini et al. (2023) and Abraham Sleiman et al. (2023).

The current study supports hypothesis H3, indicating a significant positive relationship between technology competency and effort expectancy ($\beta = 1.096$, p -value < 0.001). The rationale posited that higher technology competency reduces the effort required to use mobile payment technology. This finding aligns with Nguyen (2023) but contradicts Bailey et al. (2022), who found no significant relationship. The discrepancy may be attributed to the generally simplistic design of mobile payment technology, which minimizes the effort needed across all levels of technology competency.

The data analysis revealed support ($\beta = 0.358$, p -value < 0.001) for the proposed positive relationship between perceived compatibility and attitude toward mobile payment (H4). This relationship essentially looks at how mobile payment fits into the lifestyles of consumers. The better the fit that mobile payment provides with the consumer's lifestyle, the more likely the consumer is to have a positive attitude towards mobile payment. This finding agrees with the findings reported in studies by Nguyen (2023) and Alzaidi (2022). This could be explained by the ubiquity of mobile devices in Thailand. Those who possess a smart mobile device are likely to have that device with them for most of their waking hours. Thus, it is perceived as compatible with their lifestyles, resulting in a more favorable attitude toward mobile payment.

The data analysis results did not support H5, which proposed a positive relationship between social influence and attitude toward mobile payment ($\beta = 0.032$, p -value $= 0.283$). This finding is consistent with studies by Lu and Lu (2020) on Chinese Millennials' mobile payment adoption and Sharma et al. (2020). However, it contradicts Geng et al. (2023), who reported a significant relationship. The discrepancy may be attributed to Thailand's collectivist culture, where individuals have large social networks with diverse opinions on mobile payment. Consequently, Thai consumers may prioritize perceived benefits over social influence when deciding to adopt mobile payment.

Support was found for H6, which proposed a positive relationship between facilitating conditions and attitude toward mobile payment ($\beta = 0.392$, p -value < 0.001). Facilitating conditions, such as having a compatible device, the ability to use it, and a wireless Internet connection, are essential for utilizing mobile payment (Chawla and Joshi 2023). This finding aligns with studies by Chawla and Joshi (2023) and Roh et al. (2023) but contrasts with Abd-Alrazaq et al. (2020). Since the introduction of the Thailand 4.0 Strategy in 2016, the Thai government has promoted digital economy initiatives, enhancing mobile device usage and broadband connectivity. Collaborative efforts with the Central Bank of Thailand have further supported mobile payment adoption, fostering a positive attitude toward mobile payment among Thai consumers (Mastercard 2024).

The data analysis results did not support H7, which proposed a positive relationship between performance expectancy and the intention to use mobile payment ($\beta = 0.093$,

p -value = 0.293). This finding aligns with the results of de Blanes Sebastián et al. (2023) and Purohit et al. (2022) but diverges from studies by Bailey et al. (2022), Linge et al. (2023), and Widyanto et al. (2022). The absence of a significant link between performance expectancy and intention may be due to Thailand's longstanding preference for cash transactions, which diminishes the perceived advantages of mobile payments. Additionally, the maturity of mobile payment technology in Thailand may lead consumers to base their decision on other factors.

The analysis confirmed the hypothesized positive relationship between effort expectancy and the intention to use mobile payment (H8), with significant support ($\beta = 0.700$, $p < 0.001$). This aligns with findings from Linge et al. (2023) and Purohit et al. (2022) while contrasting with studies by Bailey et al. (2022) and de Blanes Sebastián et al. (2023), which found no significant correlation. The current study's findings may be attributed to the simplicity of mobile payment systems, which require minimal effort to use, and the technological competence of consumers who find these systems easy to adopt, thereby increasing their intention to use mobile payment.

The data analysis results did not support H9, which proposed a positive relationship between attitude toward mobile payment and the intention to use mobile payment ($\beta = 0.332$, p -value = 0.110). This finding is quite interesting and contradicts reports found in many prior studies (e.g., Lu and Ahn 2023; Yang et al. 2023). Several factors may contribute to this unexpected result.

First, it is possible that external factors, such as social influence and facilitating conditions, play a more dominant role in shaping the intention to use mobile payments in Thailand. In a collectivist society like Thailand, the opinions and behaviors of peers, family, and social networks can have a stronger impact on individual decisions compared to personal attitudes.

Second, the widespread adoption of mobile payments in Thailand may have reached a point where the intention to use is driven more by practical considerations and convenience than by personal attitudes. With the Thai government's strong push for digital economy initiatives and the collaboration with the Central Bank of Thailand, mobile payment infrastructure and support have become robust, possibly reducing the influence of personal attitudes on usage intention.

Third, the novelty effect of mobile payment technology might have worn off, making attitudes less predictive of usage intentions. As mobile payments become a standard and routine part of everyday transactions, users' intentions might be influenced more by habitual behaviors and established routines than by their attitudes toward the technology.

7. Study Implications

7.1. Theoretical Implications

The current study significantly expands upon the Unified Theory of Acceptance and Use of Technology (UTAUT) by incorporating several crucial variables specific to the mobile payment context within Thailand's dynamic market landscape. By integrating perceived privacy, perceived security, technological competency, perceived compatibility, and attitude toward mobile payment, this research enriches our understanding of the intricate factors influencing mobile payment adoption in developing regions.

This advancement is particularly noteworthy, as it sheds light on the unique considerations and challenges faced by consumers in emerging economies like Thailand. Unlike findings from more advanced economies, the factors driving technology adoption in developing contexts can vary significantly due to cultural, economic, and infrastructural differences. Therefore, this study provides valuable insights that cannot be simply extrapolated from research conducted in developed nations.

Moreover, this research endeavor addresses a notable gap in the existing literature, as identified by Bui et al. (2022), by offering a comprehensive examination of mobile payment adoption within developing economies. By delving deeply into this relatively

underexplored area, the study contributes not only to academic knowledge but also to practical understanding and application in real-world settings.

Furthermore, the dynamic nature of technological advancements, particularly in the realm of mobile payment, necessitates continuous investigation and adaptation. As new technologies emerge and consumer preferences evolve, previously significant factors may become obsolete or require re-evaluation. Thus, ongoing research efforts are crucial for staying abreast of these developments and ensuring the relevance and applicability of findings over time.

Lastly, the proposed research model serves as a robust framework that can guide future studies on mobile payment adoption in developing economies. By providing a comprehensive structure and incorporating the key variables relevant to these contexts, this model lays the groundwork for further exploration and refinement in this field. It not only facilitates a deeper understanding of mobile payment dynamics but also offers practical implications for policymakers, businesses, and other stakeholders striving to promote technological innovation and economic development in developing nations.

7.2. Practical Implications

The findings of this study provide actionable insights for mobile payment service providers, offering guidance on how to develop systems that better align with user preferences. For instance, the research highlights the paramount importance of privacy and security for Thai consumers, indicating that providers should prioritize implementing robust measures in their systems to ensure the safety and confidentiality of users' information. Additionally, the study emphasizes the significance of aligning mobile payment systems with the needs and lifestyles of Thai consumers. This is exemplified by the observed relationship between perceived compatibility and attitudes toward mobile payment, suggesting that systems tailored to fit seamlessly into users' lives are more likely to be embraced.

Moreover, the study's focus on facilitating conditions resonates with the Thai government's Thailand 4.0 Strategy, which seeks to enhance Internet connectivity and advance the digital economy. Enhancing the telecommunications infrastructure to better serve the rural areas of Thailand (see Telecom Review 2024) is only part of the solution; the Thai government should also consider implementing educational programs to boost the digital literacy of residents in the rural areas. This could be accomplished through public-private partnerships to improve the financial inclusion among the Thai population. By emphasizing the importance of user experience, the research suggests that providers should concentrate on creating intuitive user interfaces, simplifying registration and authentication processes, and refining transaction pathways. These efforts are essential for enhancing the overall user experience and fostering a greater adoption of mobile payment solutions in Thailand.

8. Conclusions, Limitations, and Future Research Directions

This study applied an extended UTAUT model as a theoretical foundation to examine Thai consumers' mobile payment adoption. The proposed research model accounted for approximately 74 percent of the variance on Thai consumers' behavioral intentions towards mobile payment adoption. This study takes a step towards filling a gap in the literature by addressing the adoption of mobile payment in the developing economy of Thailand.

By expanding the Unified Theory of Acceptance and Use of Technology (UTAUT) framework to include constructs such as perceived privacy, perceived security, technological competency, perceived compatibility, and attitude toward mobile payment, this investigation explains the impact of certain factors on the willingness of individuals to adopt mobile payments. Highlighting the pivotal role of privacy and security, this study underscores consumer apprehensions regarding the safeguarding of their financial dealings within mobile payment frameworks. Furthermore, it provides evidence of the significance of technology competency and the perceived compatibility with individual consumer lifestyles and their attitude towards mobile payments, subsequently influencing their intent to adopt.

This study provides practical insights for businesses offering mobile payment services, advocating for a concerted emphasis on bolstering privacy, security, and overall user experience. Through the alignment of mobile payment frameworks with consumer preferences and the assurance of stringent security protocols, service providers are positioned to stimulate broader acceptance among Thai consumers. Moreover, the findings furnish critical implications for policy architects, highlighting the instrumental role of enabling conditions, such as expansive broadband wireless Internet access and conducive digital economic policies, in the enablement of mobile payment adoption.

Overall, this study addresses a gap within the existing literature by delivering an exhaustive dissection of the determinants influencing mobile payment adoption in the context of developing economies. It not only corroborates the expanded UTAUT model within the Thai milieu but also offers actionable items for stakeholders endeavoring to bolster financial inclusivity and economic advancement via mobile payment technologies. Future inquiries may delve into the enduring effects of these determinants on mobile payment acceptance and investigate the transformative potential of emerging technologies in refining consumer dispositions and behaviors towards mobile payment.

Empirical research inherently has its limitations, and this study is no exception. The focus was on Thai consumers, with data collected via an online survey from self-selected participants, introducing self-selection bias as a limitation. Participants who chose to participate may hold different perspectives compared to those who did not, potentially limiting the representativeness of the sample for the Thai population. However, given the constraints of empirical research, the researchers consider the sample sufficient.

Furthermore, this study solely concentrated on participants from Thailand, despite the availability of mobile payment in numerous other developing economies. Future research could explore a more diverse sample across multiple developing countries and compare mobile payment perspectives between developed and developing economies, offering insights into cultural and economic influences. A comparative study across developing economies with diverse cultures could also be an intriguing area for future research. Additionally, exploring the impact of financial risk on mobile payment adoption in Thailand is another promising avenue for future investigation.

The investigation into mobile payment system acceptance in Thailand represents an advancement in understanding technology acceptance within developing economies. This research offers insights that can be instrumental in similar economies grappling with comparable technological adoption challenges and opportunities. Understanding the dynamics of technology adoption among consumers in these contexts is vital for businesses and policymakers aiming to drive innovation and economic progress. This study contributes to the scholarly dialogue on technology acceptance, laying the groundwork for future research endeavors in this domain and offering valuable implications for academia and industry alike.

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Appendix A. Research Questionnaire

Performance Expectancy (PE)	Mobile payment is useful to purchase products or services Mobile payment makes it easier to conduct transactions Mobile payment enables me to buy products or services faster Mobile payment saves me time Mobile payment makes my life easier
Effort Expectancy (EE)	Learning to use mobile payment is easy It does not require much effort to learn how to use mobile payment It is easy to perform the steps required to use mobile payment It is easy to become skillful at using mobile payment Conducting transactions via mobile payment is easier than using other payment methods
Technology Competency (TC)	My skills with technology are good I am not afraid of using technology My ability to learn new technology is good I am always interested in new technology I enjoy working with technology
Perceived Privacy (PP)	I believe that mobile payment providers will protect the privacy of my personal data I believe that mobile payment systems will not disclose my personal data I believe that mobile payment systems will keep transactions confidential I believe that mobile payment systems will keep my information confidential I believe that mobile payment systems will prevent others from looking at my data
Perceived Security (PS)	Using mobile payment enable me to conduct transaction securely I feel confident about the security of mobile payment system I am not worried about the security of mobile payment I believe that mobile payment systems protect me from unauthorized transactions I believe that the transactions conducted via mobile payment are secured
Perceived Compatibility (PC)	Mobile payment fits my lifestyle Mobile payment is compatible with my shopping behavior Mobile payment is compatible with my busy schedules Mobile payment is suitable for me Mobile payment is compatible with my lifestyle
Social Influence (SI)	People who are important to me find using mobile payment beneficial People who are important to me use mobile payment People who are important to me think I should use mobile payment People who are important to me encourage me to use mobile payment People who are important to me enjoy using mobile payment
Facilitating Conditions (FC)	I have the resources necessary to use mobile payment I have the knowledge necessary to use mobile payment Mobile banking is compatible with other systems I use A person (or group) is available for assistance with system difficulties I have the devices necessary to use mobile payment
Attitude toward using mobile payment (ATT)	Using mobile payment is a good idea Using mobile payment is beneficial Using mobile payment is favorable Using mobile payment is a wise thing to do I am positive toward mobile payment
Intention to Use Mobile Payment (INT)	I like to use mobile payment to purchase products and services I feel comfortable using mobile payment I intend to use/continue using mobile payment I like paying via mobile payment I will choose mobile payment if it is available

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Article

Factors Influencing the Adoption of FinTech for the Enhancement of Financial Inclusion in Rural India Using a Mixed Methods Approach

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Abstract: The swift expansion of financial technology (FinTech) can substantially improve financial inclusion, especially in the rural regions of emerging nations such as India. FinTech has the potential to drive inclusive growth, reduce inequalities, and foster sustainable economic development. This research examines the determinants affecting the adoption of FinTech services in rural India by synthesizing three theoretical frameworks: The Technology Acceptance Model (TAM), the Theory of Planned Behavior (TPB), and the Technology Readiness Index (TRI). A mixed methods approach that combines partial least squares structured equation modeling (PLS-SEM) and fuzzy set comparative qualitative analysis (fsQCA) was used to evaluate the suggested framework. The integrated PLS-SEM and fsQCA offer a comprehensive, elegant, and resilient method for data analysis. While fsQCA addresses more intricate patterns within the data, PLS-SEM effectively identifies the relationships among significant factors. This makes the mixed method approach more judicious and advantageous than the single method approach. The findings showed that attitude ($\beta = 0.35$), perceived behavioral control ($\beta = 0.28$) from the Theory of Planned Behavior (TPB), perceived ease of use ($\beta = 0.31$) from the Technology Acceptance Model (TAM), and perceived insecurity ($\beta = -0.19$) from the Technology Readiness Index (TRI) all have a big impact on how people use FinTech. The findings also indicate that the desire to adopt FinTech positively influences financial inclusion among rural residents. These research findings enhance the debate on sustainable development by demonstrating how specific FinTech interventions can close the financial inclusion gap, empower rural populations, and achieve various Sustainable Development Goals (SDGs). The study's findings could help governments, banks, and FinTech firms aiming to enhance the accessibility and use of digital financial services in rural India.

Keywords: fintech adoption; TAM; TPB; TRI; SDG; India

1. Introduction

Financial inclusion ensures that people and companies have responsible and sustainable access to reasonably priced financial products and services, including banking, credit, insurance, and payment systems (World Bank, 2018). It seeks to lower inequality by providing financial access to underprivileged and marginalized groups and encouraging economic development (Demirgüç-Kunt et al., 2021). Financial inclusion is a crucial catalyst for economic growth and poverty reduction, particularly in emerging nations such as India, where a substantial population is underbanked. Notwithstanding various government attempts and the expansion of digital financial services, financial exclusion remains a significant issue in rural India. Introducing financial technology can revolutionize this situation by facilitating access to financial services via digital platforms, mobile banking,

and financial technology (FinTech). FinTech has become a crucial catalyst in reshaping the global financial landscape. In emerging economies, it possesses considerable potential to improve financial inclusion by offering affordable, accessible, and user-friendly financial services. Characterized by its extensive rural populace, India is a principal beneficiary of this technological transformation.

Notwithstanding the government's various measures to enhance financial inclusion, a significant segment of the rural populace remains unbanked or underbanked (Demirgüç-Kunt et al., 2021). FinTech technologies, like digital wallets, mobile banking, and peer-to-peer lending platforms, provide novel methods to address this disparity by surmounting conventional obstacles such as geographical limitations, inadequate banking infrastructure, and elevated transaction costs (Kishor et al., 2024). FinTech services help to attain the SDGs, primarily in three dimensions, i.e., financial, economic, and environmental (Hasan et al., 2024). In the finance dimension, FinTech services enhance financial inclusion by expanding digital payment options, promoting crowdfunding, facilitating peer-to-peer (P2P) lending, supporting microlending, encouraging personal deposit accounts, integrating FinTech with e-commerce, and streamlining lending processes (Bayram et al., 2022). All these facilities help us attain SDG 8 (promote sustained, inclusive, and sustainable economic growth). In the economic dimension, FinTech contributes to the achievement of SDG 10 and SDG 11 by boosting market competition, generating job opportunities in the service sector, expanding financial activities, and promoting sustainable agribusiness development (Begum et al., 2023). FinTech mitigates poverty by aiding households in budget management, encouraging savings, fostering entrepreneurial initiatives, and facilitating the efficient operation of new and existing businesses. FinTech mitigates income inequality by reducing financial and economic activities via digital connectivity. FinTech can effectively mitigate income inequality within the formal financial sector. On the environmental front, FinTech enhances renewable energy production and consumption, boosts green financing for environmentally supportive projects, and encourages investment in low-carbon-emitting production technologies (Lisha et al., 2023). FinTech reduces carbon emissions and improves environmental quality by promoting low-carbon practices among users and facilitating and incentivizing reforestation efforts to reduce carbon output. Thus, FinTech contributes to the achievement of SDG 11 and SDG 13.

Over the past ten years, India has made significant progress in financial inclusion; however, certain challenges still exist. Financial inclusion in rural India presents significant socioeconomic, infrastructure, and technological challenges, notwithstanding various government programs. The challenges include (1) individuals in rural regions possessing limited knowledge of formal financial services, resulting in lower usage (M. Sarma & Pais, 2011); (2) insufficient access to smartphones, the internet, and digital payment systems complicating financial transactions (Ghosh & Sahu, 2021); (3) women in rural areas facing barriers to accessing financial services due to patriarchal norms and restricted mobility (Dahiya & Kumar, 2020); and (4) many rural inhabitants, particularly farmers and laborers, experiencing unstable incomes, hindering their ability to maintain bank accounts or secure loans (Barik & Sharma, 2019). Although digital technologies, including mobile banking, digital wallets, and biometric identification systems like Aadhaar, have enhanced the accessibility of financial services, their acceptance and effects differ significantly.

As of 2022, around 43% of India's population is unbanked due to insufficient access to financial institutions, according to the World Bank's Global Findex database (Owusu-Pepurah, 2024). Moreover, merely 28% of the population utilizes debit or credit cards, frequently attributable to the lack of nearby ATMs (Owusu-Pepurah, 2024). Furthermore, by the conclusion of 2021, India was positioned 67th among 166 nations regarding the number of commercial bank branches per 100,000 adults worldwide (Owusu-Pepurah, 2024).

India was placed 119th out of 166 countries for the number of ATMs per 100,000 adults by the conclusion of 2021, marking one of the lowest standings globally. Recently, a study by the Reserve Bank of India (RBI) showed considerable progress in access, use, and quality dimensions of financial services, which rose from 53.9 in March 2021 to 64.2 in March 2024 (Khan & Sahu, 2025). Further, reflecting the success of initiatives, including Pradhan Mantri Jan Dhan Yojana (PMJDY) in increasing banking access, adult bank account ownership in India grew to 77% by 2024 (Economic Survey, 2024). While these initiatives have considerably raised financial inclusion in India, continuous work is needed to address the remaining problems, particularly concerning reducing the gender gap in financial access and increasing the active use of financial services. Comprehending the determinants of technology uptake in rural regions is crucial for formulating targeted interventions to close the financial inclusion gap and foster sustainable development (Muthukannan et al., 2020).

Implementing financial technology (FinTech) presents a disruptive solution to this problem by delivering economical, accessible, and scalable financial services (Najib et al., 2021; Ozili, 2023). A complex interaction of elements, including personal attitudes, societal norms, and technological preparedness, affects the adoption and utilization of FinTech in rural regions (Madan & Yadav, 2021). The Technology Acceptance Model (TAM), Theory of Planned Behavior (TPB), and Technology Readiness Index (TRI) offer comprehensive frameworks for comprehending these processes. The Technology Acceptability Model (TAM) emphasizes the perceived ease of use and perceived usefulness of technology, which are essential for assessing user acceptability (Davis, 1989). The Theory of Planned Behavior (TPB) improves its framework by including social variables and perceived behavioral control. This makes it easier to see how societal norms and trust in technology use affect the use of FinTech in rural areas (Ajzen, 1991). Simultaneously, the TRI assesses consumers' inclination to adopt new technologies based on optimism, innovativeness, discomfort, and insecurity (Colby & Parasuraman, 2001). This study seeks to amalgamate these three theoretical models to examine the determinants affecting FinTech uptake in rural India thoroughly. The study aims to clarify the effective utilization of FinTech to enhance financial inclusion in these communities.

FinTech adoption is receiving more and more attention in the academic world. However, few studies have used the Technology Acceptance Model (TAM), Theory of Planned Behavior (TPB), and Technology Readiness Index (TRI) to look into this phenomenon, especially in rural India. Much research has predominantly concentrated on urban populations or examined a singular theoretical framework, resulting in a disjointed comprehension of the determinants affecting FinTech adoption (Irimia-Diéguez et al., 2023; Sharma & Munjal, 2024; G. Wu & Peng, 2024).

The economy and financial system can only grow with fair economic policies and long-term financial inclusion that help people to make social and economic progress (Lusardi, 2019; Koomson et al., 2020; Nsiah et al., 2021). However, the factors that cause this to occur in rural India remain unknown, necessitating additional investigation. The economic behavior of individuals is elucidated in the literature through several hypotheses, including the absolute income hypothesis, the permanent income hypothesis, the life cycle hypothesis, and the relative income hypothesis (Mohanta & Dash, 2022). However, these traditional models do not consider important demographic and personal traits. Instead, they focus on earnings, income, and life cycles to explain what makes people save and spend money. Evaluating the scope and impact of many initiatives, research of this nature can aid in establishing benchmarks and objectives for politicians, financial institutions, and economic development. Despite the extensive examination of technological factors, there has been insufficient focus on psychological and behavioral dimensions, especially in rural settings

where digital literacy and technological infrastructure are often inadequate (M. Ali et al., 2021). Also, not many real-world studies look at the combined effects of these factors on different age, gender, and income groups in rural areas. The impact of FinTech on improving access to financial services, as well as enhancing financial literacy and long-term financial well-being, is, as of yet, inadequately examined (Morgan & Trinh, 2020). Given the preceding debate, the study aimed to address the following research questions:

1. What are the important technological, psychological, and socio-cultural factors affecting the adoption of FinTech in rural India, as elucidated by the Technology Acceptance Model (TAM), Theory of Planned Behavior (TPB), and Technology Readiness Index (TRI)?
2. How do these factors influence the intention to accept and utilize FinTech services across various demographic segments within the rural population?
3. How can policymakers and financial institutions utilize these findings to improve financial inclusion in rural India?

This research offers significant contributions to the current literature. Initially, it amalgamates three significant theoretical frameworks, e.g., TAM, TPB, and TRI, to provide a thorough understanding of the determinants affecting FinTech uptake in rural India. This comprehensive method overcomes the shortcomings of earlier studies that depended on a singular framework, providing a more intricate examination of the factors influencing FinTech adoption (Kumari, 2024). Secondly, while previous research on FinTech investigates various factors (technical, psychological, and socioeconomical) influencing its adoption and use separately, limited studies have assessed these elements collectively (G. Wu & Peng, 2024; Musa et al., 2024; S. Singh et al., 2020; Somesanook, 2024). Furthermore, no studies in India have simultaneously examined the technological, psychological, and socioeconomic factors. Thus, this study examines how technological, psychological, and socio-cultural factors affect FinTech adoption among rural people in India. This gives specific information that can help to make FinTech solutions fit the needs of other rural communities. The research advances the discussion on financial inclusion by examining FinTech's role in facilitating access to financial services while improving financial literacy and promoting long-term financial well-being (Morgan, 2022). These findings hold practical significance for policymakers, financial institutions, and technology providers in formulating ways to enhance sustained financial inclusion in rural India.

2. Literature Review

Given the significant expectations from organizations like the World Bank and the UN regarding mobile financial services' potential to reduce poverty and foster economic development, it is essential to understand the technological and behavioral factors influencing the adoption of this innovation. FinTech services face adoption challenges compared to cash systems (Grohmann et al., 2018). Additionally, online banking poses risks that can result in financial losses, and the digital nature of FinTech transactions makes individuals hesitant to embrace the technology (Baganzi & Lau, 2017). Many of the banked population lack formal education, complicating the use of FinTech innovations (Demirgüç-Kunt et al., 2020). Furthermore, mobile services often use formal languages like English, which does not benefit many individuals with low educational levels in emerging nations. In India, most FinTech services are available in English and Hindi, creating barriers for local illiterate or semi-literate users. As a result, many individuals in developing countries remain without access to financial services. Adopting financial technology has emerged as an essential tool for increasing financial inclusion, particularly in developing economies with insufficient traditional banking infrastructure.

In India, the rapid expansion of mobile networks in rural areas has significantly contributed to this cause over the past decade (Chauhan et al., 2022; Asif et al., 2023). Payment banks have emerged as an alternative to online and mobile banking, enhancing operational efficiency and reducing costs related to service provision for customers in rural and semi-urban areas (Schuetz & Venkatesh, 2020; Chauhan et al., 2022). The Reserve Bank of India's open regulatory framework and the government's policies encouraging new businesses have benefited digital finance companies. Indian customers, known for their prudence in financial decisions, want increased confidence in FinTech enterprises. Key issues include meeting their needs and changing how people handle their money, as well as creating a strong and flexible regulatory framework that can keep up with the speed of technological progress (Asif et al., 2023; Chauhan et al., 2022). The Reserve Bank of India (RBI) uses computer algorithms to support the Unified Payments Interface, Bharat Bill Payments System, digital payments, peer-to-peer lending, and financial advice. The RBI also permitted eleven FinTech companies to launch savings, deposit, and remittance payment banks in various parts of India, focusing on rural areas. To address these socioeconomic disparities, it is crucial to understand the factors influencing FinTech utilization, enabling service providers to adapt their offerings for broader acceptance and improved financial inclusion (Demir et al., 2022). This literature review examines key studies on FinTech usage in rural areas through three theories: The Technology Acceptance Model (TAM), the Theory of Planned Behavior (TPB), and the Technology Readiness Index (TRI).

The Technology Acceptance Model (TAM), introduced by Davis in 1989 (Davis, 1989), is a prominent paradigm for comprehending technology uptake. It asserts that perceived usefulness and perceived ease of use are the principal factors influencing technology adoption. Multiple studies have utilized the Technology Acceptance Model (TAM) to investigate FinTech uptake in diverse situations. To and Trinh (2021) examined mobile payment uptake and determined that perceived ease of use and perceived utility greatly affected users' desire to use the technology. A study by Shaikh and Karjaluoto (2015) emphasized that trust and perceived risk are essential factors in the FinTech adoption process, especially in environments with poor digital literacy. Despite the well-established use of the Technology Acceptance Model (TAM) in urban environments, its application in rural regions still needs to be improved. Conventional TAM conceptions may need to address distinct issues that rural populations frequently encounter, such as low digital literacy, restricted internet access, and socio-cultural obstacles (Kumari, 2024). In this setting, augmenting the Technology Acceptance Model by incorporating additional elements such as trust, perceived risk, and socio-cultural impacts can yield a more thorough comprehension of FinTech acceptance in rural India (Madan & Yadav, 2021).

The Theory of Planned Behavior (TPB), formulated by Ajzen (Ajzen, 1991), enhances the Technology Acceptance Model by integrating subjective standards and perceived behavioral control as supplementary factors influencing behavioral intention. The Theory of Planned Behavior (TPB) has been employed to examine various activities, including adopting technology. In FinTech adoption, subjective norms denote the impact of societal pressure on an individual's choice to embrace financial innovations. In contrast, perceived behavioral control pertains to the perceived ease or difficulty of utilizing these technologies (Ajzen, 1991). Numerous studies have underscored the significance of social influences in adopting technology. Martins (Martins et al., 2014) discovered that subjective standards greatly influence the adoption of Internet banking in Portugal. In rural environments, where community impact and social interactions are significant, subjective norms may be relevant (Alharbi & Sohaib, 2021). Also, perceived behavioral control, including resource accessibility and self-efficacy, is very important in rural areas where educational and infrastructure problems may make it hard to use technology (Raza et al., 2019).

The Technology Readiness Index (TRI), developed by Colby and Parasuraman (2001), evaluates individuals' inclination to accept and utilize new technologies across four dimensions: optimism, innovativeness, discomfort, and insecurity. Optimism and innovation facilitate technology adoption, whereas discomfort and insecurity hinder it. TRI offers a comprehensive view of technology adoption by including psychological elements affecting an individual's readiness to accept new technologies. Research on the Technology Readiness Index (TRI) concerning FinTech adoption is notably limited, especially in rural areas. Various studies have demonstrated a significant impact of technology readiness on adopting self-service technologies and mobile banking (Chang & Chen, 2021; Liljander et al., 2006). However, research on the implementation of TRI in rural India still needs to be improved. Rural consumers may demonstrate varying degrees of technological readiness, influenced by differences in exposure to digital technologies, socioeconomic position, and cultural factors (Madan & Yadav, 2018). Integrating TRI into the study of FinTech uptake in rural regions can provide significant insights into the psychological impediments and motivators of technology utilization in these communities.

The exclusion from the formal economic system is widely acknowledged as an impediment to the future eradication of poverty. Numerous cultural and procedural limitations constrain the stakeholders in the FinTech ecosystem. Scholars disagree on whether mobile money systems can fully realize their growth potential in rural regions (Ozili, 2023; Asif et al., 2023). A study on financial inclusion at the bottom of the pyramid (B.O.P.) in Indian society requires transformation, focusing on developing technological solutions for underserved communities (Asif et al., 2023; Schuetz & Venkatesh, 2020). Consequently, developing creative methods for delivering financial services to economically disadvantaged individuals is imperative.

There have not been many real-world studies in developing economies that try to figure out what makes mobile technology an important tool for financial inclusion (Wang & Zhang, 2025; Asif et al., 2023). These studies seem to have a more contextual approach to alleviating poverty in less developed places. It is also important to create good practices for policymakers in this complex and constantly evolving market (Schuetz & Venkatesh, 2020). Research indicates that mobile banking and digital payment platforms can enhance access to financial services in rural areas (Bateman et al., 2019). Issues such as insufficient digital literacy, lack of faith in digital platforms, and inadequate infrastructure frequently obstruct the implementation of these technologies (Kishor et al., 2024). Current research mostly emphasizes technological and economic considerations while neglecting the psychological and behavioral dimensions of FinTech adoption in rural settings (G. Wu & Peng, 2024). Although the Technology Acceptance Model (TAM) considers perceived ease of use and usefulness, it inadequately encompasses the impact of societal norms and individual preparedness for technology adoption, which are essential in rural contexts. Likewise, although the Theory of Planned Behavior includes social and behavioral control elements, it may need to consider rural users' psychological preparedness for adopting new technology. Similarly, TRI offers a more comprehensive understanding of personal readiness, but its application in rural FinTech adoption still needs to be examined. This paper aimed to fill a gap in the current research about financial inclusion and financial technology's impact on financial services provision. This study utilized an empirical method to assess the impact of technology on fostering entrepreneurship in impoverished areas. The study also analyzed the critical success factors for the future implementation of financial technology in rural regions (Wang & Zhang, 2025; Asif et al., 2023; Ji et al., 2021).

This study employed a mixed method approach using PLS-SEM and fsQCA to predict essential factors for adopting FinTech in rural India. Researchers recognize the synergistic advantages of using integrated PLS-SEM and fsQCA methodologies to address complex

research problems. The variance-based PLS-SEM methodology predicts and identifies linear relationships. In contrast, the set-theoretic fsQCA methodology discerns linkages through configurations (Ragin, 2008). PLS-SEM assumes that relationships are additive and symmetric, so it is not efficient to handle asymmetric relations among variables (J. Hair & Alamer, 2022). Beyond PLS-SEM's linear limitations, fsQCA exposes other strategies for an outcome. Hossain et al. (2024) found that PLS-SEM gives full model fit and effect sizes, while fsQCA gives configurational insights that improve theoretical and empirical validity. PLS-SEM also thinks that effects are the same across a dataset, but fsQCA can look at subgroups and find different causal configurations (Kaya et al., 2020). The mixed method can look at the complexity of predictors using fsQCA and the ability to predict using PLS-SEM (Pappas & Woodside, 2021).

2.1. Theoretical Framework

The proposed theoretical framework integrates the Technology Acceptance Model (TAM), the Theory of Planned Behavior (TPB), and the Technology Readiness Index (TRI) to analyze the factors influencing FinTech adoption in rural India comprehensively (Figure 1). This multidimensional approach allows for an in-depth understanding of the technological, psychological, and socio-cultural determinants of FinTech adoption, which are essential for promoting financial inclusion in rural areas. This approach enables a thorough analysis of the technological, social, and psychological factors influencing adoption (Negm, 2023).

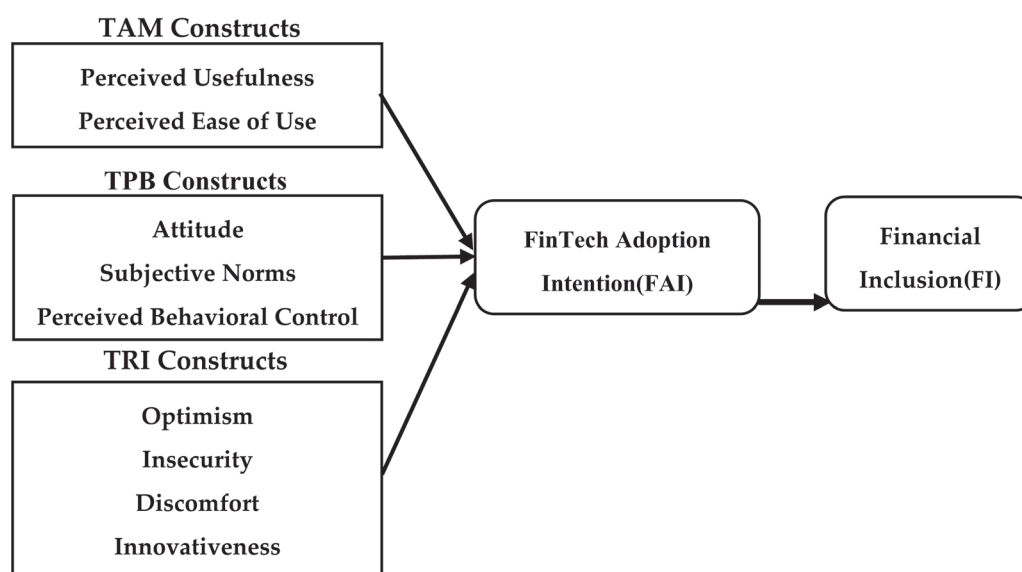


Figure 1. Proposed research framework.

The framework is structured around three core constructs derived from the TAM, TPB, and TRI models and their respective sub-constructs. It also includes financial inclusion as the outcome variable, influenced by the behavioral intention to use FinTech services.

2.2. Hypothesis Development

This section discusses the relationship between study constructs and the formulation of hypotheses based on the proposed hypothesis.

2.2.1. Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) consists of two key components: perceived usefulness (PU) and perceived ease of use (PEOU). PU indicates how much an individual believes that using FinTech services can enhance financial activities such as savings,

credit access, and transactions (Davis, 1989). Perceived usefulness is crucial in technology adoption (Yan et al., 2022). This research evaluates how perceived usefulness influences FinTech adoption among rural Indians by addressing user needs such as time efficiency and benefits. Furthermore, the study conducted by Somesanook (2024) revealed that it is unsurprising that individuals will enhance their acceptance of FinTech upon recognizing its use. Multiple studies consistently show a positive relationship between perceived usefulness and the intention to adopt FinTech (Baba et al., 2023; Igamo et al., 2024; Singh & Singh, 2023). However, some studies found that perceived usefulness had little effect on adopting electronic financial services (Mufarih et al., 2020). PEOU reflects the perception that using FinTech services requires minimal effort, which is particularly relevant in rural areas with lower digital literacy (Davis, 1989). PEU relates to an individual's effort in utilizing new technology (Davis, 1989). PEOU evaluates the interfaces of FinTech services in terms of their user-friendliness and accessibility across various devices. Research has shown a positive relationship between perceived ease of use (PEOU) and FinTech adoption (Baba et al., 2023; Igamo et al., 2024; Singh & Singh, 2023; G. Wu & Peng, 2024). The research by Darnida et al. (2024) indicated that a user's perception of a system's usability greatly influences their intention to utilize FinTech for financial services. Additionally, S. Singh et al. (2020) concluded that customers were more inclined to accept FinTech when they perceived it as more user-friendly. Based on the above evidence, the following hypotheses are proposed.

H1: *PU significantly impacts users' intentions to use FinTech services.*

H2: *PEOU positively influences people's intentions to use FinTech-based financial transactions.*

2.2.2. Theory of Planned Behavior (TPB)

The main constructs of the Theory of Planned Behavior (TPB) are Attitude (ATT), Subjective Norms (SN), and Perceived Behavioral Control (PBC). Attitude reflects an individual's favorable or unfavorable evaluation of using FinTech services (Ajzen, 1991). A growing body of literature has explored the positive impact of attitudes on the behavioral intention to adopt FinTech tools for mobile payment (Giovanis et al., 2020; Verma et al., 2021; Yadegari et al., 2024). Musa et al. (2024) also affirmed that attitude affects the adoption of FinTech among Nigerians. A study by Rai et al. (2019) established that attitude is a crucial factor influencing intentions toward financial inclusion in India. Similarly, Maune and Mundonde (2024) demonstrated that attitude significantly influences engagement behavior in financial inclusion in Zimbabwe. Subjective norms capture individuals' social pressure regarding FinTech use, which is particularly influential in rural areas where community dynamics significantly affect behavior (Ajzen, 1991). Previous research (Giovanis et al., 2020; Verma et al., 2021) indicates that subjective norms substantially enhance the intention to use FinTech applications for financial transactions, such as mobile and NFC-based transactions. Panchasara and Sharma (2019) identified a substantial positive correlation between subjective norms and the intention toward financial inclusion in India. Musa et al. (2024) have affirmed the significant correlation between subjective norms and Nigerians' intention to adopt FinTech. Perceived behavioral control pertains to the perceived ease or difficulty of adopting FinTech services, influenced by access to technology, financial literacy, and self-efficacy with digital tools (Ajzen, 1991). Perceived behavioral control over FinTech usage refers to an individual's ability to effectively manage payment transactions through various FinTech application channels (Verma et al., 2021). Several studies have highlighted the positive impact of perceived behavioral control on the intention to use FinTech applications for financial transactions (Ajouz et al., 2021; Giovanis et al., 2020; Verma et al., 2021). Maune and Mundonde (2024) found a significant positive correlation between perceived behavioral control and involvement in financial inclusion in Zimbabwe.

Musa et al.'s (2024) research revealed the substantial impact of perceived behavioral control and behavioral intention on the financial inclusion participation of Nigerian individuals. Panchasara and Sharma (2019) identified a negligible correlation between perceived behavioral control and intention toward financial inclusion in India. Thus, the study formulated the following hypotheses:

H3: *The individual's attitude positively influences their intention to use FinTech solutions for financial transactions.*

H4: *The subjective norms have a significant positive influence on FinTech use.*

H5: *Individuals' perceived behavioral controls significantly influence their desire to use FinTech solutions for transactions.*

2.2.3. Technology Readiness Index (TRI)

Optimism (OPT), Innovativeness (INN), Discomfort (DIS), and Insecurity (INS) are the core components of TRI. Optimism reflects a positive view of technology, believing it enhances control, flexibility, and efficiency in financial management (Colby & Parasuraman, 2001). As previous studies indicate, customers are more likely to adopt technology they view as empowering and flexible (Liljander et al., 2006). Individuals with a positive outlook on technology are expected to favor using it (G. Wu & Peng, 2024). Innovativeness refers to individuals acting as technology pioneers and thought leaders, crucial for early FinTech adoption (Colby & Parasuraman, 2001). Innovators experiment with new technologies and related services (Flavián et al., 2022). Those with high innovation levels are generally open minded and more likely to adopt innovations, such as mobile payments (Ramírez-Correa et al., 2020). Additionally, innovativeness influences adoption intentions; innovative consumers usually have a positive view of technological capabilities, especially when faced with uncertain potential value (Prodanova et al., 2021). Studies demonstrate that innovativeness predicts the propensity to adopt inventive technologies (G. Wu & Peng, 2024). Extensive research indicates that innovativeness positively influences technology acceptance and utilization (Ashrafi & Easmin, 2023; G. Wu & Peng, 2024), as persons with robust, innovative abilities and awareness are more inclined to adopt new technologies.

Discomfort arises from a perceived lack of control over technology and overwhelming feelings, which can impede FinTech uptake, particularly in rural areas with limited digital exposure (Colby & Parasuraman, 2001). Individuals uncomfortable with technology view it as complex and inadequate (Lu et al., 2023). Those facing significant discomfort in unfamiliar technological settings may hesitate to adopt new tech-based products and services (Flavián et al., 2022). Feelings of inadequacy in using technology can lead to rejecting new methods. People who are uncomfortable with ceding control to automated systems may be reluctant to use FinTech-based financial transactions. Insecurity involves distrust in technology and skepticism about its functionality, potentially affecting the perceived security of digital financial transactions (Colby & Parasuraman, 2001). McCloskey (2021) highlighted that security and privacy concerns are significant obstacles to technology acceptance. Dong et al. (2024) further established that insufficient security heightens apprehensions about using new technologies. C. Wu and Lim (2024) discovered that insecurity adversely impacts the adoption of new technology. Customers with high technological insecurity may avoid using such technologies (Flavián et al., 2022). Research shows that in the finance sector, apprehensive clients are likely to resist adopting technology-driven services (Caldeira et al., 2021).

Further, a study indicates that the use of new technology induces anxiety and negatively affects individuals while also hindering their acceptance of self-service technology

(Abis et al., 2024). Another investigation indicated that perceived nervousness regarding technology is inversely related (Abis et al., 2024), while technology anxiety negatively affects the time spent on modern technology (Sabir et al., 2023). The preceding discussion resulted in the formulation of the following hypotheses:

H6: *People's technology optimism significantly influences their intention to utilize FinTech.*

H7: *Users' technical innovation significantly influences their intention to use FinTech applications.*

H8: *People's discomfort with technology negatively impacts their intention to use FinTech tools.*

H9: *Users' insecurity negatively impacts their intention to use FinTech applications.*

2.2.4. Financial Inclusion (FI)

Financial inclusion is an increasingly important issue attracting global attention from financial and regulatory authorities. *Financial inclusion* can be defined as enhancing the access to and use of financial products and services for all societal segments through formal channels while addressing their needs swiftly and affordably, protecting their rights, and promoting financial literacy for informed decision-making. Numerous studies have explored the factors driving financial inclusion (Ahmad et al., 2022; Bongomin et al., 2023; Chowdhury & Chowdhury, 2024). Mobile payment utilization plays a significant role in enhancing financial inclusion, albeit requiring careful evaluation. This study examines financial inclusion through a model incorporating country-specific factors. The model consists of three components: accessibility, availability, and usage of financial services, as proposed by Sarma (Sarma, 2015). Various empirical and theoretical research has analyzed the relationship between mobile payment adoption and financial inclusion. Therefore, we have the following hypothesis:

H10: *The intention to adopt FinTech significantly and positively impacts financial inclusion.*

3. Research Methodology

This research employs the positivist paradigm, applying a clearly defined conceptual framework with explicit and direct linkages. The positivist perspective is mostly associated with the quantitative methods typically employed in the deductive process. A mixed method approach was used to analyze the data using PLS-SEM and fsQCA. PLS-SEM is a robust technique that does not strictly require normality testing like other statistical methods (J. Hair & Alamer, 2022). fsQCA is used to further validate the PLS-SEM results in the case of non-linear relations among variables. The research is carried out in the following steps:

- Step 1: Questionnaire development based on a literature review and theoretical framework;
- Step 2: Sampling processes and data collection;
- Step 3: Data pre-processing for non-response bias and common method variance test;
- Step 4: Symmetric data analysis using PLS-SEM techniques;
- Step 5: Asymmetric data analysis using the fsQCA method.

3.1. Study Instruments

A quantitative research methodology was employed, as the study relies on survey research (Bhattacharjee, 2012). The measurement items were adapted from established scales in the prior literature with minor language changes to fit the study context. Respondents rated items on a five-point Likert scale, with '1' indicating strong disagreement and '5' indicating strong agreement. Sixteen items for the Technology Readiness Index (TRI)

were adapted from (Parasuraman & Colby, 2015), ten items for the Technology Acceptance Model (TAM) (perceived usefulness and perceived ease of use) were taken from Devis (Davis, 1989), nine items for the Theory of Planned Behavior (TPB) (attitude, subjective norms, and perceived behavioral control) were adapted from Ajzen (Ajzen, 1991), three items on FinTech Adoption Intention were sourced from Bian and Moutinho (2011), and fifteen items on FinTech inclusion were derived from Sarma (Sarma, 2015).

Before administering the survey, a pilot study was conducted to improve the clarity and precision of the measurement scales (J. F. Hair et al., 2019). This study collected 30 valid responses from elderly individuals in Nagpur district, India, with Cronbach's alpha values ranging from 0.71 to 0.83. All constructs received Cronbach's alpha values above 0.7, confirming the reliability of the scale items (J. F. Hair et al., 2019). Additionally, several items were revised based on participant feedback to enhance clarity and reduce response time.

3.2. Participants and Data Collection

This study necessitated the collection of appropriate, representative data from the population to facilitate generalization and to implement a methodology consistent with the research design. A cross-sectional survey using a stratified sampling strategy was used to collect the data. Using a stratified sampling approach often improves the accuracy of statistical estimates (Creswell & Creswell, 2017). The study's sample size was established according to SEM specifications. Boomsma and Hoogland (2001) assert that a minimum sample size of 200 is essential to mitigate bias in structural equation modeling (SEM) outcomes. The minimum sample size for structural equation modeling (SEM) should be no less than ten times the free variables. A sample size of no less than 200–250 is sufficient to mitigate bias in the study results. Between March and August 2024, 1500 questionnaires were distributed to the rural residents of four states (e.g., Maharastra, Chattisgarh, Madhya Pradesh, and Odisha) from central India through social media (WhatsApp, Facebook, etc.) and in-person interactions. Before the survey, all participants were informed about the project, and their responses were guaranteed to remain confidential and utilized exclusively for research purposes. Five hundred seventy-two responses were collected, although only four hundred thirty-three were appropriate for further analysis after initial screening. An initial screening was conducted based on the following criteria: participants' bank accounts (yes), missing values, and incomplete responses.

3.3. Data Pre-Processing

In addition to utilizing several data-screening processes for missing values and outlier detection, common method variance and non-response bias tests were used to ensure data quality.

Non-Response Bias Test

Non-response bias is a major concern with data from self-administered instruments. To assess potential non-response biases, we applied an extrapolation method based on Armstrong and Overton's theory (Armstrong & Overton, 1977). We compared responses from early and late respondents to identify any mean value differences. A t-test was conducted to compare the means of the first 50 participants with those of the last 50. The results revealed no significant variation in average values ($t = 11.6, p = 0.00$). Thus, the data showed no response bias.

Common Method Variance Test

Common technique variance poses a significant challenge in cross-sectional studies (J. F. Hair et al., 2019). To address this, Podsakoff's (Podsakoff et al., 2003) strategy was used to mitigate potential common method variance in our investigation. The author

utilized the varimax rotation method to consolidate all 53 components into a single factor. After five iterations, the one-factor test yielded six factors: PEOU, PU, ATT, SN, PBC, OPT, INS, DIS, INN, FAI, and FI, explaining 41% of the total variation, which is below the 50% threshold (Harman, 1976). These results indicate an absence of common technique variance in the data.

3.4. Data Analysis Tools

The study used structural equation modeling (SEM) with a Partial Least Squares (PLS) approach to analyze existing theories and identify key determinant variables through construct projection. Data analysis was performed using R packages (pls and qca). Initially, the assumptions of multivariate normality, outliers, and missing data were assessed to ensure readiness for path analysis. The subsequent phase involved measurement model assessment. This was followed by hypothesis testing, mediation analysis, and model validation. Further, Fuzzy Set Qualitative Comparative Analysis (fsQCA) was used to tackle causal complexity and identify the optimal combination of predictors for the desired outcome. PLS-SEM shows general trends, while fsQCA uncovers multiple pathways to achieve desired levels of inventive performance. The fsQCA analysis aligns with configuration theory, enabling the exploration of complex, non-linear interactions among variables. This study employs the fsQCA method because it accommodates outcome and predictor variables on a continuous fuzzy scale. In conclusion, integrating PLS-SEM and the fuzzy sets theory's configurational approach makes a novel contribution to this research domain.

4. Results and Analysis

Various theoretical frameworks have examined the relationships among the mentioned variables. Low R^2 values from regression and PLS-SEM analyses may lead to incorrect conclusions about the extent to which different measures explain variation in dependent variables (P.-L. Wu et al., 2014). FsQCA was combined with PLS-SEM to identify multiple pathways and explore complex, non-linear interactions among variables for optimal outcomes to address these limitations. Symmetric analysis utilized PLS-SEM, while asymmetric analysis employed fsQCA. Table 1 provides the demographic profile of the participants before detailed data analysis using PLS-SEM and fsQCA. These groups are Generation X (Gen X), born 1965–1980 (≥ 42 years old now), and Generation Y (Gen Y), born 1981–1994 ($=41$ years old now) (McCrindle & Wolfinger, 2009).

Table 1. Respondents' profiles.

Variables	Labels 433	Count
Gender	Male	252
	Female	181
Education	10th and below	124
	Graduation and below	197
	Above graduation	112
Age	Gen X	182
	Gen Y	251
Income *	INR 7000 and above	265
	Below INR 7000	168

* The average income of rural India is approximately INR 7000 per month.

4.1. Symmetric Analysis

This paper employed variance-based structural equation modeling (PLS-SEM) for symmetric modeling. The first step in PLS route modeling is to assess the measurement model for internal consistency (composite reliability), convergent validity (indicator reliability and average variance extracted), and discriminant validity. The second step involves evaluating the structural model, which includes checking for the components' collinearity and assessing the proposed hypotheses' significance and relevance.

4.1.1. Descriptive Analysis

Table 2 revealed statistically significant differences in key demographic variables (gender, income, and age group) for the major dependent variables: FinTech adoption intention and financial inclusion.

Table 2. Analysis of demographic variables.

Constructs	Demographic Variables	Levels	Mean	T-Statistics (<i>p</i> -Values)
FinTech adoption intention	Gender	Male	3.89	3.78 (0.00)
		Female	3.62	
	Age	X-Gen	3.47	−4.73 (0.01)
		Y-Gen	3.76	
	Income	Below Average	3.59	−2.19 (0.00)
		Above Average	3.43	
Financial inclusion	Gender	Male	3.65	3.17 (0.03)
		Female	3.41	
	Age	X-Gen	3.52	−3.41 (0.03)
		Y-Gen	3.87	
	Income	Below Average	3.39	−1.21 (0.12)
		Above Average	3.37	

4.1.2. Measurement Model Evaluation

Table 3 presents the correlations between constructs along with the factor loadings for each item, Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) for the constructs. The values in Table 2 indicate that our data are valid and reliable at construct levels. The result includes Cronbach's alpha and composite reliability (CR) in order to assess internal consistency. Although Cronbach's alpha is less commonly used than CR in structural equation modeling, it remains a conservative measure of internal consistency (J. F. Hair et al., 2019). Values above 0.70 for both metrics signify acceptable reliability, though values exceeding 0.95 for CR are undesirable (J. F. Hair et al., 2019). In our analysis, the CR values are found to be satisfactory.

The Fornell and Larcker criterion evaluates discriminant validity by comparing the square root of each construct's average variance extracted (AVE) to its bivariate correlations with other constructs (Grégoire & Fisher, 2006). Discriminant validity is established when the square root of AVE for each construct exceeds its bivariate correlation values (Grégoire & Fisher, 2006). Table 3 shows that the square root of AVE of all the constructs exceeds the bivariate correlations with all competing constructs, confirming its discriminant validity. However, Henseler, Ringle, and Sarstedt (Henseler et al., 2015) introduced the more sensitive Heterotrait–Monotrait Ratio of Correlations (HTMT) for detecting discriminant validity. HTMT measures the mean of heterotrait–heteromethod correlations against the

mean of monotrait–heteromethod correlations (Henseler et al., 2015). An HTMT value significantly less than 1 indicates distinct constructs. The conservative HTMT_{.85} criterion requires HTMT values between constructs to be below 0.85. Table 4 suggests that all HTMT values fall below 0.85, except between PU and PEOU. The more lenient HTMT_{.90} criterion accepts acceptable values between 0.85 and 0.90 (Henseler et al., 2015). Both HTMT_{.85} and HTMT_{.90} criteria confirm discriminant validity.

Table 3. Measurement properties.

	PU	PEOU	ATT	SN	PBC	OPT	INS	DIS	INN	FAI	FI
PU	0.88										
PEOU	0.46	0.89									
ATT	0.32	0.34	0.88								
SN	0.29	0.31	0.36	0.87							
PBC	0.30	0.32	0.35	0.38	0.86						
OPT	0.28	0.27	0.31	0.32	0.31	0.88					
INS	−0.32	−0.31	−0.29	−0.28	−0.31	−0.36	0.88				
DIS	−0.25	−0.29	−0.24	−0.33	−0.28	−0.29	0.24	0.87			
INN	0.31	0.33	0.32	0.27	0.32	0.31	−0.37	−0.33	0.88		
FAI	0.47	0.43	0.39	0.37	0.41	0.39	−0.33	−0.31	0.42	0.88	
FI	0.32	0.34	0.33	0.28	0.32	0.35	−0.29	−0.30	0.33	0.44	0.88
Mean	3.89	3.92	3.67	3.58	3.41	3.51	3.29	3.19	3.45	3.67	3.71
SD	1.19	0.98	1.38	1.09	1.34	0.89	1.21	1.27	1.07	1.13	1.29
Factor Loading	0.72–0.81	0.74–0.81	0.72–0.79	0.69–0.74	0.70–0.75	0.72–0.81	0.74–0.79	0.73–0.79	0.72–0.80	0.70–0.82	0.69–0.83
Cronbach's α	0.83	0.86	0.81	0.79	0.79	0.84	0.81	0.79	0.81	0.82	0.81
AVE	0.79	0.80	0.78	0.76	0.75	0.79	0.78	0.77	0.78	0.79	0.79
CR	0.91	0.93	0.89	0.87	0.86	0.91	0.90	0.87	0.90	0.89	0.91

Note: Bold values are the mean of the squared root of AVE values.

Table 4. Heterotrait–Monotrait Ratio (HTMT).

	PU	PEOU	ATT	SN	PBC	OPT	INS	DIS	INN	FAI	FI
PU											
PEOU	0.86										
ATT	0.81	0.84									
SN	0.67	0.71	0.72								
PBC	0.71	0.77	0.79	0.81							
OPT	0.79	0.81	0.83	0.74	0.78						
INS	0.74	0.74	0.81	0.77	0.81	0.64					
DIS	0.71	0.69	0.79	0.76	0.79	0.71	0.76				
INN	0.78	0.80	0.81	0.79	0.72	0.81	0.63	0.62			
FAI	0.74	0.81	0.76	0.80	0.77	0.80	0.62	0.63	0.69		
FI	0.81	0.82	0.79	0.78	0.79	0.81	0.71	0.67	0.72	0.68	

4.1.3. Structural Model Assessment

Before hypothesis testing, it is crucial to evaluate collinearity among predictor variables (J. F. Hair et al., 2019). The variance inflation factor (VIF), which should not exceed 5, is a standard metric for collinearity assessment (J. F. Hair et al., 2019). All VIF values of the study constructs ranged from 1.78 to 3.01, indicating no collinearity among the predictors. The structural model was assessed using R^2 , beta (β), and t-value. Further, the predictive relevance (Q^2), effect sizes (f^2), and standardized root mean square (SRMR) were determined to assess the strength and prevalence of the model. The relevance and significance of the structural model links were subsequently evaluated using a bootstrapping procedure. This routine involved generating 5000 subsamples and conducting a two-tailed test using bias-corrected and accelerated bootstrapping.

Table 5 summarizes the estimation results, emphasizing the significance and magnitude of the path coefficients. All pathways, except SN→FAI, OPT→FAI, DIS→FAI, and INN→FAI, are statistically significant ($p < 0.05$), indicating that hypotheses H4, H6, H7, and H8 were not supported. Conversely, hypotheses H1, H2, H3, H5, H9, and H10 were supported. The effect sizes of the supported hypotheses, assessed using f^2 , range from medium to high, as detailed in Table 5. The model accounts for 51% of the variation in FinTech adoption intention ($R^2 = 0.51$) and 57% in financial inclusion ($R^2 = 0.57$), demonstrating moderate predictive capability (J. F. Hair et al., 2019). Henseler (Henseler et al., 2015) advised that a Standardized Root Mean Square (SRMR) value below 0.08 indicates better model adequacy. This threshold was confirmed by Cho (Cho et al., 2020) for sample sizes exceeding 100. The study result demonstrated an adequate fit with an SRMR score of 0.06.

Table 5. Hypotheses test results.

Path	Coefficient (β)	Effect Size (f^2)	Sig. (p)	R^2	SRMR
PU→FAI	0.29	0.41	0.00	0.51	0.06
PEOU→FAI	0.31	0.39	0.00		
ATT→FAI	0.35	0.29	0.02		
SN→FAI	0.06	0.09	0.12		
PBC→FAI	0.28	0.32	0.03		
OPT→FAI	0.06	0.03	0.23		
INS→FAI	−0.19	0.28	0.04		
DIS→FAI	−0.03	0.08	0.19		
INN→FAI	0.09	0.11	0.23	0.57	
FAI→FI	0.34	0.33	0.00		

The assessment of R^2 values, reflecting predictive accuracy, was complimented by calculating Stone–Geisser’s Q^2 value, H^2 , indicating predictive relevance. Wold’s blindfolding approach was used to compute the cv-communality index (H^2) and the cv-redundancy index (Q^2) for constructs and indicators (Wold, 1982). Garson (2021) states that H^2 and Q^2 values above zero validate the structural and measurement models for prediction. Table 6 shows all H^2 values exceeding 0, with a mean of 0.40, and all Q^2 values also above 0, with a mean of 0.36, indicating the measuring model’s superior quality over the structural model. Alharbi and Sohaib (2021) note that 0.02 represents a modest effect size, 0.15 is a medium effect size, and 0.35 is a large effect size. This information suggests that the proposed model has significant predictive power.

Table 6. H² and Q² indices.

Constructs	H ²	Q ²
FAI	0.39	0.36
FI	0.41	0.37
<i>Average</i>	0.40	0.36

4.2. Asymmetric Analysis

Fuzzy sets QCA (fsQCA) employs an asymmetric modeling approach that integrates fuzzy sets and logic grounded in complexity theory. This methodology is crucial as the non-linear relationships between independent and dependent variables often make correlation and beta coefficients inadequate for capturing their association. Fuzzy sets overcome this limitation by providing diverse methods that yield consistent results (Olya & Altinay, 2016; Ruffoni & Reichert, 2024). Consequently, symmetric methods like multiple regression analysis and structural equation modeling (SEM) fail to deliver accurate results in models with highly correlated independent variables (Olya & Altinay, 2016). In a symmetric framework, high values of an independent variable (X) can suggest high values of a dependent variable (Y), but they do not ensure them. In contrast, in an asymmetric relationship, high values of X are necessary and sufficient for predicting high values of Y. Therefore, examining all combinations where X influences Y positively or negatively is beneficial (Olya & Altinay, 2016). This study investigates how independent variables—PU, PEOU, ATT, SN, PCB, OPT, INS, DIS, and INN—collectively impact FinTech adoption intention.

The standardized scores from the PLS-SEM results were used as inputs for the fsQCA analysis. Rasoolimanesh (Rasoolimanesh et al., 2021) suggested calibrating these scores to a 0 to 1 range, where a score of −3 indicated no membership (0), a score of 0 represented the crossover point (0.5), and a score of 3 indicated full membership (1). A truth table was created to identify combinations of conditions that could produce the desired outcome (Sukhov et al., 2023). Rows with two cases or fewer were removed, and the analysis focused on assessing the consistency and coverage of the configurations. Configurations were selected based on having greater than 0.2 coverage and higher than 0.8 consistency (Pappas & Woodside, 2021). The fsQCA algorithm produced three outputs categorized as complicated, intermediate, and economical, with the criterion that the combination leads to the outcome consistently supporting a solution (Pappas & Woodside, 2021). This study employed the previously recommended intermediate set (Kumar et al., 2022; Rasoolimanesh et al., 2021).

The fsQCA identifies three scenarios that lead to higher FAI (Table 7). Solution 1 shows that the simultaneous presence of PEOU, PU, ATT, PBC, INS, and INN, along with the absence of OPT, can significantly increase FAI. Solution 2 indicates that PEOU, PU, ATT, and INS contribute to high FAI. Solution 3 highlights that PEOU, PU, INS, ATT, and DIS enhance the intention to adopt FinTech among individuals in rural India. Based on coverage and consistency, Solution 1 is the most effective combination for boosting FinTech adoption intent. These results align with H1, H2, H3, H5, H9, and H10. The fsQCA analysis yields valuable insights supporting and refining PLS-SEM findings.

Table 7. Significant configurations for high FinTech adoption intention.

Configurations	Solutions		
	1	2	3
PU	●	●	●
PEOU	●	●	●

Table 7. Cont.

Configurations	Solutions		
	1	2	3
ATT	●	●	●
SN			
PBC	●		
OPT	○		
INS	●	●	●
DIS			●
INN	●		
Consistency	0.942	0.941	0.936
Raw coverage	0.798	0.613	0.622
Unique coverage	0.238	0.106	0.103
Solution coverage	0.789		
Solution consistency	0.889		

Legend: “Black circles” = presence of the variable; “Hollow circles” = absence of the variable; “Blank” = not considered in the solution.

5. Discussion

In 2014, the Indian government launched the Jan Dhan Yojana (PMJDY) to improve access to financial services. Since then, research has increasingly highlighted how digital financial services boost financial inclusion and economic development, emphasizing the crucial role of FinTech in sustainable development, particularly in India. Financial inclusion is now recognized as a critical strategy for alleviating poverty, reducing income inequality, and driving economic growth (Demirgüç-Kunt et al., 2021). The rise of digital financial services, fueled by technological advancements, offers new solutions to address the financial needs of individuals (Mendoza et al., 2021). Therefore, three research questions were investigated to predict various significant enablers to increase the FinTech footfall in rural India. To address the first research question, this study utilized an integrated framework of TAM, TPB, and TRI models to identify key factors, i.e., technological, psychological, and socio-cultural factors influencing FinTech adoption and its effects on financial inclusion among rural populations in India. The framework was empirically tested using a mixed methods approach, incorporating symmetric (PLS-SEM) and asymmetric (fsQCA) techniques. This approach addressed the limitations of commonly used methods like PLS-SEM. While SEM focuses on comparing alternative models rather than assessing effect size within each model (J. F. Hair et al., 2019), it captured path coefficients but did not identify indirect effects. Additionally, both methods failed to account for variability in causal conditions leading to similar outcomes (Tóth et al., 2015). Therefore, this study employed fuzzy set qualitative comparative analysis (fsQCA) to identify causal factors, circumventing the limitations of quantitative methods like PLS-SEM.

The findings reveal a significant correlation between various characteristics and rural Indians' inclination to adopt FinTech. Among the variables in the Theory of Planned Behavior, attitude is the key factor influencing the intention to adopt FinTech among rural respondents in India (hypothesis 3). This aligns with previous research emphasizing the importance of user attitudes toward FinTech services (Setiawan et al., 2024). Additionally, the COVID-19 pandemic has notably impacted individuals' decisions to adopt FinTech due to increased familiarity with digital technology, contrasting with studies conducted

before the pandemic (Shareef et al., 2018). Furthermore, consistent with our findings, prior research indicates that perceived behavioral control (PBC) also significantly and positively influences users' intentions to adopt FinTech (Setiawan et al., 2024).

The perceived ease of use (PEOU), a Technology Acceptance Model (TAM) component, positively influences consumers' intentions to adopt FinTech, promoting the use of digital financial technologies (hypothesis 2). Research shows that users favor eco-friendly FinTech solutions that are simple and user-friendly (Q. Ali et al., 2021). Technology with a low learning curve and minimal effort boosts perceived ease of adoption (Q. Ali et al., 2021; Davis, 1989; Kamal et al., 2020; Paganin et al., 2023). These findings suggest that banks and FinTech providers focusing on user-friendly, sustainable technology will likely see higher adoption rates and enhanced financial inclusion in rural India. Similarly, perceived usefulness (PU) significantly impacts the likelihood of adopting FinTech services, corroborating earlier studies (hypothesis 1). This result is supported by various past studies (Kamal et al., 2020; Paganin et al., 2023; Rafique et al., 2024). Consumers are drawn to these technologies for their perceived benefits, such as environmental protection and sustainability. Innovations aligning with ecological values and demonstrating benefits in resource conservation increasingly resonate with a societal shift toward sustainability (M. Ali et al., 2021; Davis, 1989; Kamal et al., 2020; Paganin et al., 2023).

Insecurity regarding the utilization of FinTech services adversely affects the propensity to adopt them (Radnan & Purba, 2016). It reflects a lack of trust in emerging technologies, including worries about accuracy and harmful effects. The study found that insecurity (INS) was the only TRI dimension significantly and negatively impacted individuals' willingness to adopt FinTech (hypothesis 9). Increased exposure to FinTech technologies appears to boost adoption as users gain confidence in the technology's functionality and experience reduced concerns about adverse effects (hypothesis 10). Previous research supports these findings (Haddad et al., 2020; Hasheem et al., 2022; O'Hern & Louis, 2023). Khadka and Kohsuwan (2018), observing that security and privacy concerns hinder technology adoption, while Pham et al. (2020) found that inadequate security increases anxieties about new technologies. All the aforementioned findings contribute to addressing the second research question.

These findings are especially pertinent to India, considering the nation's commitment to sustainability as articulated in Vision 2030. The country confronts distinct environmental issues, including water scarcity and increasing energy usage, and is implementing green IT solutions to achieve its sustainability objectives. Economic factors such as resource efficiency and cost reduction are crucial in India, making these insights indispensable. India can advance green IT by shaping user views and using sustainability trends. Furthermore, they enhance technology while decreasing expenses associated with environmentally detrimental activities (Alqublan, 2021).

6. Conclusions

This study highlights the transformative potential of financial technology (FinTech) in promoting financial inclusion in rural India, thoroughly examining the key factors influencing its adoption to advance the sustainable development goals (SDGs). Utilizing the Technology Acceptance Model (TAM), Theory of Planned Behavior (TPB), and Technology Readiness Index (TRI), it demonstrates the significance of attitude, perceived behavioral control, and perceived insecurity in shaping individuals' intentions to use FinTech. The mixed methods approach, employing both PLS-SEM and fsQCA, enhances and broadens the theoretical framework, clarifying the complex factors affecting adoption in rural areas. The findings provide policymakers and FinTech providers with actionable insights for improving digital literacy, strengthening infrastructure, and tailoring services to meet the

specific needs of rural communities. The study's findings also support the achievement of SDGs by illustrating how FinTech adoption fosters financial inclusion, economic empowerment, and reduced inequalities in rural India. By implementing targeted interventions and promoting collaboration, FinTech can effectively bridge the financial inclusion gap and support the obtainment of sustainable development goals in emerging economies. The following subsections discuss the contributions of the research findings to address the third research question.

6.1. Theoretical Contribution

Our research contributes significantly to the literature on financial inclusion and FinTech adoption among rural populations in India. This study is among the first to explore the key factors influencing the intention to adopt FinTech and enhance financial inclusion. By integrating the Technology Acceptance Model (TAM), Theory of Planned Behavior (TPB), and Technology Readiness Index (TRI), we create a comprehensive theoretical framework for analyzing FinTech uptake in rural, less technologically advanced communities. This work contributes to knowledge by achieving a prediction accuracy of 57.4%, surpassing the frequently utilized TAM, which typically explains between 32% and 53% of the variance (Liébana-Cabanillas et al., 2021). This synthesis elucidates the interactions between social influences, attitudes, and technological readiness, making it applicable to other disadvantaged areas facing similar digital adoption challenges. Additionally, our research advances the discourse on FinTech's role in sustainable development by linking technology adoption to financial inclusion and highlighting technological acceptability as a catalyst for economic empowerment aligned with sustainable development goals (SDGs). This connects adoption theories with sustainability literature, demonstrating FinTech's potential as a transformative tool for financial inclusion. We emphasize the value of mixed methods approaches, including PLS-SEM and fsQCA, for the robust validation of theoretical models, providing nuanced insights into the complex interactions influencing technology adoption that single method approaches might overlook.

6.2. Practical Implications

This study offers practical recommendations for policymakers, FinTech companies, and government agencies seeking to enhance financial inclusion in rural India. Since perceived usefulness and attitude are crucial for FinTech adoption, targeted digital literacy initiatives should highlight benefits such as transaction simplicity, financial security, and time efficiency. This approach can shift rural perceptions, fostering a more positive view of digital financial services. Both government and private sectors must prioritize improving digital infrastructure, including internet connectivity and mobile networks in remote areas. Furthermore, stakeholders must enhance user interfaces to assist individuals with limited digital literacy by incorporating regional languages, voice navigation, and visual elements. Enhanced access to digital tools will reduce perceived behavioral control barriers, encouraging broader FinTech adoption. Additionally, banks and other stakeholders should focus on developing microfinance solutions that offer flexible repayment options aligned with the seasonal income patterns observed in rural India. Incorporating digital literacy modules into rural development initiatives such as the Pradhan Mantri Gramin Digital Saksharta Abhiyan (PMGDISHA) also can help to boost financial inclusion in rural India. The insecurity associated with digital services, as highlighted by the Technology Readiness Index (TRI), emphasizes the need for strong data protection policies, user-friendly platforms, and transparent financial products. FinTech providers must focus on these aspects to build trust and confidence among rural users, ensuring secure transactions. Given rural residents' varying readiness levels and financial needs, FinTech companies should tailor their

services accordingly. Collaboration among the public sector, private FinTech providers, and community organizations is crucial for achieving sustainable financial inclusion. Such partnerships will improve service implementation, increase accessibility, and foster trust within rural communities, ultimately narrowing the financial inclusion gap. In conclusion, a combination of governmental support, user-centric service design, and robust community participation can facilitate the closure of the rural financial divide and advance India's sustainable economic development.

6.3. Limitations and Future Directions

This study provides valuable insights into the acceptance and use of FinTech services for financial inclusion among India's rural population, but it has limitations. The sample primarily comes from India, and while rural populations often show similar technological adoption patterns, the study fails to account for cultural and socioeconomic differences in Western countries, affecting the generalizability of the findings. Future research should explore ways to adapt these models to better meet rural people's needs and align with the Indian cultural context, including the impact of cultural values on technology acceptance. Additionally, incorporating factors like self-efficacy, perceived risk, and health anxiety may enhance understanding of the predictors of FinTech adoption. Future investigations should take into account variables such as socioeconomic status and education level to explore their influence on financial inclusion. Furthermore, expanding the sample size through cross-cultural comparisons or longitudinal designs, including rural peoples from diverse backgrounds, would improve the generalizability and relevance of the results.

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Article

Financial Literacy and Behavioral Intention to Use Central Banks' Digital Currency: Moderating Role of Trust

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Abstract: Building on the Innovation Diffusion Theory, this study proposes and explores the influence of financial literacy on the behavioral intention to use central banks' digital currency (CBDC) and the moderating role of trust of respondents in the financial institution on the above relationship. This study has employed a quantitative research design to examine the relationship between financial literacy, behavioral intention to use CBDC and trust. The final sample comprised 241 respondents who had used CBDC across India. The statistical relationship between the above variables was assessed using PROCESS macro in SPSS 23.0. Findings revealed that financial literacy emerges as a strong predictor of CBDC use. Individuals with higher financial literacy are more likely to understand the features, benefits and risks associated with adopting CBDC. The interaction effect reveals that as financial literacy increases, the relative importance of trust diminishes. On the other hand, those who lack sufficient knowledge of financial literacy depend more on trust to fill in their knowledge gaps. This is one of the first studies to scientifically support the relationship between trust and financial literacy and how both influence behavioral intention to use CBDC. This research contributes valuable knowledge to the discourse on the use of CBDC, which is crucial for achieving a nation's broader digital transformational goal.

Keywords: financial literacy; central banks' digital currency; CBDC; behavioral intention; trust; digital payment

1. Introduction

The concept of money has changed overtime (Moore, 2023). Earlier communities used the barter system, in which they directly traded products and services, to create money (Peneder, 2022). This led to the adoption of commodity money, which included shells, animals, grains and eventually metals. Because physical currency wears out and needs to be replaced on a regular basis, using it is costly and requires significant investment in labor and anti-counterfeiting equipments (Adamu Ahmed et al., 2022). Businesses and banks invest a lot of money in security measures to thwart theft and robbery, as well as cash handling services including sorting, counting and reconciling transactions. The cost of printing currency varies significantly across countries, depending on the volume of currency required, complexity of security features and materials used (Bindseil et al., 2021). In the United States, the Bureau of Engraving and Printing (BEP) spends approximately \$1 billion annually to produce banknotes. Further, depending on the denomination, approximately 5 to 14 cents are incurred to print each note.

The Reserve Bank of India (RBI) annually incurs approximately \$500 million on printing new notes (Tagat et al., 2024). Countries invest heavily in advanced security features to

prevent counterfeiting, further increasing their printing expenses (Butticè et al., 2020) The per capita currency availability was ₹23,000 as of 2023 (Eichengreen et al., 2022). The late 20th and early 21st centuries saw an era of digital banking, with the widespread adoption of online banking, mobile banking apps and contactless payment systems (Wewege et al., 2020). These technological innovations have reshaped the way currency is handled, making transactions faster, more efficient and more secure than ever. As electronic banking systems began to proliferate, central banks explored the potential benefits of issuing digital versions of their fiat currencies (Dow, 2019).

The Bank of International Settlements report revealed that 86 percent of central banks around the globe are actively researching the potential for issuing and using CBDC, 60 percent are experimenting with the usage of technology in using CBDC and 14 percent are deploying pilot projects (Egyir Biney, 2024). CBDC can be broadly divided into two categories, wholesale CBDC and retail CBDC. In wholesale CBDC, it facilitates interbank settlements, cross-border remittances and settlements in capital and security markets. This allows the central bank to retain its control over the underlying CBDC network. A retail CBDC can be a direct issuance, hybrid issuance or indirect issuance. Banks handle retail transactions whereas the central bank handles wholesale transactions (Priyadarshini & Kar, 2021). The CBDC can also be used as ‘helicopter money’, which aids in emergencies. Another major benefit of using CBDC is offline payment, which is based on near-field communication (NFC) technology. Locations with weak networks will be highly secure and an easy solution for performing peer-to-peer transactions (Eichengreen et al., 2022). Even though the adoption and usage of CBDCs have more gains, they are not free from pain while them. Cyber hacks leading to server blockages, unforced timeouts, service declines or cyber threats including distributed denial of service may disrupt services (Pachare et al., 2023).

India boasts of over 750 million smartphone users, a number that has continued to grow rapidly due to affordable devices and data plans (Rana et al., 2023). Despite this technological penetration, approximately 190 million adults remain unbanked (Sinha & Piedra, 2021). This discrepancy highlights the potential of mobile technology to bridge the financial inclusion gap (Falaiye et al., 2024). However, barriers remain, including digital literacy, financial literacy and internet connectivity in rural areas. CBDC not only caters to the requirements of tech-savvy youth but also serves the needs of featured phone users from lower socio-economic groups within the country (Pachare et al., 2023). The usage of central bank digital currencies is gaining global attention, yet its success depends on individual’s behavioral intentions to use it in the day-to-day life of a common man. Further CBDC was introduced in India only by December 2022, making it relatively a new financial instrument. Despite the increasing push for digital currencies globally, there is a lack of research exploring the interplay between financial literacy and trust in determining behavioral intention to use CBDCs in developing nations like India. This study seeks to address this gap by investigating how financial literacy impacts individuals willingness to use CBDC. Further, we examine the moderating role of trust and whether they affect the relationship between financial literacy and end users’ behavioral intention towards using CBDC. Understanding the influence of the above variables is essential for policy makers, financial institutions and central banks to develop effective educational programs and trust-building strategies that enhance the use of CBDC.

Thus, this study examines the impact of financial literacy on the intention to use CBDC transactions.

1.1. Theoretical Framework and Hypothesis Development

This study is based on Innovation Diffusion Theory (IDT). The usage patterns of innovative ideas, products and technologies spread within a population or social system over time (Miller, 2015). In this study, we place financial literacy as Financial Innovation as enabler of the usage of central banks' digital currency (CBDC). Individuals with high exposure to financial literacy are more likely to understand the benefits, risks and other operational aspects of using CBDC, which in turn increases their behavioral intention to adopt this new technology. Trust plays a moderating role as individuals perceive the credibility and security of digital innovation, thus enhancing the diffusion of CBDC in society among those with higher financial awareness. financial literacy and trust fosters the smoother diffusion of CBDC.

1.2. Financial Literacy and Behavioral Intention to Adopt CBDC

The term financial literacy emerged during the late 20th century, gaining momentum as a response to increasing financial complexity and the need for individuals to make informed financial decisions (Goyal & Kumar, 2021). Financial literacy refers to an individual's ability to understand financial concepts and apply them in everyday decisions related to money (Lučić et al., 2023). When an individual is financially literate, they are better equipped to budget and manage their income and expenses, which can lead to improved financial stability and reduced financial stress (Andarsari & Ningtyas, 2019). A study by (Gomes et al., 2021), revealed that financial literacy enables an individual to be a more cautious consumer, capable of comparing financial products and services to secure better deals and avoid unnecessary fees. They can plan for emergencies and unexpected expenses, creating a safety net that provides peace of mind and resilience against financial setbacks. Financial literacy plays a vital role in understanding the concept of central banks' digital currency and how it is issued, stored and transacted (Narayanan, 2020). This enables individuals to assess numerous factors such as transaction costs, security features and other privacy concerns when transferring funds, making purchases or withdrawing money is exposed to significant risks in the digital financial ecosystem, necessitating the crucial role of financial literacy (Lusardi & Messy, 2023). Individuals who lack sufficient financial literacy may fall as a victim or hesitate to use CBDC, limiting the overall usage of CBDC for day-to-day life transactions. Such kind of detailed evaluation empowers individuals to make informed decisions about whether to use CBDCs for their transactions and savings (Fernández-Villaverde et al., 2021). A recent study in revealed that digital financial literacy positively influences the financial Decision-Making of Women in India (Mishra et al., 2024). Financial literacy fosters awareness of the regulatory environment surrounding CBDCs. This knowledge enhances their confidence in adopting CBDCs within a regulated framework, thus ensuring compliance with financial laws and regulations. It promotes responsible financial behavior when using CBDCs as they tend to be better equipped to manage their CBDC wallets securely, protect their digital assets from fraud and cyber threats and navigate potential risks associated with digital currencies. Financial literacy plays a crucial role in helping individuals understand, evaluate and adopt central bank digital currencies (Naveenan et al., 2024). It enables individuals to comprehend the concept, technical aspects, implications and regulatory environment of CBDCs, empowering them to make informed decisions and using digital currencies responsibly. As central banks continue to explore and develop CBDCs, financial literacy will remain essential in ensuring that individuals can effectively participate and benefit from the evolving digital economy. However, according to a National Centre for Financial Education (NCFE) only 27% of the Indian population is financially literate (2023–2024). Making it even more crucial to be studied in India scenario.

At the same time, the complexity of CBDC may deter its adoption, especially among individuals with lower financial literacy (Shkliar, 2020). At the same time the complexity of CBDC such as understanding digital wallets, encryption and how transactions are processed on a block chain-based system may deter adoption, especially among individuals with lower financial literacy (Narula et al., 2023). Individuals with higher financial literacy may already be familiar with digital payment systems such as mobile banking and UPI payments, because adopting CBDC is a natural progression in the digitalization of financial services (Kumar & Gupta, 2024; Mahesh et al., 2024). Financial literacy enhances this sense of compatibility, further strengthening the intention to use CBDC. CBDC refers to the ability to experiment with an innovation before making full commitment, while observability refers to the visibility of the innovation's benefits to others. Based on the above discussion we hypothesize that financial literacy positively influences the behavioral intention to use CBDC.

H1. *Financial literacy positively influences the behavioral intention to use CBDC.*

1.3. The Moderating Role of Trust

The trust refers to belief or confidence in the reliability, integrity and abilities of an individual, organization or system (Colquitt & Baer, 2023). In the financial market, the lack of awareness and trust in financial institutions among individuals play a crucial role in the usage of financial instruments and trade. A recent study examined that positive attitude and confidence when combined with financial literacy, empowers individual investors with the knowledge and skills for appropriate financial decision-making (Maheshwari et al., 2025). Trust plays a significant role in personal relationships, business transactions and social interactions of an individual as it facilitates cooperation, reduces uncertainty and fosters a sense of security and mutual respect (Schilke et al., 2021). In alignment with IDT, this suggests that innovations are more likely to be adopted when they are perceived as more dependable and trustworthy. Individuals with higher financial literacy are more capable of critically evaluating the security features of CBDC in terms of encryption and the role of central banks in digital currency management (Amarta & Latifah, 2023). Trust as a moderator of individuals' financial knowledge, enhances their behavioral intention to use CBDC (Tronnier et al., 2022). Trust also mitigates the perceived risks and uncertainties associated with the adoption of CBDC in integrating it into daily life (Mazambani, 2024). Trust in financial institutions has been established to impact crucial individual financial markers, like risk-seeking attitudes of clients in the digitalization of microfinance (Sajan & Joseph, 2024). In the financial trade context, trust is of vital concern and encompasses various dimensions including trust in the issuing authority, the technology underlying the digital currency and the overall financial system (Zhang et al., 2021). S. Gupta et al. (2023) revealed that when users trust that technology is secure, dependable and will perform as expected their intention to adopt and use of CBDC increases. (Sutton-Lalani et al., 2023; Sugio, 2022) revealed that testimonials, reviews and word-of-mouth recommendations build large amounts of social proof and encourage wider use of CBDC. Various researchers (Kaur et al., 2024; Bijlsma et al., 2024) have examined trust as a predictor of an individual's willingness to adopt CBDC, and less attention has been paid to the relationship between financial literacy and the intention to use CBDC in their day-to-day life. Further, in their study Adil et al. (2023) emphasized that financial institutions should promote trust and trusting behavior in financial institutions as it is vital from the perspective of financial development and also to empower the individuals to gain from institutional services as well as to guard them, from possible negative effects (like financial frauds), which are more likely to be present outside of regulatory boundaries. Thus, the trust in financial institutions plays a crucial role alongside financial literacy. Based on these discussions we propose the following,

H2. *Trust moderates the positive relationship between financial literacy and behavior intention to use CBDC, such that the relationship is stronger when trust is high.*

Based on the propositions theoretical model was framed as depicted in Figure 1.

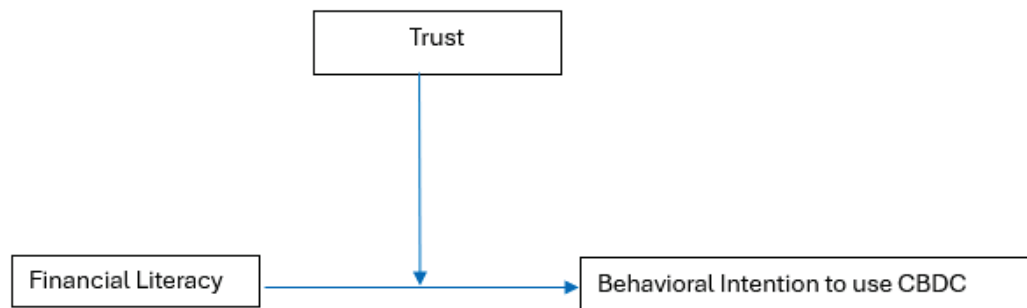


Figure 1. Proposed Moderated Model.

1.4. Behavioral Intention to Use CBDC

Behavioral intention refers to an individual's subjective probability of engaging in a specific behavior Bai (2020). Behavioral intention remains the key predictor, and the stronger the intention to engage in a behavior, the more likely it is that an individual will perform the actual behavior (Singh & Srivastava, 2020). Behavioral intention is influenced by several factors and when individuals believe that CBDC will enhance their financial transactions by faster payments, execute transactions at lower costs and ensure greater security, their 'behavioral intention to use CBDC strengthens (S. Gupta et al., 2023). Various studies (Chee et al., 2024). Liu et al. (2024) have used perceived ease of use, ease of use, attitude, social influence and trust as predictor of behavioral intention to use CBDC, but less consideration has been to assessing the relationship between the predictors of behavioral intention.

2. Methods

2.1. Participants and Procedure

The main objective of this study is to investigate the link between financial literacy and behavioral intention to use CBDC. The study also examines how trust moderates the relationship between financial literacy and behavioral intention to use CBDC among the public. The population of the study comprises all those who are aware of CBDC and are willing to use CBDC. An online survey was carried out using google forms across social media to collect data. Convenience sampling was used for this study. Participants in this study were assured of the strict confidentiality of the data for academic usage and anonymity of their responses. To ensure that respondents were aware of CBDC, we used a pre-screening filter question 'Are you aware of Central Bank's Digital Currency' to confirm respondents familiarity with CBDC, ensuring that those who had read about, discussed or used CBDC were included. Originally, the instrument was shared to 900 respondents, out of which we were able to get replies from 248. Among the 248 respondents screened, 7 were cast off due to incomplete responses, resulting in a sample size of 241 respondents for this study.

2.2. Measures

The study employed a multi-item scale to measure three key constructs: financial literacy, trust and behavioral intention using a 5-point Likert scale from 1 to 5; 1 = strongly disagree and 5 = strongly agree. Financial literacy was assessed using items related to understanding the purpose of the CBDC, its purchase methods and security measures.

Trust was measured by items assessing the perceived trustworthiness and reliability of the CBDC mobile application and the assurance provided by the legal and technological structures. behavioral intention was evaluated based on the respondents' willingness and intention to accept and use CBDC for various transactions. (Table 1) shows the items adapted from previous research and designed to capture the study variables.

Table 1. Measures of the study variables.

Dimensions	Items	References
Financial Literacy	I know about the purpose of using CBDC.	(Ravikumar et al., 2022)
	CBDC tokens can be purchased through mobile application.	
	I know how to protect myself from risk such as phishing, spyware and other risks while using CBDC transaction.	
	I never share username, password or PIN with anyone.	
Trust	The CBDC mobile application is trustworthy.	(Belanche et al., 2012; Mehrabian et al., 2024)
	The CBDC mobile application is honest and truthful.	
	The CBDC mobile application can be trusted.	
	I feel assured that legal and technological structures adequately protect me from problems on the internet.	
Behavioral Intention	I am willing to accept CBDC payment in my day-to-day consumption.	(Jariyapan et al., 2022)
	I plan to accept CBDC payment for all product purchases in my daily life.	
	I intend to use CBDC payment for all product purchases in the future.	
	I am willing to use CBDC as a means of payment for all my purchases in the future.	

2.3. Data Analysis

Hypothesis formulation and mediation analysis were performed based on the methodological recommendations of Hayes 2008. Warp PLS was used to conduct confirmatory factor analysis (CFA), examining measurement model and validity of the adopted study measures. This confirms the discriminant and convergent validity of the instrument items. Subsequently, using the PROCESS macro in SPSS 23.0. With five thousand bootstrapped samples following Preacher and Hayes (2008), the structural equation model (SEM) was used to test the hypothesized moderation model. Of the 241 respondents, 38 were female and 203 were male. Also, 43% of respondents were between the age group of 21 and 30 years, 35% of respondents were between 31 and 40 years, 13% were between 31 and 40 years, 8% were between 51 and 60 years and 1% were above the age of 60 years. Further analysis was conducted in two stages. In the first stage, Harmon's single-factor test was applied to check for common method bias. Initial descriptive tests were conducted using SPSS software. The reliability and validity of the scales were confirmed. The reliability of the scales was assessed using Cronbach's alpha values. In the second stage of the study, the hypotheses were assessed using structural equation modeling using warp-PLS. The moderation effects were assessed using SPSS Macro-Hayes Model Template 1.

2.3.1. Analysis and Results

The fit of the proposed model depicted in Figure 1 was tested using warp-PLS v.6.0 statistical software (Kock, 2015). Each of the constructs such as financial literacy, behavioral intention to use CBDC and trust are represented by latent factors and each of the latent factors was assessed using specific scale items. The fit indices are provided in Table 2, which shows the fit of the acceptance model. The mean, standard deviation and correlations (Table 2) indicated a reliable correlation between the variables under study. Convergent and discriminant validity were assessed using average extracted variance (AVE) and maximum shared variance (MSV), which were found to be above threshold levels and approve validity and reliability tests for the measures (Table 3). The reliability of the constructs (Cronbach values) was above the accepted threshold (financial literacy 0.817, trust 0.829, behavioral intention to use CBDC 0.917).

Table 2. Model Fitness.

Fit Index	Value	Threshold Limit
Average path coefficient (APC)	0.290	$p < 0.001$
Average R-squared (ARS)	0.281	$p < 0.001$
Average adjusted R-squared (AARS)	1.122	$p < 0.001$
Average block VIF (AVIF)	1.624	acceptable if ≤ 5 , ideally ≤ 3.3
Average full collinearity VIF (AFVIF)	1.683	acceptable if ≤ 5 , ideally ≤ 3.3
Tenenhaus GoF (GoF)	0.445	small ≥ 0.1 , medium ≥ 0.25 , large ≥ 0.36
Simpson's paradox ratio (SPR)	1.000	acceptable if ≥ 0.7 , ideally = 1
R-squared contribution ratio (RSCR)	1.000	acceptable if ≥ 0.9 , ideally = 1
Statistical suppression ratio (SSR)	1.000	acceptable if ≥ 0.7
Nonlinear bivariate causality direction ratio (NLBCDR)	1.000	acceptable if ≥ 0.7

Table 3. Correlation Table.

	1	2	3	4	5	Mean	SD
1. Age	1					1.93	0.99
2. Gender	−0.163 *	1				NA	NA
3. Financial Literacy	0.134 *	0.042	1			3.76	0.72
4. Trust	0.038	−0.008	0.159 *	1		15.35	3.03
5. Behavioral Intention	0.038	−0.008	0.159 *	1.000 **	1	15.35	3.04

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed); NA—Not Applicable

2.3.2. Test of the Measurement Model

Each of the constructs, such as financial literacy, trust and behavioral intention, are represented by latent factors. Each latent factor was assessed using specific scale items. Fit indices are provided in Table 2, which permits an acceptable fit value for the model.

The mean, standard deviation and correlations (Table 3) indicated a reliable correlation between the variables under study. Convergent and discriminant validity were assessed using average extracted variance (AVE) and maximum shared variance (MSV) which were found to be above threshold levels and approves validity and reliability tests for the measures (Table 4).

Table 4. Convergent and Discriminant Validity of measures.

Constructs	Type	CR	Cronbach	AVE	VIF
1. Trust	Reflective	0.829	0.724	0.549	2.133
2. Financial Literacy	Reflective	0.817	0.7	0.53	1.276
3. Behavioral Intention	Reflective	0.917	0.879	0.734	1.834

The first step in structural equational modeling is to assess the measurement model, which includes the evaluation of construct reliability, indicator reliability, convergent validity and discriminant validity of the outlined constructs. Construct reliability was determined using composite reliability (CR) and Cronbach's alpha (CA) the criterion is that the CR value should exceed 0.07 (Nunnally, 1978) to indicate the adequate reliability of the construct. The measurement model results, as tabulated in Table 4 showed that the CR values obtained for the present study were greater than 0.8, thus confirming adequate construct reliability. The reliability of the next indicator was assessed using Cronbach's alpha, in which CA values must be higher than 0.7. As a result, the CA for all factors was acceptable. The convergent Validity of the constructs for this study was verified using Average Variance Explained (AVE), which should exceed 0.50. As the result revealed that all constructs had substantial AVE, the convergent validity of constructs for this study was verified. Detecting multicollinearity using Variance Inflation Factors (VIFs), a VIF measures the extent to which multicollinearity has increased the variance of an estimated coefficient. The general rule of thumb is that VIF value exceeding 4.00 corresponds to tolerance value of 0.25, which is taken as $1/0.25 = 4$. The VIF value of 10.00 corresponds to the tolerance value of 0.10 ($1/0.10 = 10$), these indicate the signs of serious multicollinearity required correction (Hair et al., 1995). Based on the test of multicollinearity diagnostics, all the VIF values listed in Table 4 are below the common threshold value of 5, which indicates that multicollinearity is not a significant concern for these constructs in the identified model. The VIF values suggest that the predictor variables are moderately correlated but are not a major issue in the regression analysis. The CA, CR, AVE and VIF values are listed in Table 4.

2.3.3. Hypothesis Testing

To assess the existence of a direct effect between financial literacy and behavior intention to use CBDC path analysis was conducted using Warp PLS. Direct effects were assessed using structural model. The study found a significant positive effect of financial literacy on the behavioral intention to use CBDC. Hypothesis 1 was accepted. Next, to assess the moderating role of trust in Hypothesis 2, the PROCESS method (Preacher & Hayes, 2008) was used to deduce the presence of indirect effect if present. The bootstrapping procedure was followed with approximately five thousand samples to obtain a 95% confidence interval (CI) with indirect effect estimates. The codes for moderation analysis were captured from the SPSS—Hayes Macro output, and graphical representation were created using MS Excel. Lastly, regarding the moderating hypothesis, H2, the indirect outcome of financial literacy on the behavioral intention to use CBDC was significant for OBSE (beta = 0.333 **), and the positive moderating role of trust is represented in Figure 2. Table 5 depicts the interaction effect of financial literacy on the behavioral intention to use CBDC. The direct effect of financial literacy on the behavioral intention to use CBDC in the presence of trust as well interaction (moderation effect) effect is evident from the tables.

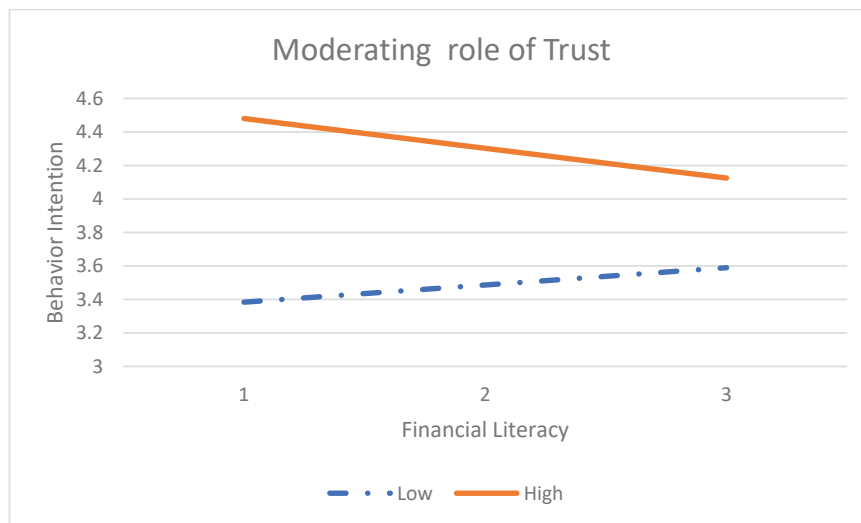


Figure 2. Interaction between trust and financial literacy on behavioral intention to use CBDC.

Table 5. Interaction between Trust and Financial Literacy on Behavioral Intention to use CBDC.

Predictor	Beta	SE	t	p	LLCI	ULCI
Constant	−3.6217	1.0198	−3.5515	0.0005	−5.6307	−1.6128
Financial Literacy	1.2634	0.3128	4.0385	0.0001	0.6471	1.8797
Trust	1.9554	0.2489	7.8569	0.0001	1.4651	2.4457
Financial Literacy × Trust	−0.3335	0.0746	−4.4717	0.0001	−0.4804	−0.1866

Dependent variable: behavioral intention to use CBDC.

In the estimation of SEM using Warp PLS, the results were assessed using the outer and inner models, which were assessed using a linearity test based on the RRT—Ramsey RESET test to determine the relationship between two linear latent variables. Based on the results in Table 2 with an α value of 0.05, the relationship between financial literacy and trust, trust and behavioral intention to use CBDC was found to be significant, whereas there was no linear relationship between financial literacy and behavioral relationships

3. Discussion

The main purpose of this paper was first to look whether financial literacy has an optimistic effect on the behavioral intention to use CBDC, and the second one was to look at whether trust has a positive effect on the above-mentioned relationship. The results revealed sufficient support for H1 (financial literacy has a positive impact on the behavioral intention to use CBDC) and the moderating hypothesis put forward was also accepted. Interpreting trust moderated the relationship between financial literacy and behavior with the intention to use CBDC. The results of the study are in accordance with (S. Gupta et al., 2023). Our findings align with Innovation Diffusion Theory, which posits that a more informed and educated population is more likely to adopt innovative financial technologies. Financial literacy emerged as a significant predictor with a beta of 1.2634 indicating a positive relationship with the intention to use CBDC. Conversely, individuals with lower financial literacy may depend more on trust to drive their intention to adopt CBDC. This interaction effect highlights the complexity of the adoption process, suggesting that educational initiatives to increase financial literacy could be beneficial in fostering trust and intention to use CBDC.

3.1. Theoretical Implications

This study investigates the role of financial literacy on behavioral intention to use CBDC from the perspective of innovation diffusion theory. The major factors that reflect the usage of CBDC are awareness and knowledge about the usage of financial products and services in combination with the application of technology. This study is the first to investigate the impact of financial literacy on behavioral intention to use CBDC. This study is significant because of the unique economic landscape with large, diverse populations with varying levels of financial literacy, from urban, tech savvy individuals to rural populations with limited access to financial education. Trust is equally significant, where the adoption of digital payment has surged, but concerns about data security and privacy remain high. Trust-building initiatives are essential to drive the adoption of CBDC ensuring the participation of both financially literate and less literate populations and fostering a smoother transition to digital currency adoption.

3.2. Practical Implications

The practical implications of studying financial literacy, trust and their interaction on the behavioral intention to adopt central banks' digital currency are multifaceted. financial literacy plays a pivotal role in the innovation process in a country with has diverse population and significant disparities in education levels and access to financial information. Practical implications for policy makers and financial institutions include developing widespread, accessible educational programs on digital currencies that can be incorporated into existing financial inclusion programs, such as Pradhan Mantri Jan Dhan Yojana (PMJDY, 2014) Pradhan Mantri Mudra Yojana (PMMY), Atal Pension Yojana (APY, 2015) and Digital Payment Initiatives, India Post Payments Bank (IPPB, 2018) especially unbanked rural population that may lack access to traditional banking services. Trust is a fundamental element in reducing uncertainty regarding innovative technologies. Building trust becomes even more crucial in CBDC, which involves managing sensitive financial data and requires confidence in digital infrastructure. More transparent communication about the safety, security and privacy of CBDC transactions is essential by expanding the internet and mobile connectivity, especially in rural areas as any system failures or security breaches could severely undermine trust. Providing robust customer support to manage concerns and technical issues will reduce barriers to use, especially for first time users who are unfamiliar with digital currencies.

The interaction effect between financial literacy and trust, reinforces the notion that adoption is non linear. The negative interaction observed between financial literacy and trust suggests that as financial literacy increases the relative importance of trust diminishes. This highlights that trust-building efforts may need to be more intensive for those with lower levels of financial literacy, who may sometimes rely more on institutional trust to compensate for their lacunae in knowledge about financial literacy. On the other hand, individuals with higher financial literacy might require less focus on trust building but more emphasis on technical features. Early users with their experience can serve as role models or informal educators for their communities, contributing to the diffusion of CBDC (M. Gupta et al., 2023). This user-centered approach not only enhances the trust and literacy around CBDC but also the system based on real world needs and concerns, further accelerating its widespread usage and reach of the specific needs of different population segments.

3.3. Limitations and Future Research

Future research could explore the role of digital literacy alongside financial literacy could provide further insights, as digital platforms have become increasingly integrated into financial services. Longitudinal studies could track changes in public perception and

behavioral intention over time as public awareness increases and CBDC infrastructure also developed. Cross-cultural studies that compare the adoption of CBDC with other countries with similar or contrasting economic and technological landscapes could provide valuable insights into CBDC. Further investigations regarding the impact of various trust-building mechanisms such as government policies, regulatory frameworks on enhancing financial literacy and trust in CBDC can be attempted. Another perspective is to understand how to mitigate risks related to privacy, cybersecurity and fraud, which can also offer useful insights for building trust and the adoption of CBDC. Finally, investigating the role of CBDC in promoting financial inclusion, particularly for marginalized or underserved populations, can provide insights for more inclusive policy development. The research areas mentioned above are critical for supporting the successful transition and usage of CBDC.

4. Conclusions

In conclusion, our study and model provide critical insights for ensuring a successful and inclusive update of CBDC. Trust in financial institutions and central banks' digital systems plays a pivotal role in overcoming hesitancy. For individuals with lower financial literacy, building trust through transparency, secure infrastructure and user-friendly platforms becomes essential, while for more literate users, more focus is placed on the technological advantages of using CBDC. By carefully addressing the above, central banks can create a robust, trust-driven environment that encourages the widespread usage of CBDC across its diverse socio-economic landscape, leading to greater financial inclusion and efficiency in the digital economy.

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Article

Digital Financial Literacy and Its Impact on Financial Decision-Making of Women: Evidence from India

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Abstract: Despite the increasing accessibility of digital financial instruments globally, a number of women encounter obstacles in properly using these platforms due to insufficient digital financial literacy, which profoundly affects their financial decision-making and economic empowerment. This study aims to promote digital financial literacy and Fintech adoption for women in India by examining the effects of digital financial literacy on financial decision-making while considering the mediating effect of government support and digital financial literacy. Furthermore, in this study, we analyzed the relationship between independent variables such as financial attitude (FAtt), subjective norms (SNs), perceived behavior control (PBC), digital financial literacy (DFL), and financial accessibility (FA) on the dependent variable, i.e., financial decision-making (FDM). We also explored how financial decision-making impacts women's intention towards investment (INT). By analyzing 385 Indian women respondents using Structural Equation Modeling (SEM), this study revealed that financial attitude (FAtt) leads to higher financial decision-making (FDM), exerting moderate effects. Similarly, subjective norms (SNs), perceived behavioral control (PBC), digital financial literacy (DFL), and financial accessibility (FA) significantly lead to financial decision-making. Overall, the five predictors of financial decision-making explained around 71% of the variance. Financial decision-making exerted a significant and robust effect on women's intention towards investment. Financial resilience significantly moderated the effects of financial decision-making on women's intention towards investment. These findings emphasize the necessity of implementing a distinct government strategy and programs to enhance the adoption of Fintech among women living in urban and rural regions across India. This study is aligned with UN Sustainable Development Goals, especially Sustainable Development Goal (SDG) 1: No Poverty, SDG 5: Gender Equality, and SDG 8: Decent Work and Economic Growth.

Keywords: digital financial literacy; financial inclusion; women's empowerment; financial decision-making; Saudi Vision 2030; Sustainable Development Goals (SDGs); financial resilience

1. Introduction

In recent years, the world has witnessed significant advancements in technology and digital transformation, revolutionizing various sectors and aspects of our lives. Alongside these developments, there has been a growing recognition of the crucial role played by digital and financial literacy in empowering individuals, particularly women, and achieving the United Nations Sustainable Development Goals (SDGs). Women's empowerment is a multifaceted concept encompassing social, economic, and political aspects, and it plays a pivotal role in achieving sustainable development. It is widely acknowledged that empowering women leads to a cascade of positive outcomes, not only for women

themselves but also for their families, communities, and societies at large. Recognizing this, the SDGs, a global agenda for development adopted by the United Nations, highlight gender equality and women's empowerment as one of the key goals (SDG 5) (Cui et al. 2017; Beloskar et al. 2024; Tanzile et al. 2023).

Digital and financial literacy, on the other hand, are critical components in enabling women to participate fully in the modern digital economy and economic systems. Digital literacy, in simple terms, refers to the ability to access, understand, and utilize digital technologies effectively. On the other hand, financial literacy describes the skills and information needed to handle finances, manage resources, and operate within financial systems (Lusardi 2019; OECD 2023). The percentage of women in the world's population is around 49.58%. India was expected to have 1.4 billion people living there in 2021, a 0.97% increase from 1.38 billion in 2020. India is ranked 112th in terms of population growth rate and 2nd in terms of population in the world. In India, there were 108.15 men for every 100 females in 2021. In India, there are 669.44 million women and 723.97 million men. The percentage of females in the population is 48.04%, while the percentage of males is 51.96%. In India, there are 54.54 million more men than women. India ranks 189th out of 201 nations or territories in the world in terms of the ratio of women to men (Statisticstimes 2021). According to the National Family Health Survey (NFHS-5) for 2020–2021, India's Sex Ratio in 2023 was 1020 females per 1000 males, which is improved by 12 points. The total labor force in India was reported at 507,704,840 in 2021, which increased to 593,729,164 in 2023, according to the World Bank collection of development indicators. India's female labor force participation rate saw no significant changes in 2021 compared to 2020 and remained at around 22.99% (Klapper and Miller 2021; PIB 2021).

The latest results of the Periodic Labor Force survey (PLFS), released by the Labor Bureau in October 2023, showed a considerable increase in women's participation. In 2017–2018, the participation rate was 23.3%, and in 2022–2023, it was 37%. In India, the labor force participation rate among females is 32.7%, and among males, it is 76.8% for 2023. Currently, the employment gap between men and women is about 58%. At the moment, there is about a 58% employment disparity between men and women. Furthermore, reducing that difference may increase India's GDP by about a third by 2050, according to Bloomberg Economics research. However, ignoring the problem could impede the nation's efforts to develop into a competitive manufacturer for international markets (Mazumdar and Chaudhary 2022).

According to Duflo (2012), financial inclusion, literacy, and female employment engagement are contributing aspects to the nation's development and advancement in the global context. Consequently, women are now contributing to the financial decision-making process, which leads to quicker, healthier financial well-being (Haque and Zulfiqar 2016). Well-being is every individual's desire. The element of financial well-being holds more importance than physical, community, social, and career aspects (Rath and Harter 2010). In Southeast Asia, financial services play a significant role in the digital economy and can promote financial inclusion (Son et al. 2019). Women have more opportunities to engage in society and the economy when they use Fintech, a cutting-edge mobile payment platform, particularly in areas such as investment, entrepreneurship, and money management.

Women are empowered by Fintech because it expands their economic prospects and improves their financial literacy. Additionally, it increases their accessibility to financial services. By offering solutions suited to their needs and challenges, Fintech adoption also encourages women's originality and resourcefulness (Babar 2023). As a result, promoting women's adoption of Fintech can aid in sustained and equitable economic growth and boost productivity and monetary stability (Adera and Abdisa 2023; Sharma and Changkakati 2022). This study provides useful information to both Fintech service providers and policymakers by addressing the gender gap in Fintech adoption. A previous survey found that just 21% of women and 29% of men use Fintech, indicating a significant and pervasive gender gap in this area. The gender gap in financial services access is a pervasive issue in many countries, as evidenced by the data showing significant discrep-

ancies in Fintech usage between men and women (Chen and Guo 2023; Chen et al. 2023b). Since having access to Fintech is a prerequisite for financial inclusion, closing this gap is crucial for the empowerment of women (Sherwani et al. 2023; Sundarasan et al. 2023; Yathiraju and Dash 2023; Setiawan et al. 2024). Additionally, improving financial awareness and education among women might further drive their demand for financial services (Morsy 2020).

1.1. Financial Decision-Making

Financial decision-making refers to selecting the best course of action for the person (in the short and longer term) while considering current financial and economic realities. Essential considerations include balancing the need to grow in the longer term (through astute and careful investments, mindful of potential risks involved) (Skill Maker 2018). In order to obtain financial goals, financial decision-making entails choosing, evaluating, and analyzing various choices for data extraction and utilization. The entire process is centered on analyzing financial data using risk and return trade-offs and then carrying out executive decisions in accordance with long-term goals. It has been a complex process that includes a range of tasks such as setting financial objectives, obtaining financial data, analyzing possibilities, determining alternatives, weighing risks and benefits, coming to judgments, and more.

Over the past decade, the discrepancies in financial planning and diminishing savings have garnered significant attention towards FDM (Brüggen et al. 2017). It is based on the premise that individuals possess the liberty to choose from an extensive array of financial alternatives that ensure wealth optimization. The prospect hypothesis originates from the concept proposed by Kahneman and Tversky (1979), which advocates for conducting a cost-benefit analysis (CBA) of available options, favoring those with minimal negative financial repercussions and a satisfactory degree of assurance in achieving success. Theoretical argument underscores the inadequacy of predetermined analytics in facilitating decision-making due to conflicting objectives and contexts associated with those decisions. As FDM is inherently a cognitive process, it exhibits diverse patterns influenced by personality factors (such as risk aversion or reward-seeking), speed, and the extent of autonomy in decision-making.

As a result, in the context of India, this research assumes that FDM is the result of variables such as digital financial literacy (DFL), financial accessibility (F), subjective norms (SN), perceived behavior control (PBC), and financial attitude (Fatt), in addition to a demographic element such as gender (Ali et al. 2024).

1.2. Digital Financial Literacy

The relevance of Digital Financial Literacy has expanded due to the development and decentralization of Fintech products and services. People are taking responsibility for their financial planning and becoming more financially independent, which ensures financial autonomy and inclusion. DFL not only improves financial inclusion but also empowers citizens to embrace a cashless economy and warns them against digital fraud, including phishing and hacking (OECD 2023). It also facilitates the efficient use of Fintech products and services (Ozili 2018). Similarly, (Park 2011) argues that familiarity with the technological components of the Internet, awareness of standard institutional norms, and comprehension of current privacy regulations are three distinct dimensions of digital literacy that significantly influence privacy-related online behavior.

1.3. Women's Empowerment

The concept of women's empowerment itself is multifaceted and has many definitions and connotations. As per the UNDP Human Development Report (1995), empowerment is defined as the ability of individuals to take part in the process of making decisions that affect their lives. Economic growth and development depend heavily on giving women the authority to make their own decisions and empowering them.

One of the most crucial factors in assessing a person's growth and development is their level of participation in the economy, particularly when considering sustainable development objectives. Everyone must uphold the national priorities of women's empowerment, status advancement, and effective involvement in all spheres of life. In recent years, the global development agenda has placed a greater emphasis on women's financial inclusion. Women's access to finance has been identified by national and international development organizations as a primary objective and element of their development initiatives.

The World Bank established Universal Financial Access (UFA) as a strategic aim in 2013 with the intention of granting access to financial transactions to all adult people worldwide, regardless of gender. A primary goal of the G20's development agenda was to clearly incorporate financial inclusion as a means of empowering women economically in 2015 (World Bank 2021). The importance of women's financial inclusion in achieving sustainable development and pro-poor growth was highlighted by including women's access to finance as a prerequisite to attaining the fifth goal of the United Nations Post-2015 Sustainable Development Goals (SDGs), which are in force until 2030. Giving women access to economic and social opportunities—such as banking services, real estate, employment, and other productive assets—will enable them to advance their rights, take more charge of their lives, and engage in society. Hence, most of the UN state members have reacted to comply with the SDGs. For example, currently, the Kingdom of Saudi Arabia (KSA) has announced in its 2030 Vision a high level of women's empowerment in all forms of social, economic, and political activities (Saudi Vision, Saudi Vision 2030 2016). Such governmental intervention by KSA is seen as a response to the SDGs to implement all policies and regulations related to women's rights. This is known as women's economic empowerment (Ferrant and Thim 2019). The five components of women's empowerment includes: their sense of self-worth, their right to make financial decisions, their right to access opportunities and resources, their right to have the power to control their own lives, both within and outside the home, and their ability to influence the direction of social change to create a more just social and economic order, both nationally and internationally. Education, training, awareness-raising, self-confidence development, expanded choices, increased access to and control over resources, and actions to transform the structures and institutions that perpetuate gender discrimination and inequality are critical tools for empowering women and girls to assert their rights in this context. This is discussed in Figure 1.

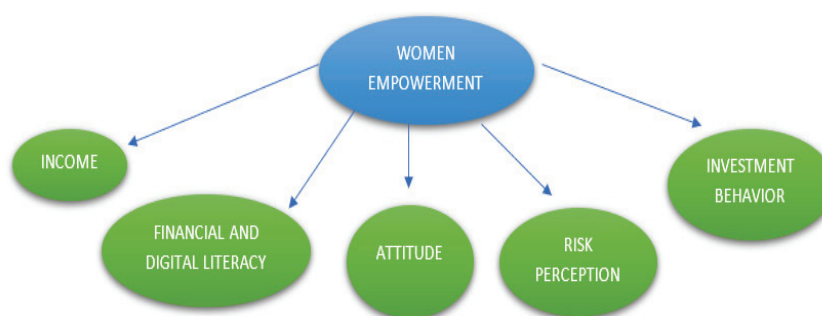


Figure 1. Elements of women's empowerment (Hendriks 2019).

Financial inclusion, especially through digital financial services, is recognized to enhance women's income and alleviate poverty, both of which are crucial for women's economic empowerment (Hendriks 2019). Approximately 1.7 billion individuals are reported to be unbanked (Demirguc-Kunt et al. 2018), presenting numerous obstacles to sustainable development. Moreover, women constitute 56% of the unbanked demographic and are disproportionately represented in certain nations, such as China, Bangladesh, and India. The growing popularity of cell phones and the Internet has positioned mobile-enabled financial services as a crucial catalyst for enhanced financial inclusion and the advancement of social development.

1.4. Financial Accessibility

The ability of people and businesses to use financial services such as loans, savings, insurance, and payments is referred to as “access to finance”, and it has a favorable effect on both financial and economic growth (Guney and Demirel 2019).

1.5. Elements of Sustainable Development Goals (SDGs)

The 2030 Agenda for Sustainable Development demands a fresh, ground-breaking perspective. Gender equality is given top importance among 17 UN Sustainable Development Goals that are integrated and indivisible. Goal 5 stands alone, and gender equality is mainstreamed across the SDGs to address women’s empowerment and gender equality as stated priorities. The 2030 Agenda acknowledges multifaceted inequalities both within and across nations and is a pledge to “leave no one behind” (United Nations Sustainable Development Group 2019; Mackie and Allwood 2022). This is discussed in Figure 2.

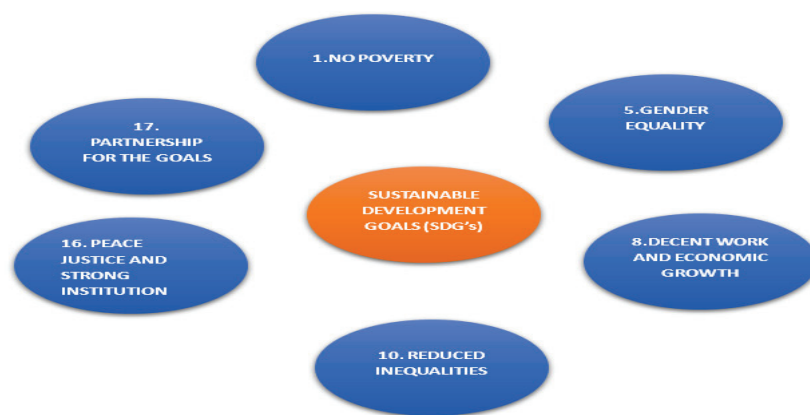


Figure 2. Elements of SDGs.

The first thorough assessment of the state of women’s empowerment and gender equality in Asia and the Pacific under the Sustainable Development Goals framework was created in a collaboration between the Asian Development Bank (ADB) and the UN Women Regional Office for Asia and the Pacific (Cerise 2018).

1.6. Theoretical Underpinning

Individuals in behavioral science and behavioral finance are considered irrational, i.e., they take different financial decisions and act differently in different situations, have limited access to information, and enjoy utility derived from short-term decisions. Their financial decisions can influence individuals’ financial well-being with a given level of capability. This study is grounded on behavioral theory, i.e., the Theory of Planned Behavior provided by (Ajzen 1991).

Ajzen’s (1991) Theory of Planned Behavior

This theory expands on the idea of planned behavior to explain why people choose to act in a certain way when they feel like they have behavioral control (see, for example, Sharahiley 2020). High levels of accuracy can be used to predict intentions to carry out specific actions based on attitudes toward the conduct, subjective norms, and perceived behavioral control. Together, these intentions and perceptions of behavioral control explain a significant portion of the variation in actual behavior. Although the precise nature of these relationships is yet unknown, attitudes, subjective norms, and perceived behavioral controls are related to appropriate sets of salient behavioral, normative, and control beliefs about the activity.

The theory is utilized to identify and derive three distinct groups of factors, which include the following:

(a) Attitude Influencing financial decision-making

According to Vargas-Sánchez et al. (2016), attitude is the way a person perceives and assesses something or someone, as well as a predisposition or a tendency to react either favorably or unfavorably to a particular idea, item, person, or circumstance. Rai et al. (2019), discovered strong evidence that financial attitude and financial literacy positively influence financial behavior in their study *Improving Financial Decision Making: The Mediating Role of Financial Behavior*. While financial literacy (FL) may not have a significant impact on investment decisions (IDs) by itself, studying the relationship between FL and IDs can provide valuable insights into investor behavior. This can be achieved by analyzing how attitude (ATT) and overconfidence bias (OCB) act as mediators in the connection between FL and IDs. The results suggest that foreign language proficiency, when paired with a positive attitude and excessive self-assurance, enables individual investors to possess the necessary knowledge and abilities to make appropriate decisions (Maheshwari et al. 2024; Brooks and Williams 2021; Kumar et al. 2023a).

(b) Subjective norms/prescriptive influence influencing financial decision-making

The belief on whether the majority of people accept or disapprove of the behavior is discussed in (Khaw et al. 2023; White et al. 2019). It has to do with a person's ideas regarding whether or not important people and peers believe that he or she should participate in the conduct. Learning practices within the home context were perceived as influential on future behavior in their study of factors that influence financial decisions and effectiveness (Vyvyan et al. 2014).

(c) Perceived behavioral control influencing financial decision-making

The term "perceived behavioral control" describes how easy or difficult a person believes a particular behavior to be. A person's behavior is greatly influenced by how confident they are in their capacity to complete a task. Because a range of connections between attitudes, beliefs, intentions, and actions can be explained by self-efficacy (Sharahiley 2020), in this case, perceived financial capability is interpreted as confidence or self-efficacy. Financial self-efficacy is a crucial sign of financial decision-making ability in consumer finance, according to (Xiao et al. 2014). They also discovered that as people age, their perception of financial decision-making rises.

The structure of this paper includes Section 1, which discusses the concept and motivation behind this study. Section 2 discusses the literature review and hypothesis formulation used to conduct this research. Section 3 presents the research methods employed to conduct this research, while Section 4 presents the results from the data analysis. Section 5 presents the conclusion, Section 6 presents the implications, Section 7 presents recommendations and suggestions, and Section 8 presents scope for future work and the limitations of this study.

2. Literature Review and Hypothesis Formulation

This literature review aims to critically analyze and synthesize existing research on the relationship between digital financial literacy, financial accessibility, subjective norms, perceived behavior control, and financial attitude on the financial decision-making of women.

A systematic literature search was conducted using academic databases, including Scopus, Science Direct, and Google Scholar. The search terms included "digital and financial literacy", "financial well-being", "financial resilience", "financial decision making", "investment behavior", and "women empowerment". The inclusion criteria involved empirical studies published in peer-reviewed journals between 2014 and 2024, written in English, and focusing on the impact of social media on mental health. The initial search yielded 500 articles, of which 153 met the inclusion criteria. Using the guidelines of (Choong 2014; Matthews and Marzec 2012; Paul et al. 2017; Paul and Rosado-Serrano 2019) in the literature review, the articles have been collected from high-quality and high-impact journals indexed in electronic databases including ScienceDirect, Scopus, Web of Science (WoS), Google Scholar, and ProQuest.

This research work started with searching and reviewing the literature on a broad area of Financial Inclusion and Sustainable Development from 1993 to mid-2024. The keywords used related to the study are sustainable development goals, self-help groups, financial technology, financial literacy, financial exclusion, and the policies related to these by various countries. The search was conducted across the selected databases with the following terms: ‘financial inclusion’, ‘financial exclusion’, ‘sustainable development’, ‘Fintech’, ‘financial capability’, ‘financial literacy’, ‘Artificial intelligence’, and ‘self-help groups’. The available papers were refined by setting the scope of the review to include empirical studies. Tools such as publication trends and citation network analysis were applied in the present study. Publications related to the theoretical perspective of Financial Inclusion and its other related areas were considered for review work. The articles selected were analyzed and understood thoroughly, considering the topic’s relevance. The research also included secondary data sources such as RBI, SLBC, NITI Aayog reports, magazines, newspapers, and information from websites.

2.1. Financial Attitude Influencing Financial Decision-Making

According to earlier studies, Attitude is the inclination of an individual to assess their preferences and aversions in relation to a certain item, activity, person, group, or situation (Ajzen 2011; Sharahiley 2020).

In the context of this study, assessing AT comprises figuring out if an individual has a favorable or negative viewpoint regarding digital financial literacy and using Fintech services, as well as their degree of comfort and interest in the service and their ability to make financial decisions. Several past studies considered AT while deciding whether to employ Fintech services (Nathan et al. 2022; Akinwale and Kyari 2022). Previous research findings have shown a noteworthy association between the adoption of AT and Fintech and financial decision-making. However, a new study has discovered that although Fintech usage and attitudes toward technology are closely related, other factors contribute very little to the total disparity (Chen and Guo 2023; Chen et al. 2023a). Diverse psychological, behavioral, and demographic aspects influence financial decision-making, promoting the creation of a viable and profitable financial portfolio to secure the long-term financial well-being of households (Kumar et al. 2023a). In light of the empirical evidence presented above, the following hypotheses are posited:

H1. *Financial Attitude is a significant determinant of financial decision-making.*

2.2. Subjective Norms/Prescriptive Influence Influencing Financial Decision-Making

This refers to the perception of whether the majority of people find the behavior acceptable or not. It has to do with a person’s thoughts regarding whether or not important individuals and peers believe that he or she should engage in the behavior (Green and Heekeren 2009). The desire for financial security is increasing in a society characterized by economic instability. Individual differences are crucial in attaining an elevated state of financial well-being (Kaur et al. 2023). Diverse psychological, behavioral, and demographic aspects influence financial decision-making, promoting the creation of a viable and profitable financial portfolio to secure the long-term financial well-being of households (Kijkasiwat 2021). Retirement attitude, perceived behavioral control, and subjective norms each show a positive correlation with the intention to plan for retirement. Moreover, the findings indicated that behavioral intention and perceived behavioral control are positively correlated with the financial behavior of working individuals. The results may assist financial educators and advisors in providing the appropriate combination of financial knowledge to help working individuals make improved financial decisions and engage in sound financial practices (She et al. 2023).

The growing intricacy of the investing landscape has expedited the demand for enhanced financial advisory services of superior quality. An essential aspect of providing high-quality guidance is the advisers’ precise evaluation of their clients’ risk profiles.

Usually, a client's risk characteristic is evaluated by assessing their risk tolerance rather than their risk perception. In order to evaluate the extent to which this approach is unable to accurately determine the client's level of risk, we examine both their willingness to take on risk and their perception of risk within the context of investment decision-making (Nguyen et al. 2019; Antonides and Van Der Sar 1990).

H2. *Subjective Norms or family factors are significant determinants of financial decision-making.*

2.3. Perceived Behavioral Control Influencing Financial Decision-Making

Perceived behavioral control refers to an individual's perception of how easy or difficult it is to do a specific behavior. A person's confidence in their ability to execute a task significantly impacts their behavior. Self-efficacy helps to explain a variety of links between beliefs, attitudes, intentions, and behavior. Here, perceived financial capability is taken as self-efficacy or confidence. This study discovered a notable and beneficial influence of financial literacy, as well as its various aspects, on both financial self-efficacy and financial well-being. Additionally, it was discovered that the impact of financial literacy on financial well-being is partially influenced by financial self-efficacy (Lone and Bhat 2024). Attitude, subjective norms, and perceived behavioral control exert a favorable and substantial impact on investment intentions. Nevertheless, financial literacy has an insignificant effect on investing intention (Hidayati and Destiana 2023).

There is a favorable correlation between financial knowledge and the attitudes towards retirement, perceived behavioral control, subjective standards, and financial behavior of working adults. Furthermore, the results indicated that retirement attitude, perceived behavioral control, and subjective norms were all positively correlated with the intention to engage in retirement planning. Moreover, the findings showed a significant correlation between the purpose of acting and the perceived ability to control one's behavior with the financial actions of employed individuals (She et al. 2023; Che Hassan et al. 2023). The components of the Theory of Planned Behavior (TPB), namely, attitude (ATT) and subjective norms (SNs), have a strong correlation with investment intentions (INTs). However, perceived behavioral control (PBC) does not have a significant correlation with INTs. In addition to the original components of the TPB model, Trust in Financial Institutions (TFI) and Financial Literacy (FL) were also included in the model. These factors have a substantial impact on investors' desire to invest in the stock market (Adil et al. 2023).

H3. *Perceived behavioral control is a significant determinant of financial decision-making.*

2.4. Digital Financial Literacy Influencing Financial Decision-Making

Digital literacy refers to using and navigating digital technologies effectively and responsibly. It encompasses the skills, knowledge, and attitudes required to utilize digital devices, applications, and online platforms for various purposes, such as communication, information retrieval, critical thinking, problem-solving, and creativity. Digital literacy involves understanding digital tools, evaluating information from digital sources, managing digital content, and protecting privacy and security in the digital realm. It also includes adapting to new technologies and continuously learning and upgrading digital skills (Martin 2008).

Understanding and weighing the costs, risks, and rewards of financial goods and services, such as bank accounts, credit cards, loans, insurance, and investments, is a necessary component of financial literacy. In order to accomplish both short- and long-term financial goals, it also entails evaluating financial data, including statements, budgets, and economic indicators, and making wise financial decisions (Lusardi and Mitchell 2014).

H4. *Digital and financial literacy have a significant influence on financial decision-making.*

2.5. Financial Accessibility Influencing Financial Decision-Making

The capacity of people or businesses to obtain financial services, such as credit, deposits, payments, insurance, and other risk management services, is known as access to finance (Demirgüç-Kunt et al. 2008). Access to financial services gives opportunities for generating income, accumulating assets, and participating more fully in economic activities, thereby encouraging economic and social empowerment. In addition to providing resilience against shocks such as the COVID-19 pandemic, financial inclusion emphasizes the need to make sure that the most vulnerable groups have access to formal financial services (World Bank 2021), as financial inclusion and accessibility are recognized as critical drivers of economic growth and poverty alleviation. It ensures universal access to valuable and affordable financial services delivered responsibly and sustainably. The Reserve Bank of India, releasing the National Strategy for Financial Inclusion (2019–2024), defined ‘financial inclusion’ as “the process of ensuring access to financial services and timely and adequate credit where needed by vulnerable groups such as weaker sections and low-income groups at an affordable cost” (PRS 2020)

H5. *Financial accessibility has a significant influence on financial decision-making.*

2.6. Financial Decision-Making Influencing Intention towards Investment

The intention of the investors to invest in various instruments is known as investment intention or intention towards investment. It is clear from the study that behavioral factors have an impact on the investment intentions of investors. Emotional factors have a significant effect on investors’ financial investment decisions. Investment paradigms often disregard emotions. Anxiety, happiness, and optimism are reliable markers of a more complex concept known as emotional finance. The results also indicated a strong correlation between emotional intelligence in financial matters and investing performance. Simultaneously, it has been determined that investor protection is not correlated with investment performance (Irfan et al. 2023). Financial literacy should be regarded as an essential entitlement and universal necessity rather than a privilege limited to a small number of customers with exclusive access to financial knowledge or guidance. Financial literacy should be regarded as equally significant as basic literacy, which refers to the capacity to read and write in the modern period. In the absence of it, both individuals and society are unable to achieve their maximum capabilities (Lusardi 2019).

H6. *Financial decision-making is a significant determinant of intention towards investment.*

2.7. Financial Resilience Influencing Financial Decision-Making and Intention towards Investment

Resilience is the capacity to creatively adjust to complicated life events and perform well in the face of uncertainty, upheaval, or difficult or dangerous circumstances. Financial resilience is the capacity to withstand both favorable and unfavorable life circumstances that have an impact on one’s assets and/or income (Xiao and O’Neill 2011). One of the study’s proposed hypotheses was to check how financial resilience affects the relationship between financial decision-making and intention toward investment. Financial resilience is built upon the adoption of sound financial planning practices (Yeo et al. 2023).

Research revealed a strong and significant correlation between financial literacy and investment decisions. Furthermore, the findings indicate that having excessive confidence had a beneficial impact on investment choices. Additionally, the connection between financial knowledge and investment selections was positively and significantly influenced by overconfidence (Seraj et al. 2022; Kumar et al. 2023b).

H7. *Financial resilience has a significant influence on intention towards investment.*

It is evident from the literature review that the studies on financial capability are mainly conducted on consumers, emerging adults, and millennials, and few studies deal with measuring the financial resilience of women. Similarly, most of the studies are conducted in developed nations such as European countries and North America. Similarly, there is a lack of studies that deal with measuring the financial capability of women, as most of the studies deal with financial literacy and financial inclusion and do not cover the behavioral aspects combined with the knowledge and skills of this group or their perspectives. Similarly, no such study has yet been conducted that shows how financial capability influences women's intention to invest. Similarly, most of the studies conducted on women deal with financial inclusion, women's empowerment, and financial literacy, and none of the studies focused on analyzing the behavioral aspects of women dealing with either financial capability or financial resilience. Thus, it is imperative to know the financial capability of women and also how it affects their financial well-being. Furthermore, globally, women have fewer economic opportunities. Less than half of all eligible women participate in the labor force, compared to 75% of men (Dhanamalar et al. 2020).

Additionally, women are more likely to hold vulnerable, low-paying, or devalued occupations as well as engage in informal employment. The COVID-19 pandemic exacerbated the situation by resulting in unparalleled employment losses, primarily affecting women and exacerbating gender disparities. The availability of financial services is not equal for men and women. Women made up 56% of those without bank accounts even before the pandemic, which means that about a billion women lack access to banking (Kumar 2023). The epidemic has prompted economies to reconsider, reconstruct, and transition toward inclusive, environmentally sustainable digital communities and enterprises. Technology plays a crucial role in making the vision possible, and women are leading the way in embracing digital and environmentally friendly financial solutions to attain economic and social objectives. Nevertheless, women continue to be inadequately represented while experiencing more negative impacts from environmental issues and having less access to digital money compared to males (Tailor 2023).

Proposed Hypothesis:

This study seeks to promote digital financial literacy and Fintech adoption among women in India by examining the impact of various factors on their behavioral intention and usage patterns. In this study, the relationships were examined between several independent variable, namely, financial attitude (FAtt), subjective norms (SNs), perceived behavior control (PBC), digital financial literacy (DFL), and financial accessibility (FA), on the dependent variable financial decision-making (FDM), as shown in the Figure 3.

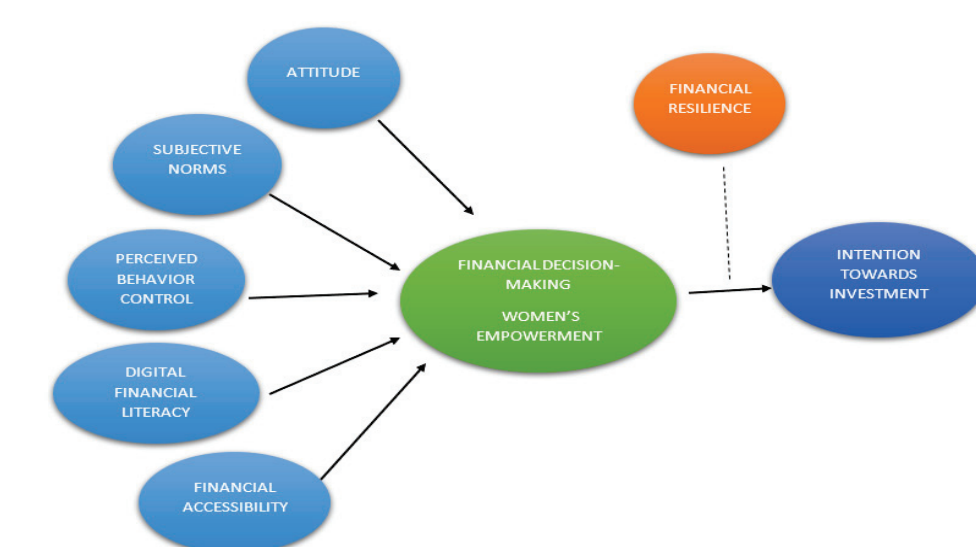


Figure 3. Conceptual framework of financial decision-making.

3. Materials and Methods

Selection of Research Approach:

Based on the study requirement, the researchers decided on the type of study to be conducted.

Research Approach:

We used quantitative methods to analyze the responses received through questionnaires. Digital and financial literacy is part of financial inclusion, which has a natural environment and is connected with many other factors that are directly tied to the empowerment of urban and rural people. The data are exploratory as they test the hypotheses pertaining to the independent and dependent variables. The analysis of the literature revealed that a number of important elements, including income, employment, bank fees, the quality of services, financial education, and accessibility of financial instruments and services, had an impact on the degree of digital and financial literacy. The purpose of this study is to ascertain the variables or elements influencing women's financial decision-making.

Quantitative methods:

This research used quantitative methods, such as a survey, to collect data from women in the States of Uttarakhand and Uttar Pradesh in India who had received financial and digital literacy training. The survey included questions about their economic participation, financial decision-making skills, and the impact of financial and digital literacy training on their lives. The data collected were analyzed using statistical software to identify any correlations or patterns.

Research Design

This section includes the study population, sampling frame, sample size determination, and sampling technique used. The study space was composed of women working in different sectors such as SHGs, MSMEs, healthcare, and educational institutions in the States of Uttarakhand and Uttar Pradesh in India.

Sample Size:

The sample size was determined based on the formula given by (Yamane 1967). (Cochran 1977) developed the equation for large populations to yield a representative sample for proportions.

$$n_0 = Z^2 pq / e^2 = (1.96)^2 (0.5)(0.5) / (0.05) = 385$$

This is valid where n_0 is the sample size, Z^2 is the abscissa of the normal curve that cuts off an area α at the tails ($1 - \alpha$ equals the desired confidence level, e.g., 95%), e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and q is $1 - p$. The value for Z is found in statistical tables, which contain the area under the normal curve.

Sampling Method

This study makes use of purposeful sampling. Purposeful sampling is a common technique used in quantitative research to identify and select cases that are highly informative about the subject of interest. Purposeful sampling is a technique that is commonly used in qualitative research to locate and select samples that are rich in information and make the most of the limited resources available (Patton 2002). This entails locating and picking people, or groups of people, who have particular expertise or understanding of an interesting subject (Creswell and Clark 2011).

Source of Data Collection:

This study collected data from both primary and secondary sources. The primary data were collected for analysis using the survey method with the help of a structured

questionnaire. The questionnaire was developed based on the literature review. However, the scale was modified to suit the needs of the study. Respondents received prior instructions on completing the questionnaire and were informed that their information would remain confidential and used solely for research purposes. The primary data for the study were collected by a survey method utilizing a structured questionnaire included as Supplementary material. The data were gathered by a questionnaire administered to respondents during in-person conversations. Prior to data collection, the respondents received a briefing on the aims of the data collection, and the questionnaire was explained to them in Hindi or their native language before they completed it with the assistance of an interpreter. Open-ended questions were used to collect data regarding the respondents' backgrounds and demographics. The data pertaining to the various constructs or variables of the study were gathered using questions formulated using a Five-Point Likert Scale. The entire questionnaire was segmented into sections according to the study's variables.

A structured questionnaire was used for the survey. A 5-point Likert scale was used, with 5 points assigned to "very strongly", 4 points to "strongly", 3 points to "neutral", 2 points to "disagree", and 1 point to "strongly disagree". A semi-structured questionnaire for respondents was designed and utilized to collect data from working women. Data collection for the study was conducted in the months of December 2023 to June 2024. The questionnaires that were half-filled and did not have proper responses, i.e., incomplete questionnaires, were removed from the analysis. The questionnaire was carefully and systematically designed according to the objectives of the study. For quantitative data analysis, a **reliability test** was performed to determine the reliability of items used in the questionnaire, and then a confirmatory factor analysis was conducted to confirm the factors that influence the investment behavior of women working in the States of Uttar Pradesh and Uttarakhand in India. The researcher administered the questionnaires through email and personal contacts to collect the data from women. Secondary data were collected based on keywords such as financial literacy, digital literacy, Fintech, Sustainable Development Goals (SDGs), women's empowerment, financial well-being, financial resilience, and financial decision-making and considered various research articles, journals, newspapers, and reports that are relevant to our research topic and research objectives. The measurement scale items for "financial literacy" were adopted from (Rastogi and Ragabiruntha 2018).

SEM was used to understand the impact of Digital and Financial literacy on Investment behavior.

Dependent Variables:

In line with earlier studies (Allen et al. 2012; Demirguc-Kunt and Klapper 2013; Nino-Zarazua and Copestake 2008; Efobi et al. 2014; Y. Gitaharie et al. 2014) that focused on the sample using a structured questionnaire. This research recognizes digital and financial literacy by considering women as 'included' if any are financially and digitally literate. The dependent variable is the 'Inclusion Score'. The various factors (explanatory variables) selected are in accordance with the findings of the literature.

Digital and financial literacy is an indicator of investment behavior and contributes to women's empowerment. We analyzed the association or impact of digital literacy on women's empowerment, which includes financial decision-making, financial access, literacy, and resilience.

Independent Variables:

The independent variables included Gender, Income, Age, Education, Occupation, Bank information (bank account, loan, deposits, savings, no. of accounts, chequebook, ATM, credit and debit cards, frequency of access, ease of access), Ethnicity, and Investment objective. Integrating the perspective of the "digital divide between digital natives and digital migrants among women" would enhance the study by examining this divide and its influence on financial decision-making. Comprehending these distinctions would facilitate the creation of more inclusive digital financial literacy initiatives, ensuring that women of all ages and backgrounds are enabled to engage in the digital economy.

Moderating Variable: Financial resilience was used as a moderating variable between financial decision-making and intention towards the investment of women.

Reliability Analysis:

For checking the reliability of the scale after modification, Cronbach's Alpha value was used, which is significant in social science research for testing the reliability of the scale. Hence, if Cronbach's Alpha value is found nearer to 0.70, the researcher can continue with the questionnaire for his studies (Taber 2018).

Confirmation of Measurement Items

The measurement items were confirmed under the latent constructs through Confirmatory factor analysis (CFA). The CFA model confirmed the validity and reliability of scaled measurement items.

Assessment of Reliability and Validity of the Measurement Instrument:

To assess the accuracy of the measurement models, construct reliability, convergent validity, standardized factor loadings, critical ratio (*t*-value), composite reliability (CR), and average variance extracted were used.

4. Results

It is evident that the majority of respondents are married, with 81% of the 385 total respondents being married and 19% being single. The predominant demographic of respondents is aged 30 to 35. The highest proportion of women are literate at the graduation level, followed by those educated up to the 12th grade, postgraduate level, and the illiterate population. Approximately 60% of employed women have two children. A total of 29% of respondents are agricultural laborers, 20% are daily wage earners, 33% are salaried employees, and 18% are business owners. Nearly 55% of the respondents belong to the monthly income bracket of INR 20,000 to INR 40,000, whereas 15% are classified within the income range of INR 40,001 to INR 60,000. Additionally, 20% belong to the income bracket of INR 20,000 or below, while 10% earn above INR 100,000. The predominant percentage of respondents identifies as Hindu, at 85%, followed by Sikh, Muslim, and Christian affiliations. Sixty-five percent belong to the General category, twenty percent to OBC, ten percent to the SC category, and five percent to the ST group.

4.1. Hypotheses Testing

At first, a preliminary inspection of the data was conducted to check for data accuracy, missing values, outliers, and normality. The analysis revealed no major issues except for some missing values, which were excluded from further analysis. Next, Structural equation modeling (SEM) was used to test the proposed hypotheses. As suggested by (Hair et al. 2010b), a two-step approach was adopted, wherein the measurement model (Confirmatory Factor Analysis) was run first to check the reliability and validity of the study constructs (Anderson and Gerbing 1982, 1988; Hair et al. 2010b, 2019). Thereafter, the structural model was specified and executed to test the structural path hypotheses. For the above purposes, AMOS 20.0 software was used. Since the data collection procedure involved a cross-sectional self-reported questionnaire, common method bias can be a problematic issue. Hence, it was deemed suitable to test for common method bias before moving on to the main analysis. The following are the results:

4.2. Common Method Bias (CMB)

The CMB in the data was checked by deploying Harman's single-factor test. According to this test, the presence of CMB is recommended if a single factor explains most of the covariance, i.e., more than 50%. To rule out the presence of CMB, all 31 items were included in an unrotated principal component exploratory factor analysis, and a single factor was extracted. The results revealed that the first factor explained only 41.67% of the variance,

which is far less than the suggested cut-off of 50%. Hence, the threat of CMB was completely ruled out (Podsakoff et al. 2003).

4.3. Confirmatory Factor Analysis (CFA), Reliability, and Validity Analysis

A confirmatory factor analysis on all 32 items was performed in this step. As suggested by Bentler and Bonett (1980), the measurement model has a satisfactory goodness-of-fit to the data if the CFI, TLI, NFI, and GFI values are greater than 0.90 and the RMSEA value is less than 0.08. In the present case, the CFA measurement model achieved a satisfactory goodness-of-fit to the data (Chi square/df = 2.774; CFI = 0.906; NFI = 0.898; TLI = 0.912; GFI = 0.917; and RMSEA = 0.071).

Next, the reliability and validity analyses were performed to assess the measurement quality of the study constructs. For this purpose, the values of the average variance extracted (AVE), composite reliability (CR), and Cronbach's alpha for all the constructs were calculated. According to (Hair et al. 2010a), the convergent validity is achieved if (a) the factor loading of each of the items is statistically significant and exceeds 0.70, (b) the reliability score for each of the constructs exceeds 0.70, and (c) the AVE value for each of the constructs exceeds 0.50.

The results of this analysis are presented in Figure 4 and Table 1 below, which clearly indicates that the measurement item loadings were significant and surpassed the threshold value of 0.70. Additionally, the AVE values for all study constructs surpassed the threshold value of 0.50. Moreover, the Cronbach's alpha values for all the constructs surpassed the required threshold. Hence, the convergent validity was well achieved (Table 1).

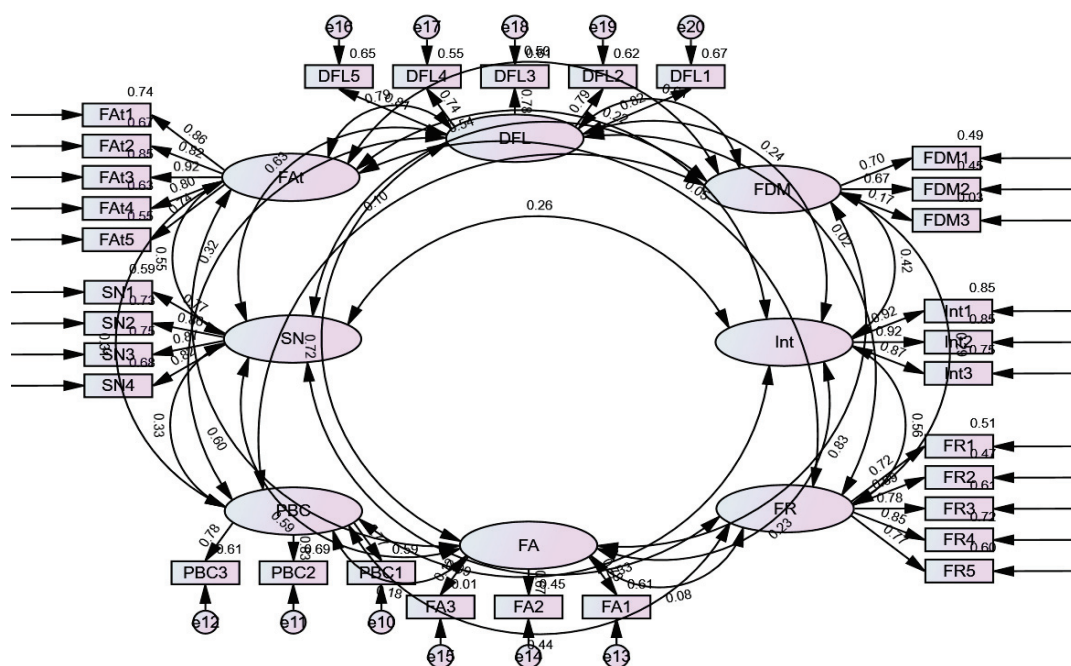


Figure 4. The measurement model.

Now, having found satisfactory convergent validity for each of the study constructs, an assessment of discriminant validity was performed. As suggested by (Hair et al. 2010b), discriminant validity is achieved if the square root of the AVE values exceeds the inter-construct correlations. The results of this analysis are presented in Table 2, which suggests that each construct is different from the other, and hence, discriminant validity is verified.

Table 1. Reliability and convergent validity analysis.

Construct and Item	Standardized Estimate	Sig.	CR	AVE	Cronbach's Alpha
Financial Attitude					
FAtt5	0.745	***	0.815	0.69	0.913
FAtt4	0.795	***			
FAtt3	0.921	***			
FAtt2	0.82	***			
FAtt1	0.862	***			
Subjective Norms					
SN4	0.823	***	0.898	0.689	0.821
SN3	0.869	***			
SN2	0.857	***			
SN1	0.768	***			
Perceived Behavioral Control					
PBC1	0.768	***	0.836	0.629	0.86
PBC2	0.831	***			
PBC3	0.78	***			
Financial Accessibility					
FA1	0.779	***	0.86	0.523	0.89
FA2	0.671	0.035			
FA3	0.716	***			
Digital Financial Literacy					
DFL5	0.805	***	0.891	0.621	0.903
DFL4	0.744	***			
DFL3	0.784	***			
DFL2	0.788	***			
DFL1	0.817	***			
Financial Decision-making					
FDM1	0.702	***	0.836	0.609	0.845
FDM2	0.867	***			
FDM3	0.765	***			
Intention Towards Investment					
Int1	0.921	***	0.93	0.815	0.923
Int2	0.922	***			
Int3	0.865	***			
Financial Resilience					
FR1	0.716	***	0.874	0.582	0.916
FR2	0.688	0.029			
FR3	0.779	***			
FR4	0.848	***			
FR5	0.772	***			

Note: *** = significant at 1%, CR = composite reliability, AVE = average variance extracted.

Table 2. Discriminant validity results.

Construct	FA	Fat	SN	PBC	DFL	FDM	Int	FR
Financial Accessibility (FA)	0.629							
Financial Attitude (FA _{tt})	0.604	0.831						
Subjective Norms (SNs)	0.593	0.551	0.830					
Perceived behavior Control (PBC)	0.298	0.308	0.327	0.793				
Digital Financial Literacy (DFL)	0.668	0.601	0.633	0.323	0.788			
Financial Decision-making (FDM)	0.631	0.496	0.539	0.491	0.613	0.567		
Intention towards investment (Int)	0.551	0.444	0.558	0.331	0.236	0.421	0.903	
Financial Resilience (FR)	0.562	0.452	0.503	0.439	0.521	0.289	0.562	0.763

Note: Off-diagonal elements represent inter-construct correlations, whereas the diagonal elements represent the square root of the average variance extracted.

4.4. Path Analysis and Hypotheses Results

Following a two-step approach (Anderson and Gerbing 1988), the data were examined using structural equation modelling. To do so, data imputation was performed, and path analysis was performed on the imputed values of the latent constructs. Similar to the measurement model, the path model also showed good model-fit diagnostics (Chi square/df = 2.805; CFI = 0.911; NFI = 0.890; TLI = 0.913; GFI = 0.912; and RMSEA = 0.072). This indicated that the model fits well with the data.

The hypothesis results are presented in Table 3. As indicated in Table 3 and Figure 5, all the main effects as proposed in Hypotheses 1–6 were found to be statistically significant ($p < 0.05$) and thus supported. As hypothesized in H1, financial attitude (FA_{tt}) leads to higher financial decision-making (FDM), exerting moderate effects. Similarly, Subjective norms (SNs), perceived behavioral control (PBC), digital financial literacy (DFL), and financial accessibility (FA) significantly lead to financial decision-making (refer to Table 3). All five predictors of financial decision-making explained around 71% of the variance. Finally, financial decision-making exerted a significant and robust effect on intention towards investment (beta = 0.48, $p < 0.05$) and explained 23% of the variance. The results are shown in Figure 5 and in Table 3 below.

Table 3. Hypotheses results.

Hypothesis	Relationship	Unstandardized Estimate	Standardized Estimate	S.E.	C.R.	<i>p</i>
H1	FDM<---FA _{tt}	0.133	0.145	0.045	2.984	0.003
H2	FDM<---SN	0.169	0.221	0.032	5.273	***
H3	FDM<---PBC	0.146	0.198	0.024	6.062	***
H4	FDM<---DFL	0.228	0.243	0.046	4.984	***
H5	FDM<---FA	0.371	0.45	0.037	10.031	***
H6	Int<---FDM	0.762	0.481	0.074	10.285	***

Note: FDM = financial decision-making, FA_{tt} = financial attitude, SN = subjective norm, PBC = perceived behavioral control, DFL = digital financial literacy, FA = financial accessibility, Int = intention towards investment, S.E. = standard error, C.R. = critical ratio. The *p* value is the same for all hypothesis i.e., 0.03. *** = significant at 1%

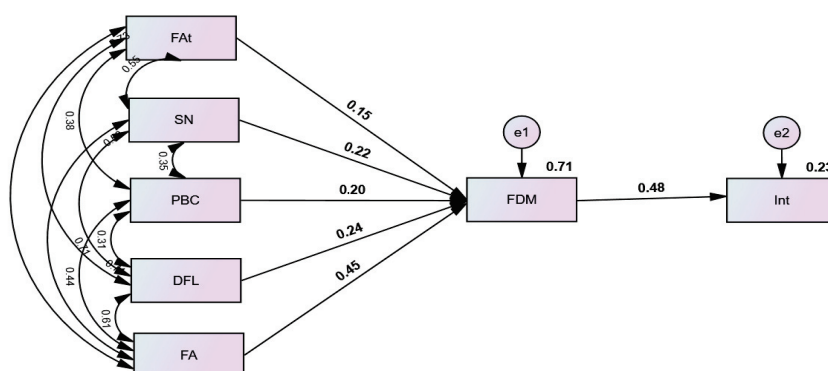


Figure 5. Path model.

Moderation analysis:

One of the proposed hypotheses of the study was to check how financial resilience affects the relationship between financial decision-making and intention toward investment. In statistical parlance, the idea was to test whether the effects of financial decision-making on intention towards investment are moderated by financial resilience. To do so, the SPSS PROCESS macro was used, and model 1 was run in accordance with Hayes (2022). The results showed that financial resilience significantly moderated the effects of financial decision-making on intention towards investment (from Table 4, interaction term = 0.342, $t = 11.7931$, $p = 0000 < 0.01$).

Table 4. Test of moderation.

Effect	Interaction	Beta	SE	T	<i>p</i>	LLCI	ULCI	Moderation
PA → AL_P	Int_1	0.342	0.029	11.7931	000	0.0215	0.0327	Yes

Further, a deeper look at the conditional process analysis shows that the effects of financial decision-making on intention towards investment were highest for those who had higher financial resilience and low for those who had lower financial resilience. These results are summarized in Table 5 below.

Table 5. Conditional process analysis of the values of the moderator.

Relationship	Moderator Values	Beta	SE	<i>t</i>	<i>p</i>	LLCI	ULCI
FDM → Int	Low	0.1539	0.0555	2.77297	0.0031	0.0547	0.2441
	Medium	0.3448	0.0294	11.7279	0000	0.3472	0.4325
	High	0.6086	0.0533	11.4184	0000	0.5157	0.7325

5. Conclusions

Globally, emerging technologies are utilizing alternative data to evaluate creditworthiness, eliminating the requirement for conventional credit records or collateral. As women have a lower likelihood of owning fixed assets compared to males, this is contributing to the narrowing of the gender gap. Insufficient financial knowledge is hindering numerous women from taking advantage of technology advancements. Therefore, it is crucial that we actively advocate for digital literacy initiatives specifically targeting women, as these campaigns aim to develop their abilities and knowledge in this field. Furthermore, by facilitating women's access to financial services, policymakers can open up several possibilities to increase their involvement in the digital realm.

The correlation between the empowerment of women and green microfinance is partially influenced by their level of financial literacy. Local wisdom-based financial literacy is

identified as a viable option for integrating women's empowerment into local development. Furthermore, it is important for gender-specific initiatives to take into account policies that promote literacy in order to achieve long-term sustainability in green microfinance. This study enhances the existing knowledge on the correlation between women's empowerment and green microfinance by including financial literacy as a mediating variable (Lee and Huruta 2022). The inclusion of women in financial literacy initiatives is a significant catalyst for attaining many Sustainable Development Goals. Providing women with equal opportunity for financial literacy results in extensive societal advantages, including poverty alleviation, economic expansion, and gender equity. Consequently, emphasizing inclusivity in financial literacy programs transcends gender concerns and serves as a means to attain sustainable development and mitigate global disparities. Governments should have a pivotal role in advancing green finance by providing policy assistance and fostering partnerships with financial institutions, enterprises, and civil society organizations. Policymakers can foster regional economic resilience by establishing regulatory frameworks, providing tax incentives, and offering subsidies that promote green investments (Wei 2024). To render digital financial literacy genuinely successful and inclusive, it is imperative to incorporate financial and cyber fraud awareness as a fundamental element. Such actions would not only alleviate the threats associated with cybercrime but also enhance confidence and security for women as they engage with the digital financial environment. Failure to overcome this constraint in digital financial literacy programs may render women susceptible to financial exploitation, hence hindering their complete engagement in the digital economy and compromising initiatives aimed at achieving gender parity and financial inclusion in accordance with the SDGs. The reduced reliance on others due to digital financial literacy is a vital aspect of women's empowerment, providing them with autonomy, privacy, and the capacity to make independent financial decisions. Incorporating this element into the research would bolster the case for digital literacy as a vital instrument for achieving gender equality and financial autonomy. It strongly coincides with the Sustainable Development Goals (SDGs) pertaining to gender equality (SDG 5), poverty alleviation (SDG 1), and economic advancement (SDG 8).

6. Implications

With a clear vision for boosting financial capability and inclusion, this research has important implications for policymakers. The ability of policymakers to create and implement policies that produce better outcomes and give people the necessary financial knowledge and skills to survive in the modern world is enhanced. This study offers helpful data that will enable the authorities to concentrate on people's financial literacy and inclusion, which will ultimately lead to their financial independence and contentment. This report offers recommendations on how women in the financial and non-financial sectors should handle money-related decisions and issues. Furthermore, this study provides recommendations to researchers and academicians for improving their comprehension and awareness of the changeable orientation toward finance that the researchers have not thoroughly investigated. India, with a population of over 1.4 billion, serves as a case study for digital and financial inclusion initiatives in emerging economies. Investing in digital financial literacy for women transcends just economic necessity; it serves as a potent instrument for social transformation. The analysis undertaken in India will offer essential insights into the role of digital financial literacy in promoting financial inclusion and advancing the Sustainable Development Goals worldwide. We urge governments, officials, international organizations, and stakeholders to endorse and advance policies that foster a more inclusive and equitable society for women. This plea emphasizes the issue's local importance and global relevance, positioning the research as a crucial advancement in fulfilling the SDGs and fostering gender equality globally.

7. Recommendations and Suggestions

- a. More education campaigns about the advantages of basic banking services should be developed at all levels, particularly in rural and economically underdeveloped areas.
- b. In order to fulfill the goal of conducting these promotional programs—namely, to give basic banking facilities on a bigger scale—the government should make sure that their different programs, such as the “Jan Dhan Yojna”, explicitly reach tribes, especially those living in rural and tribal areas.
- c. If someone truly wants to increase their financial literacy, they must seize the opportunity and make use of the available financial resources. To do so, people must attend an increasing number of workshops, seminars, and financial management courses in their local area.
- d. Banks should use vernacular, regional, and local languages when communicating with customers in rural areas, as this may make information more accessible for women to understand. This is because women’s literacy rates, particularly in rural areas, are meager.
- e. The government should disseminate information about literacy programs, particularly in rural and underdeveloped areas, to enable rural residents to participate and acquire basic numeracy skills, which will aid in their empowerment and the well-being of their families.
- f. Families should discuss matters pertaining to basic finance and money-related issues, particularly with regard to female children. This will help the latter understand the true meaning of empowerment from an early age and help them grasp the fundamentals of financial literacy and its importance for their future.
- g. In order for women to use their earned income more wisely to ensure their future and after retirement, which eventually aids in reaching their financial objective, they need to develop the habit of financial planning as soon as they begin earning and be clear about their long-term financial goals.

8. Scope for Future Work

Addressing current challenges, including cybersecurity awareness, access inequities, behavioral economics, and the influence of innovative technology, can yield more complete solutions for enhancing financial inclusion. Collaborative, international research and longitudinal impact studies can expand the scope, ensuring global significance and promoting inclusive development. Further studies should examine women’s empowerment levels in KSA in light of the UN SDGs and Saudi Vision 2030 (Saudi Vision, Saudi Vision 2030 2016).

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Article

Fintechs and Institutions: Evidence from an Emerging Economy

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Abstract: Institutions play a vital role in restricting or encouraging the performance of any economic agent. In this context, fintechs represent a vector of exponential change in the global financial system and its institutions. However, despite the existing relationship between fintechs and institutions, there is a need for more studies exploring the connections between them. Beginning with a framework that integrates aspects of the relation between fintechs and institutions in the financial system, the objective of this article is to empirically demonstrate the interaction between fintechs and financial system institutions in an emerging country. To do so, the chosen research method was an embedded case study, which involved documental analysis and semi-structured interviews conducted with different agents in the Brazilian financial system, belonging to the following categories: technology providers, fintechs, regulatory institutions, financial institutions, and consumers. The findings validate the applicability of the theoretical framework, highlighting that fintechs drive institutional changes across stakeholders with different characteristic traits. Based on these results, we created theoretical propositions that guide future studies on the topic of fintechs and institutions. This study's contributions provide valuable insights for financial policymakers, regulators, and technology providers, particularly regarding the adaptation of regulatory frameworks and technological infrastructures in emerging economies. For policymakers, this study suggests guidelines to foster financial inclusion through fintech initiatives, while managers are encouraged to develop strategies that reduce operational gaps in digital financial services.

Keywords: fintechs; institutions; institutional change; financial system; Brazil

1. Introduction

Fintechs represent a multidisciplinary object of research that has sparked the interest of financial market managers and researchers from the economic, management, financial, and technological fields (Zavolokina et al., 2016). In the literature, studies about fintechs discuss different topics, such as mobile internet (Feld et al., 2021; Soloviev, 2018); financial inclusion (Velazquez et al., 2022; Joia & Cordeiro, 2021); cryptocurrency (Zetzsche & Preiner, 2018); blockchain technology (Brophy, 2020); and institutional change (Campanella et al., 2022; Deng et al., 2018; Tarkhanova et al., 2018). Regarding the adaptive process of institutions¹ to the dynamism of fintechs, the literature highlights disturbances and, consequently, changes

to the institutional system that are generated by the introduction of new technological concepts (Bukhtiarova et al., 2018).

Due to this dynamism, some innovations brought about by fintechs can present risks to the traditional institutional system (Chiu, 2017). Thus, the analyses referring to fintechs and institutions require more amplitude and depth. In Germany, Ruhland and Wiese (2022) emphasize the relevance of fintech collaboration with both the institutional and financial systems. In Canada, Turcan and Deák (2022) highlight fintechs as a vector that pushes Canadian institutions out of their comfort zone, and they point out the importance of exploring the relationship between fintechs and other agents. In Italy, Campanella et al. (2022) understand that the demands regarding the quality of service provided by fintechs (and their perceived risk) have an impact on the satisfaction of Italian consumers. However, despite fintechs exhibiting similar behavior in similar institutional contexts, our study is directed towards understanding this economic agent in other institutional contexts. Upon identifying this gap, Hassan et al. (2023) began the analysis in another institutional context, more specifically, that of Islamic economies. There is no doubt that studying fintechs in other unexplored institutional contexts can increase understanding about this subject, as such, the present study.

The present study focused on an empirical analysis of the Brazilian institutional system. Although analyses regarding fintechs and institutions are topics evaluated in countries with developed economies (Ruhland & Wiese, 2022; Turcan & Deák, 2022; Campanella et al., 2022), it is rare to analyze institutional arrangements and structural changes in emerging economies (Doré & Teixeira, 2023). These countries exhibit specific social and economic characteristics, such as social inequality (Amar & Pratama, 2020). and political instability (Vianna & Mollick, 2018), unlike developed countries. In this sense, the choice of Brazil is justified since, despite exhibiting these characteristics, it is an important emerging country, and it holds particular relevance for market operators, policymakers, and individual investors (Maciel, 2023).

More specifically, we selected the Brazilian financial system for three reasons. Firstly, Brazil is the largest economy in Latin America, with a GDP of 1.894 trillion USD in 2022 (IBGE, 2023). Secondly, the Brazilian financial system exhibits a solid and robust structural organization, meaning that the probability of systemic risks is low, even in critical contexts (da Rosa München, 2022). Finally, since Brazil is a part of the BRICS, it represents a growing economy and counts on a resource exchange framework in order to be a part of this economic block. In fact, the PWC's economic prediction report singles out Brazil as potentially being one of the five main global economic powerhouses in 2050 (Hawthornthwaite et al., 2017). In this sense, an empirical analysis of the Brazilian context presents aspects that can be replicated in other developing countries with institutional structures that are able to adapt to financial technologies.

Thus, the objective of this article is to empirically highlight the interaction between fintechs and financial system institutions in an emerging country. Although the academic community seeks to systematize the relationship between fintechs and institutions through different perspectives (Ruhland & Wiese, 2022; Bellardini et al., 2022; Feld et al., 2021), this study will use the framework systematized by Tello-Gamarra et al. (2022) as its base, since it presents an integrative approach regarding the agents, stages, and the process of change brought on by the fintechs in the financial system institutions. This analysis will be developed through a case study involving 15 agents of the Brazilian financial system, belonging to the following categories: *technology providers, fintechs, regulatory institutions, financial institutions, and consumers*. This study's development included rounds of semi-structured interviews based on an extensive literature review and the analysis of documents available online, such as institutional documents and reports.

This study differs from the other empirical studies about fintechs and institutional perspectives in three ways. Firstly, we utilize a framework that integrates multiple aspects that exist between fintechs and institutions. In this sense, this empirical analysis presents multifaceted aspects concerning the fintech phenomenon in an institutional context. Secondly, previous studies identified specific aspects concerning fintechs and institutions. However, this article is not limited to the study of these two economic agents, integrating evidence from three other economic agents (technology providers, consumers and financial institutions) involved in the Brazilian financial system. Thirdly, this is a boundary study that integrates aspects of finance, management, economics and sociology. Based on this integration, it presents structural proposals regarding the process of institutional change brought on by the fintechs.

2. Fintechs

Through digital transformation and access to technology, the financial market has experienced a recurring entrance of new agents. Considering this, fintechs appeared with the aim of filling gaps pertaining to transaction costs and financial service and product accessibility (Rabbani et al., 2022b; Thakor, 2019; Sylla, 1998). Thus, the study of the fintech phenomenon appears to be evolving since, with the advancement of information technology, the operational activities and data-processing capacity of these new economic agents tend to grow exponentially (Rabbani et al., 2022a; Rehman et al., 2022; Thakor, 2019).

Fintechs translate into a vector for the generation and optimization of business models in the financial system (Zavolokina et al., 2016). They use digital resources to provide consumers with financial services and products with higher aggregated value (Hassan et al., 2022; Zachariadis & Ozcan, 2017). Thus, fintechs present financial innovations to users from different economic layers (Senyo et al., 2021; Uddin et al., 2020). However, despite fintechs earning their space in the market, defining the term “fintech” is still a controversial subject matter, with the result that there is still a lack of consensus regarding this agent’s definition (Puschmann, 2017; Zavolokina et al., 2016).

The term “fintech” is derived from the combination of the terms “financial” and “technology”, which generically represents the connection between modern technology and the financial services sector (Gomber et al., 2017). Due to the wide range of activities that fintechs can encompass, Tello-Gamarra et al. (2022) categorized the term fintech based on three perspectives: products and services, firms, and financial system agents. Based on this categorization, they defined fintechs as “*The main agents in the process of innovation within the financial system, which use technology to provide consumers with different financial resources*”.

As for the interaction between fintechs and institutions, since it involves the actions of the main agents in financial system innovation, it is relevant to identify in the literature how this process of institutional change occurs. Based on this, it is possible to identify the impact of fintechs on institutions and how this change occurs due to the appearance of fintechs. Thus, describing an integrative approach clarifies in a more encompassing manner how the stages of institutional change occur.

2.1. Institutions: An Integrative Approach

Institutions have the complex task of predicting, managing, and strategically governing the behavior of different actors in the market (Voigt, 2013). North (1990) clearly states that institutions are crucial for restricting and encouraging human activities as well as stimulating economic development. However, understanding the behavior and relevance of institutions is a complex matter (Berger & Luckmann, 2016).

The studies regarding institutions discuss the fact that market institutionalism stems from a determinist structure of organizations (Giddens, 1984; Meyer & Rowan, 1977;

DiMaggio & Powell, 1983). Meyer and Rowan (1977) define this structuring of institutional practices as myths that structure the social behavior of agents in a specific market for them to survive. DiMaggio and Powell (1983) see this institutionalization as an isomorphism, which protects organizations from the market's social pressures. However, despite being protected from external pressures, DiMaggio (1988) points out that new firms have specific interests and beliefs that can encourage institutional change.

In this sense, Douglas North (1991) brought about a perspective that considers institutional change to be a relevant factor in market optimization and transaction cost reduction. This change can represent the appearance of new practices in a sector and the creation of new rules in a specific market (Seo & Creed, 2002; North, 2005). In the financial system, fintechs can represent the vector for these rules, since North (1990) described the market as a “game” and defined the institutions as “the rules of the game”. Furthermore, he described the organizations as players and considered that institutional adaptation to new market trends represents changes to the rules of this game.

North (1990) described the process of institutional change towards an increase in market performance. Thus, through a structure of incentives, institutions build tacit knowledge, which culminates in a phenomenon known as institutional learning. This learning contributes to a change in the habits and customs of market operators, bringing about new informal rules. These informal rules are institutionalized and formalized. And so, the agents of the market can maximize their performance, reduce transaction costs, and, consequently, improve their economic performance (see Figure 1).

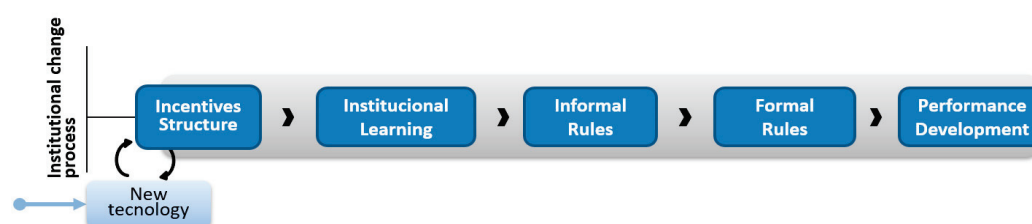


Figure 1. Process of institutional change. Source: Adapted from North (1990) and Tello-Gamarra et al. (2022).

Upon evaluating the role of fintechs in this system, Tello-Gamarra et al. (2022) created a framework integrating fintechs and institutions. In this sense, there are four dimensions that are considered responsible for the process of institutional change brought on by fintechs. As such, this process stems from the interaction between the different “players” and emerging technologies, supporting the search for understanding the impact fintechs have on the “rules of the game”.

2.2. The Evolutionary Process of Institutional Change Brought on by Fintechs

Upon evaluating fintechs as a pivotal point for changes in institutions, we identified the quest undertaken by researchers to map these changes through economic, political, and sociological approaches. The technology brought by fintechs creates an evolving change in institutions within the financial system. In the last few years, different models have been developed to explain this interaction between fintechs and institutions. These models were proposed by Bellardini et al. (2022), Ruhland and Wiese (2022), Takeda and Ito (2021), Bollaert et al. (2021), Gomber et al. (2017), and Tello-Gamarra et al. (2022).

Bellardini et al. (2022) investigated how financial institutions react to digital transformation through the direct investment channel and the regulatory structure's impact on the choice of financing tools. Ruhland and Wiese (2022) emphasized the collaboration of fintechs, considering their financial returns, reputation, and credibility in the financial system. Chen et al. (2023) stated that the fintech sector acts as a net risk receiver and

evaluates risk transmission at an institutional level. C. C. Lee et al. (2023) analyzed the impact mechanisms of fintechs in commercial banks, constructing the fintech development index through the dynamic panel-generalized model of moments. Takeda and Ito (2021) reviewed the types of firms that boost fintechs and the benefits derived from innovations brought on by fintechs. Bollaert et al. (2021) summarized how fintechs affect access to financing and the regulatory challenges presented by services such as fintech lending (including peer-to-peer lending), crowdfunding, and ICOs (initial coin offerings). Meanwhile, Gomber et al. (2017) reviewed topics regarding fintechs and digital finances on three dimensions: business functions, technology, and technological concepts and institutions created to offer solutions.

In this study, we will use the framework proposed by Tello-Gamarra et al. (2022) for three reasons: Firstly, these authors systematized the literature pertaining to institutions in categories, they systematized the literature that discusses fintechs alongside institutions, and they presented potential connections with agents of the financial system. Secondly, the authors exhibited an approach integrating the dimensions that systematize literature on fintechs and institutions and the variables that comprise these dimensions, as well as their interaction with the other agents of the financial system when an innovation appears in the market. Thirdly, Tello-Gamarra et al. (2022) highlighted the need for empirical validation of this framework in different institutional contexts, as these generate political and management implications regarding institutional adaptation in extreme contexts (see Table 1).

Table 1. Dimensions and variables of institutional changes due to fintechs.

Dimensions	Variables	References
Dematerialization of access	• Digital literacy • Access democratization • Financial inclusion	Hadad and Bratianu (2019) Jünger and Mietzner (2019) Ozili (2018) I. Lee and Shin (2018) Cumming and Schwienbacher (2018) Petrushenko et al. (2018)
Operational architecture	• Facilitation of P2P resources • Financial Incentives • Elimination of intermediaries • Smart contract creation	Chen and Bellavitis (2020) Jiang et al. (2018) Brownsword (2019) Soloviev (2018) Shkodina et al. (2019) Shkarlet et al. (2018)
Transactional regulation	• Integration of regulatory technology • Integration of regulatory platforms • Integration of regulatory authorities	Gomber et al. (2017) Yang and Li (2018) Irwin and Dawson (2019) Brownsword (2019) Bukhtiarova et al. (2018) Romanova et al. (2018)
Transactional efficiency	• Shared economy • Security in operations • Technological risk management	Zveryakov et al. (2019) Zetzsche and Preiner (2018) I. Lee and Shin (2018) Kraus et al. (2020) Tarkhanova et al. (2018)

Source: Tello-Gamarra et al. (2022).

According to the review conducted by Tello-Gamarra et al. (2022), the dimensions are systematized in the following manner: Dematerialization of access has to do with the capability of users to conduct transactions without formal intermediaries, such as physical

banks. Operational architecture pertains to how financial operations occur. Transactional regulation refers to the measures that protect operations from risks related to operational changes in transactions. As for transactional efficiency, it has to do with the functioning of financial operations and how fintechs improve them. In this systematization, the authors described how a new technology promoted by fintechs goes through four sequential stages (see Figure 2).



Figure 2. The evolutionary process of institutional change brought on by fintechs. Source: Tello-Gamarra et al. (2022).

Tello-Gamarra et al. (2022) described how the appearance of a new technology interacts with a structure of incentives and dematerializes access to financial services. After that, the market's operational architecture is modified and integrates new resources for consumers. These resources become informal rules in the market, but the rules are formalized through the process of transactional regulation. These new rules increase the market's transactional efficiency, and the economy begins to have an increased availability of capital.

The higher availability of capital is important for the process of institutional change since this capital, if translated into financial incentives, can promote investments in research and development. Thus, the fintechs exhibit important interactions with agents of the financial system throughout this process, since the interaction of new technologies with a structure of incentives and knowledge leads to institutional changes (North, 1990). In this sense, the framework that systematizes this process of institutional change is proposed by Tello-Gamarra et al. (2022), connecting agents and dimensions as seen in Figure 3.

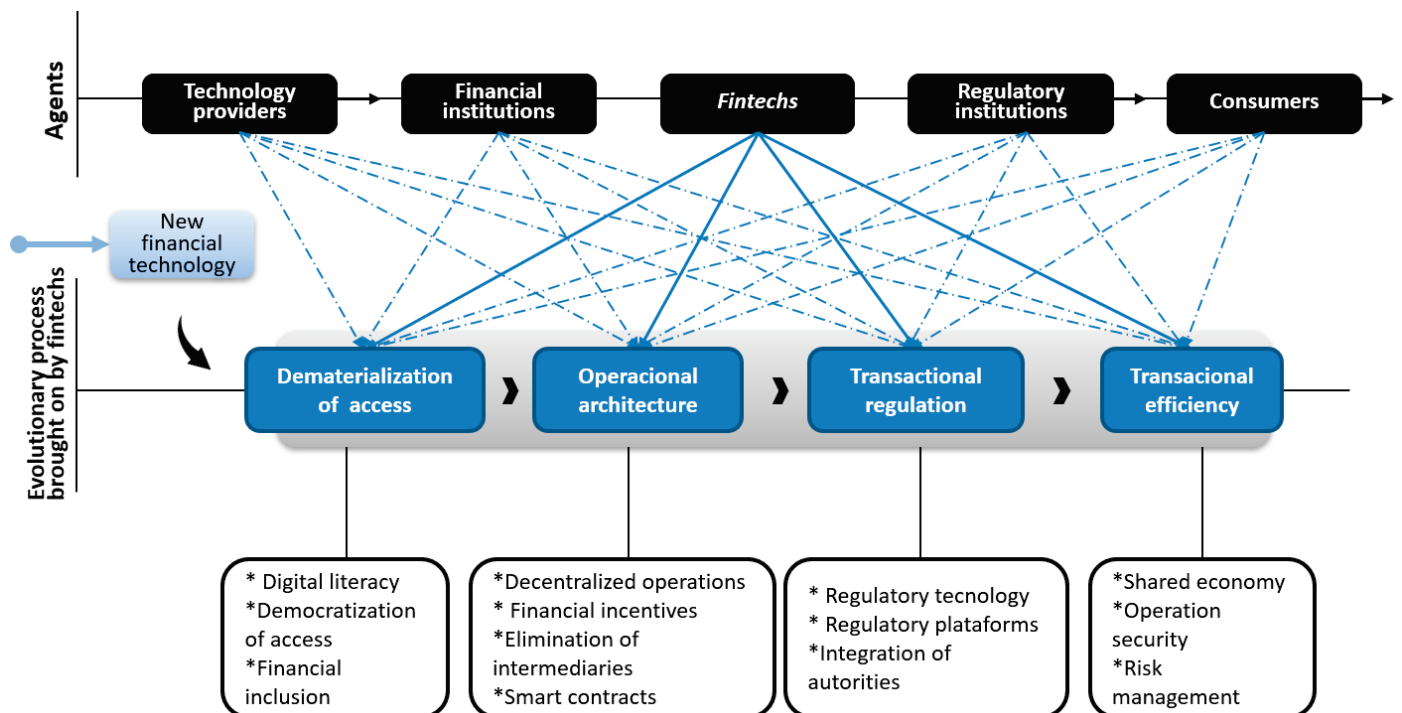


Figure 3. The evolutionary process of institutional change due to fintechs. Source: Tello-Gamarra et al. (2022).

To validate this framework, these dimensions were empirically analyzed with the involvement of representatives from each agent involved in the process. Through the validation of the described dimensions and variables, it is possible to qualitatively describe how fintechs and financial system institutions interrelate, generating institutional change.

3. Method

With the goal of identifying empirical evidence of interaction between fintechs and institutions in an emerging country, we conducted an embedded case study based on Yin (2014). This study followed the following stages: research design, case characterization, data collection, and results analysis and summary (see Figure 4).

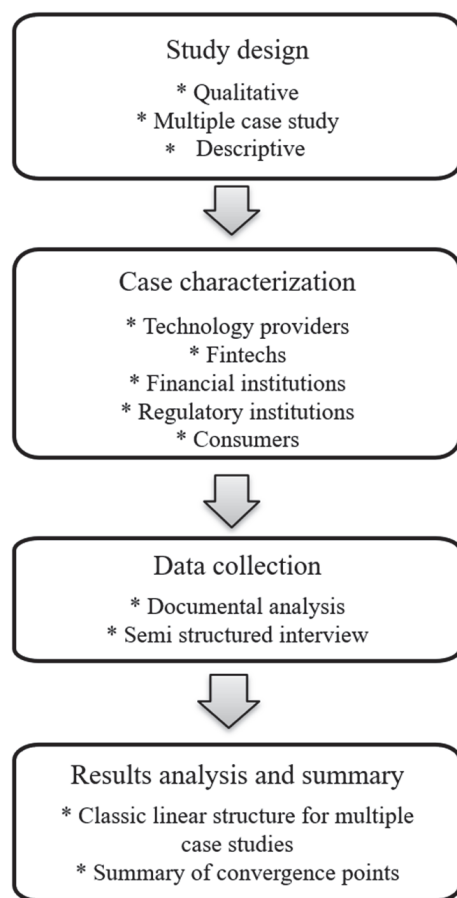


Figure 4. Summary of the methodological process. Source: Created by the authors (2022).

3.1. Study Design

This study method has been defined as an embedded case study. An embedded case study involves the examination of subunits of analysis that compose a single unit of analysis (Fletcher & Plakoyiannaki, 2011). According to Yin (2018), it is necessary to rely on a holistic data collection strategy for studying a main case, which is the Brazilian financial system. Thus, we collected data about subunits of analysis.

This study is descriptive and qualitative in nature, seeking to describe characteristics of a phenomenon occurring in an emerging country's financial system. It is qualitative because it allows us to understand certain phenomena from the perspective of participants that are a part of this environment, in this case, agents from the financial system. It is descriptive due to its usefulness in demonstrating the dimensions of the phenomenon, which in this case is the appearance of fintechs. This study analyzed the Brazilian financial system as a representative of an emerging country.

Regarding institutional arrangements and structural changes, this study is peculiar, as it analyzes emerging economies (Doré & Teixeira, 2023). These countries exhibit specific social and economic characteristics, such as social inequality (Amar & Pratama, 2020) and political instability (Vianna & Mollick, 2018), unlike developed countries.

3.2. Case Characterization

To conduct this study, the main economic agents (embedded cases) of the Brazilian financial system (holistic case) were selected from the following categories: technology providers, fintechs, financial institutions, regulatory institutions, and consumers. Each agent was questioned regarding the theoretical dimensions of our study, which are: Dematerialization of access, operational architecture, transactional regulation, and transactional efficiency. To select the five economic agents, we defined inclusion criteria for each type.

Technology providers: Technology provider firms were selected in accordance with the following criteria: (i) being active in Brazil; (ii) conducting their activities at the nationwide; (iii) providing resources that are applicable in the financial market. In these firms, executives in the CTO (Chief Technology Officer) position provided more detailed data.

Fintechs: To select the fintech managers, we considered both of the following criteria: (i) operating at the national level; and (ii) belonging to one of the five different categories of fintechs according to the *Fintech Map* created by Finnovation (2019). Among the five categories, we selected the following sectors due to their relevance: Digital banks, Payments, and Investments. Considering this, the different categories provided a multifocal view of the proposed institutional change process.

Financial institutions: The three types of financial institutions that were selected are (i) Banks and Savings Banks; (ii) Credit cooperatives; and (iii) Securities brokers and distributors. The choice to select one representative from each model operating in the Brazilian financial system had to do with the amplitude of the aspects pertaining to fintechs and institutions.

Regulatory institutions: In the analyzed financial system, the Brazilian Central Bank (BCB—Banco Central do Brasil in Portuguese) is the main regulatory institution. In this sense, we selected managers from different departments within the BCB. Since the BCB is composed of nine departments, we selected the following departments according to their relevance to our research topic: (i) *Department of the Central Bank's Financial System Regulation* (DENOR); (ii) *Department of Cooperatives and Non-Banking Institution Supervision* (DESUC); and (iii) *Department of Financial Market Competition and Structure* (DECEM).

Consumers: Finally, we selected the consumers based on the following criteria: (i) being private individuals; (ii) being Brazilian; (iii) using the services of a fintech at the moment of this study; (iv) having a college degree; and (v) belonging to different social classes. These criteria allow users to make multifocal comments about the topic with a good level of detail, due to their education.

Since we selected three representatives for each of the five economic agents, 15 total participants were selected. While the absolute number of participants may appear limited, their relevance stems from their prominent roles and activities at the national level. It means that their institutional power and their structure are enough for the understanding of how the Brazilian institutional system works. Moreover, the depth and comprehensiveness of the interviews conducted further substantiate the adequacy and significance of the selected sample. Information about the economic agents' representatives who were interviewed appears in Table 2.

Table 2. Participants information.

Institution	Position	Headquarter	Characteristics
Technology providers			
Technology provider 1	Co-Founder and CTO	São Paulo, BR	SAAS platform provider
Technology provider 2	Edge Specialist Senior Manager	California, US	Edge computing full stack platform
Technology provider 3	Co-Founder and CTO	São Paulo, BR	SAAS platform provider
Fintech			
Fintech 1	Founder and COO	São Paulo, BR	Digital Bank
Fintech 2	Founder and CEO	Florianópolis, BR	Investment
Fintech 3	Founder and Senior Advisor	São Paulo, BR	Payment
Regulatory Institution			
Regulatory Institution 1	Senior Advisor at DENOR	Brasília, BR	DENOR
Regulatory Institution 2	Technical Manager at DESUC	Brasília, BR	DESUC
Regulatory Institution 3	Associate Director at DECEM	São Paulo, BR	DECEM
Financial Institution			
Financial Institution 1	Cooperative Business Manager	Rio Grande do Sul, BR	Credit Cooperative
Financial Institution 2	Senior Operations Specialist Manager	Madrid, ES	Banks and Savings Banks
Financial Institution 3	IT Application Development Manager and Business Specialist	São Paulo, BR	Securities brokers and distributors
Consumers			
Consumer 1	Entrepreneur	São Paulo, BR	Entrepreneur
Consumer 2	Research Fellow	São Paulo, BR	Earns twice the minimum wage
Consumer 3	Student	Rio Grande do Sul, BR	Earns minimum wage

Source: Created by the authors.

3.3. Data Collection

We defined the data collection process in two different stages: documental analysis and an interview conducted with managers in the field. We conducted the documental analysis through a systematic document review procedure (for both printed and electronic documents). Based on a theoretical review, we created a semi-structured questionnaire to interview the agents. The interviews were conducted with managers from different levels of governance within the company. As an analysis strategy, we conducted a corroboration of the findings (Yin, 2018; Mills et al., 2010). Corroboration consists of the cross-checking of two sets of collected data. In our case, we collected documental data and cross-checked it with the data collected in the interviews. If any data were missing at the time of the interviews, we asked support questions as reinforcement in order to precisely define the results. In this sense, the quotes present in this document result from the cross-checking of the collected data.

The documental analysis consisted of a process to review and evaluate different aspects of the financial system. Based on theoretical references, a semi-structured protocol was established. This protocol was developed with open-ended questions which permit the collection of information about different aspects of fintechs and institutions. In the first stage, different documents were used to conduct a systematic analysis. These documents consisted of letters, news items, reports, and manuals. Afterwards, with the intent to reduce research bias, we cross-checked these data with that of the questionnaire given to the 15 interviewed managers until we reached theoretical saturation. The questionnaire was created based on the selected framework and an exhaustive literature review.

The interview questions were organized in blocks. Each block contained a general question and various specific ones. In order to not confuse the interviewee, each general question was accompanied by specific questions pertaining to each of the major research

topics. When the data (documents and responses) did not match, support questions were added until theoretical saturation was reached. According to Mills et al. (2010), gathering and analyzing evidence from multiple sources is recommended for enhancing the quality of case studies. The corroboration of findings from two different data sources adds validity to the issue of interest. During the interview, once one topic was finished, the next one began. All the interviews were recorded and transcribed afterwards. After this stage, a content analysis was conducted to codify the relevant information within a structured perspective. Any information that was unclear was clarified through follow-up questions.

3.4. Data Analysis and Summary

All the data obtained in the interviews were stored in a database to be transcribed and analyzed. Through the interview script, the data were structured within a coherence pattern denominated by Yin (2014) and Mills et al. (2010) as the classic linear structure for embedded case studies. We categorized and grouped the main information from each group of agents based on their respective discourses.

The categorization was composed of three rounds of codification. These three rounds were used with the intent to identify clusters of information based on the quotes from the interviewees. The first-tier codes consisted of the specific identification of relevant quotes for our study. These quotes were broad and literal regarding the interviewees' statements. The second-tier codes were aligned with the dimensions identified in the literature. In this sense, the codification was aligned with the results of the variable analysis presented in Table 1 for each of the interviewed agents. Finally, the third-tier codes consisted of clusters that grouped the second-tier codes into the most relevant macro points within each of the variables. These points represent the main findings from each dimension.

4. Findings

In this section, we present and analyze the findings we obtained in the study. Considering this, this topic is divided into an analysis of the four dimensions based on each of the interviewed agents' individual viewpoints. Thus, subdimensions were identified and described in each set of interviews.

4.1. Dematerialization of Access

Regarding the process of dematerializing access to financial products and services, we highlight a structure of incentives for agents to follow the market's digital transformation process. Due to this process, the financial system exhibits a general concern with presenting artifices that ensure the user is present in this non-material market. In this sense, the dimension of dematerialization of access has digital literacy, access democratization, and financial inclusion as its variables, and its findings are presented in Table 3.

Table 3. Findings pertaining to the dematerialization of access dimension.

Variables	Digital Literacy	Democratization of Access	Financial Inclusion
Technology providers	- Financial education in a digital environment - Mapping users' needs - Gamification of financial operations.	- Adapting financial assets - Final consumer access - Small business access	- User trust - Profile analysis - Availability of financial products
Fintechs	- Breaking down the bureaucracy of financial services - Knowledge of digitalized processes - Incentives from the fintechs	- Modifying the financial operation system - Symmetry and centralization of information in platforms	- Changes in service provision - Conducting social measures geared towards inclusion.

Table 3. Cont.

Variables	Digital Literacy	Democratization of Access	Financial Inclusion
Regulatory institutions	- Digitalized population - Taking the financial system to the people - Digital infrastructure	- Changes in physical infrastructure - Impact on the payments market - Impact on the credit market	- Change in the users' social structure - Impact on the payments market - Impact on the credit market
Financial institutions	- Attention paid by financial institutions to final users - Adaptation of the other market operators	- Increased availability of the platforms - Open Banking	- Low-cost financial products - Volume of financial product users
Consumers	- Transition from the analogical to the digitalized market - Traditional users' adaptive process	- Influence of new financial products on consumers - Access for users from different social classes	- Internet used for financial services - Internet used to access information

Source: Created by the authors.

4.1.1. Digital Literacy

Regarding digital literacy, the five agents emphasized the need to establish a flow of digital information going to the users. In their interviews, different forms of digitalization were pointed out, as well as knowledge of digitalized processes, financial education in a digital context, and the adaptive process undergone by users in a digitalized market within this variable. Financial Institution 2 stated the following:

“A long time ago, talking about applications was something that people only understood as savings, fixed income, something that was barely explored. Nowadays, in the financial market, anywhere you go online [...] everything talks about the financial market in a very detailed manner that everyone understands”.

4.1.2. Access Democratization

As for the process of democratizing access to financial services, all the agents highlighted the restructuring of the financial environment and its impact on users from different social classes. When access is democratized, users consume different financial products to which they previously had no access. Financial Institution 2 pointed out that this availability of platforms and digital operations brings about the possibility of democratized access to financial services and products. He explains that

“It is a single channel on the platform to which everyone has the same access. The platform is the same for all. So if I want credit, I go there and I see if there is credit available to me, just like any other person, regardless of social class”.

4.1.3. Financial Inclusion

As a consequence of having access to financial services and products, consumers and small businesses undergo a process of financial inclusion, in which access to credit and financing is equally distributed. In this sense, the cost of accessing financial products goes down, and the structure for supplying financial products changes. Technology Provider 2 highlights the role played by technology in this process, stating that

“The point is to give people without access to credit, access to certain financial products that can benefit them... And what do we do for them? We make their applications more secure and efficient. The larger the public they can reach, the more need they have to hire us, so we have indirect gains”.

Thus, due to web resources, the boundaries for the public with access to financial cards and products is increased by the internet, regardless of the brand.

4.2. Operational Architecture

In the context of the transformation of the financial system's operational architecture, the interviewees presented the adaptation of strategies, processes, negotiations, and operations to a digitalized structure to make them competitive and current. Such findings were exhibited by the dimensions of facilitation of P2P resource facilitation, financial incentives, elimination of intermediaries, and digital contracts (see Table 4).

Table 4. Findings of the operational architecture dimension.

Variables	Facilitation of P2P Resources	Financial Incentives	Elimination of Intermediaries	Smart Contracts
Technology providers	- Change in business environment - Digital management	- New processes due to digital resources and partnerships - Reduction in agency and operational costs	- Facilitation of contract execution - Operation cryptography	- Contract execution - Contract cryptography
Fintechs	- Changes in the technological domain - Dynamism of operations	- Influence of authorities on the appearance of new financial activities	- Changes in service provision - Digitalization of payment methods	- Reduction in regulatory framework - Emergence of digital signatures - Changes in the flow of resources
Regulatory institutions	- New operations - New banking correspondents	- Incentive for operational improvements - Exploration of opportunities	- Insertion of digitalized communities - Desire from institutions to migrate to a digital environment	- Digital signatures
Financial institutions	- Elimination of physical currency - Increase in competition - Acquisition of other fintechs	- Payment intermediation means - Process improvement	- Changes in the agency operation model	- Introduction of a technological base in the financial system
Consumers	- Appearance of new processes in the financial system - New model for taxing operations	- Availability for intermediation - Integrity of intermediation	- Economy of resources	- Economy of resources - Control of financial information

Source: Created by the authors.

4.2.1. Facilitation of P2P Resources

As for the measures facilitating decentralized transactional resources, the dominance of technology in the transactional environment created changes pertaining to the protocols of communication between companies. In a communication of a transactional nature, for instance, PIX (PIX is a payment method created by the Central Bank of Brazil to transfer funds between accounts instantly, at any time, and without cost) became a highly used payment method in the Brazilian market. Fintech 2 states that *“Currently, almost all of our communication happens with API (Application Programming Interface) integration, and that was one of the changes PIX brought, changing the communication protocol”*. It is through fintechs that peer-to-peer payment resources can expand.

4.2.2. Financial Incentives

Within a digitalized market, financial incentives are needed for the incorporation of technologies in a more robust manner by a higher number of agents. Among the agents, it was possible to demonstrate the appearance of opportunities for partnerships and the improvement of processes due to the presence of digital resources, which reduce agency costs. For example, Technology Provider 1 understands that these new processes bring about the opportunity to reach markets that have not been touched yet, as described in the following statement:

“For the actual entrepreneurs, you begin to notice that there is the opportunity for a partnership with a certain market that you wouldn’t have access to by yourself. You end up providing the final users with more opportunities, which to them translates into lower prices, more products, and more offers”.

These new market opportunities function as financial incentives, as they make it possible to increase client’s portfolios and the processes that are carried out. However, the interviewee understands that Brazilian regulations use these rules in an attempt to protect possible intermediaries in these operations.

4.2.3. Elimination of Intermediaries

The financial intermediary elimination indicator demonstrated that the facilitation brought by technology connects users directly to service providers without the need for intermediaries. In this sense, the agents pointed out that the institutions are in the process of migrating to a digital environment, with decentralized operations and a reduced number of resources. Regulatory Institution 1 highlights this migration process:

“Now, also based on new regulations, there are other infrastructures in the financial market that belong to depositary registers which are also going digital. There is increased competition with new companies currently acting in this field”.

4.2.4. Digital Contracts

Regarding the appearance of digital contracts, the interviews emphasized the factors of reduced time for contract execution, cryptography, and digital signatures. Through these factors, an entire regulatory base is modified to validate this new contract model. Regulatory Institution 3 explained the rules that link digital contracts to the acquisition of CCBs (Banking Credit Notes) in credit operations. Despite CCBs being an extrajudicial executive title, it is possible to obtain them digitally, thus acquiring them from the bank. Regulatory Institution 2 emphasizes the concern institutions exhibit regarding the integrity of these contracts. He states that

“Of course, the institutions are concerned about frauds. So, they have to specialize themselves in this operation model [...] there are advanced systems that conduct identity and identity theft verification”.

Through these supervision systems, it is possible for new processes to be created in the market. As for the dimension of operational architecture, Table 4 summarizes the incentives, variables, and findings of this dimension, which supports new processes that need regulation.

4.3. Transactional Regulation

Regarding the appearance of a new model of transactional regulation, all the agents stated, in different ways, that after the appearance of a structure of informal rules, there is a need to regulate these rules. In this sense, with the intention of conducting the regulatory

process, fintechs operate through the interaction between technologies, platforms, and regulatory authorities (see Table 5).

Table 5. Findings regarding the transactional regulation dimension.

Variables	Integration of Regulatory Technologies	Integration of Regulatory Platforms	Interaction Among Regulatory Authorities
Technology providers	- Defense of government platforms - Used for informational exchanges	- Control of user information - Automation of the authorities' services	- Authorities' limitations regarding management - Authorities' limitations regarding operations
Fintechs	- Security in processing operations - Managing the market alongside the authorities	- Direct interaction with the Central Bank - Open banking	- Regulatory landmarks - Regulatory chamber activities
Regulatory institutions	- Improvement by regtechs - Improvement by suptechs - Reduction in regulatory costs	- New standards of platform-based operation - BCB data management	- Integration of information through API - Change in supervision methods
Financial institutions	- Increase in the latency of financial technologies - Increase in the volume of transaction	- Information input - Formation of partnerships	- Digitalization of closing processes - Use of digital resources in transfers to regulatory authorities
Consumers	- Management and customer service conducted by fintechs - Use of biometry to validate operations	- Transparency of operations - Reduction in operational problems	- Smart reports - Incorporation of technologies from fintechs

Source: Created by the authors.

4.3.1. Integration of Regulatory Technologies

When asked about regulatory technologies and their integration into the financial system, the agents emphasized that these tools represent an important instrument for monitoring institutions' internal and external operations. As such, by using technology, it is possible to map the operations conducted by the users, as well as the institutions' internal operations, with regtechs and suptechs in improving the institutions' activities and reducing regulatory costs.

Regulatory Institution 2 states that: "We use many regtechs and suptechs based on artificial intelligence and machine learning in the credit and treasury departments". Regulatory Institution 1 points out that these technologies "make it easier to supervise things remotely, without needing to be physically present at an agency or institution to conduct the supervision", which makes it easier to conduct the BCB's work. Considering this, Regulatory Institution 3 mentioned that regulatory costs went down by more than 90% after the introduction of regulatory technologies.

4.3.2. Integration of Regulatory Platforms

Regarding the interaction between regulatory platforms, fintechs appear to be important resources for the interrelation between platforms, regulatory authorities, and consumers. In this sense, the main points mentioned in the interviews were the automation and direct management of the platforms with the Central Bank and the open banking movement.

Thanks to technology, it is possible to integrate information from different platforms on the same website, which has been made more popular by the open banking movement. From an open banking perspective, the agents highlighted the benefits of regulatory platforms concerning partnership formation and the feed of information that is available. Fintech 2 points out that the payment flow is gradually changing. In this sense, the financial system begins to deal with a model of operations that does not require the direct action of

regulatory authorities. Furthermore, open banking is presented as a regulatory landmark where the platforms are connected to an instantaneous payment layer. Fintech 2 states that:

“I do not believe that the regulation itself was broken. It will be broken later on due to open banking. Because we changed this model of transaction percentage fees to a model of transaction fees. . . And the fintechs are the driving force behind this cost reduction”.

In summation, fintechs see themselves as vectors for the open banking movement, in which they can connect with all institutions and offer services with a greater reach.

4.3.3. Integration of Regulatory Authorities

Among the results obtained pertaining to the integration of regulatory authorities, the agents emphasized the importance of digital resources in the processes of system closing and sending information to regulatory authorities. In this sense, the technologies represented essential factors for data collection by the Central Bank of Brazil (BCB) and file exchanges.

Within the digital processes, some of them were cited by the interviewees, such as the integration of information through APIs. The BCB has direct access to the integration of client data (Banks) and data from companies (varying sectors) to manage and supervise it. Furthermore, new resources, such as cookies, artificial intelligence, and biometry, were cited by the consumers. From the perspective of perceived usefulness, Consumer 1 emphasized the use of artificial intelligence for management and customer service when stating that: *“artificial intelligence is always there. It does not depend on that specific time, between 10 a.m. and 3 p.m., it’s there 24 h a day”*. And Consumer 3 cites the use of *“biometry to validate operations”*. However, all of them believe that there is still much to be developed in this market.

Considering this, the agents suggested a boost to increase competitiveness in the Brazilian financial market. The Central Bank paid attention to this factor when it created a department of competition in the financial market, since competition encourages efficiency in the Brazilian market. Table 5 summarizes the different approaches taken by the agents of the financial market regarding the perspectives discussed in this dimension.

4.4. Transactional Efficiency

When asked about the transactional efficiency dimension, the agents explained that, after formal regulation, there is the need to improve processes. In this sense, the fintechs interact with the institutions to promote transactional efficiency through the shared economy, operation security, and technological risk management (Table 6).

Table 6. Findings pertaining to the transactional efficiency dimension.

Variables	Shared Economy	Security in Operations	Technological Risk Management
Technology providers	- Evaluation systems - Integration among users	- Posture of the players in this market - Data protection	- Technology related to information leaks - Filling the user knowledge gap
Fintechs	- Improvement of financial resources - Modification of the traditional transactional model	- Cybersecurity usage - Adherence to the LGPD	- Optimization of risk exposure
Regulatory institutions	- Impact on the payments market - Spread optimization	- Open banking - Data protection measures	- Regtechs as a vector of risk management
Financial institutions	- Modifications to customer service	- Banking secrecy - Biometry	- Higher profitability of investments - Presence of robots

Table 6. Cont.

Variables	Shared Economy	Security in Operations	Technological Risk Management
Consumers	- Massification of technology in the financial system - Generation of trust among the users	- Evaluation programs - Control over a large volume of data	- Mechanisms for preventing virtual crimes - Increased traceability of the financial market

Source: Created by the authors.

4.4.1. Shared Economy

As for the shared economy, the interviewees emphasized that technology decentralizes the current transactional model. In the interviews, we highlighted the change in the flow of financial resources with group payments and shared operations and their impact on the banking spread, bringing about a modification of the transactional model.

As an example, Regulatory Institution 3 details this change in the transaction model and flow of resources:

“There are many things in the banking spread that the financial institution must cover. One of them is the institution’s own costs, its funding costs, deposit costs, and operational costs. . . Then, if you compare it with the banks, there are the opportunity costs, inflation costs, the operation’s liquidity premium. For the fintechs, this type of operational cost matters the most. So operational costs were significantly reduced. And not just fintechs, but any institution that decides to invest in digitalizing its processes ends up getting returns pertaining to its costs”.

4.4.2. Security of Operations

When asked about the security of operations, all participants emphasized that, among the security aspects of the current market, data security plays an important role. In this sense, all interviewees cited the importance of the General Data Protection Law (Lei Geral de Proteção de Dados—LGPD) in maintaining banking secrecy of information.

For example, Regulatory Institution 3 states that due to the LGPD, in an ecosystem containing open banking, there is the matter of consenting to the sharing of the information used in the transactions, leading to the existence of a whole technical part geared towards how data are shared in open banking.

Furthermore, the agents cited resources such as biometric registration, digital authentication, and evaluation systems supporting this digital management model. These resources help users feel safer, as stated by Consumer 2:

“My mother raised me, telling me to not talk to strangers. Now, I get into an unknown person’s car just because he has five stars. . . So I think that technology plays a fundamental role in creating this bridge and this confidence”.

4.4.3. Technological Risk Management

Within the logic of technological risk management, the agents cited technological advents, such as the appearance of regtechs, robots with artificial intelligence for conducting financial analyses, and operation cryptography. In this sense, the findings connected to this variable are applied to IT governance models. Technology Provider 3 mentions measures pertaining to this governance model:

“We try to work with cryptographed client data, which makes it much more difficult for others to access our base. Double authentication is a factor that also helps customers protect themselves in their operations”.

Thus, with resources such as artificial intelligence, the market tends to reach increasingly higher levels of efficiency. In this sense, there is the appearance of a culture of innovation in the financial system geared towards the continued increase in its efficiency. Table 6 presents the findings pertaining to transactional efficiency.

Within the section that describes the impacts of fintechs on the other institutions of the financial sector, it was possible to highlight that there is support for an innovation culture, which leads to new rules being institutionalized. In this sense, the increase in economic performance is brought on by automation and risk management. This performance ensures that the system as a whole has resources to provide a number of incentives. In this study, it was possible to note that in the long term, this economic structure provides incentive for a general change within the system.

5. Contributions

The findings contribute with a set of insights pertaining to the agents that are present in the financial market and interact directly with fintechs. This information is discussed and compared to the current status of the research. In the comparison, the data are categorized to validate the framework base, which integrates the perspectives of the five agents in the four dimensions. Considering these results, propositions are made based on the described analyses.

5.1. An Integrative Framework

Based on the findings, we found evidence of the four dimensions present in the framework developed by Tello-Gamarra et al. (2022), which are present in the Brazilian financial system. They appear in a cyclical manner. When each new technology, process, state or strategy appears in the market, the same cycle repeats itself (Hodson, 2021). This cycle is repeated for all agents but in a sequential manner, and the appearance of innovations in this market represents a source of ignition.

From the moment innovations enter the market, technology suppliers are responsible for transforming this innovation into material technology that is applicable in the market (Chen & Bellavitis, 2020). The implementation of new technological concepts is faster in agents with a more flexible institutional structure. In this sense, fintechs represent agents that have a stronger tendency to implement these new concepts, due to their organizational model being based on the implementation of technologies in the financial sector (Rahman et al., 2025).

As the fintechs validate the applicability of a new technological concept, a new, informal rule emerges in the financial market. In response to the stimulus generated by the validation of this informal rule, regulatory institutions develop an adaptive structure to formalize this new rule. Consistent with Muganyi et al. (2022), this adaptation process indicates an institutional response to technological incentives, demonstrating the relevance of regulatory technologies (regtechs) in shaping institutional structures. Thus, the regulatory institutions exhibit the four dimensions in the process of adapting current regulations to fintech activities.

This new institutional environment, which includes new technological concepts formalized by the regulatory institutions, accelerates the market. These concepts permit the growth of competitiveness between new entrants and traditional institutions. This competitiveness aligns with assertions in the literature highlighting fintechs' ability to reduce informational asymmetries and operational costs, thereby promoting market competitiveness (Huang et al., 2020). In this sense, financial institutions adjust their operations to this new market context, which enables a consumer service delivery model that competes with

organizations that have a higher level of institutional flexibility. For this adjustment to happen, the financial institutions go through the four dimensions.

Finally, consumers, in general, begin to have access to said financial service, promoted both by fintechs and traditional institutions. This process happens faster for those who consume these financial products through fintechs since, due to their flexible structure, they are able to offer innovative services earlier. When these services are formalized and offered by all financial institutions, the more conservative consumers begin to exhibit evidence of the four dimensions in their practices. In this sense, fintechs have the capability to swiftly democratize financial resources, especially benefiting lower-income and previously underserved segments (Carlos et al., 2024; Qureshi et al., 2021). Figure 5 shows a more detailed framework of this process within the logic of the different agents, considering the dimensions that were previously mentioned.

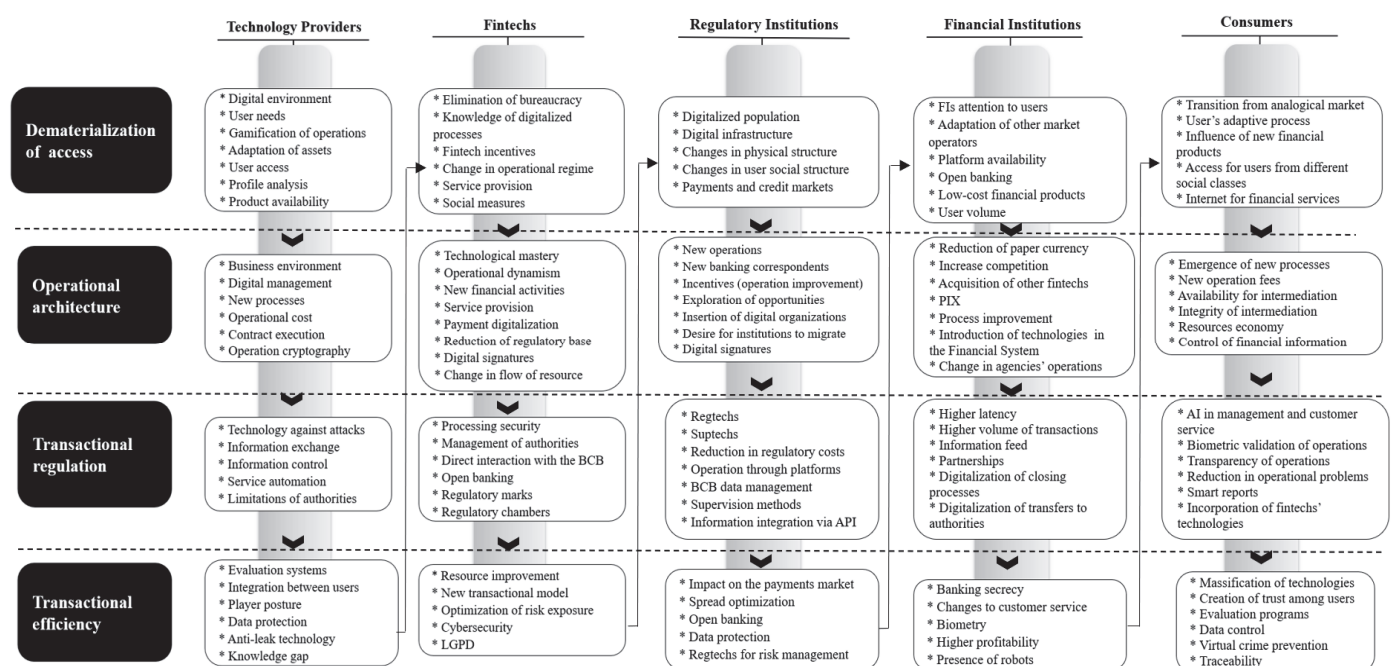


Figure 5. Framework results. Source: Created by the authors.

In fact, all four dimensions are reflected in all financial system agents in the process of institutional change. This process may originate from an external impact on the institutional system, such as the introduction of a new technology, or it may be endogenous, such as the development of a new process.

In both cases, the four dimensions are present in all of the agents. Since the agents are heterogeneous, the results exhibited distinct characteristics for each of them, which were classified among the characteristics explained in this document. Due to the heterogeneity of the five agents and the specificity of their practices, the four dimensions present characteristic traits in their results. Thus, each dimension has a specific characteristic tied to the findings of each type of agent. These traits demonstrate that the findings from the four dimensions may present the dominant traits of learning, digital structuration, strategy, accessibility, or security (Figure 6).

In the dematerialization of access dimension, the technology providers present characteristic traits pertaining to digital structure, as they highlight the structuring of a digital environment, gamification of operations, asset adaptation, and product availability. The fintechs exhibited characteristic traits linked to strategy due to the change in operational regimes, elimination of bureaucracy, and social measures geared towards user inclusion. The answers from representatives of the Brazilian regulatory institution showed character-

istic traits connected to the digital structure, emphasizing changes in the physical structure for providing financial products, as well as in the social structure of digitalized product users. The characteristic trait highlighted by the financial institutions is that of accessibility, since they emphasize open banking, platform availability, and financial products with lower costs. The consumers presented characteristic traits of learning, since they highlighted the user's adaptive process, the transition from an analogical market to a digital one, and the access to this technology for users from different social classes.

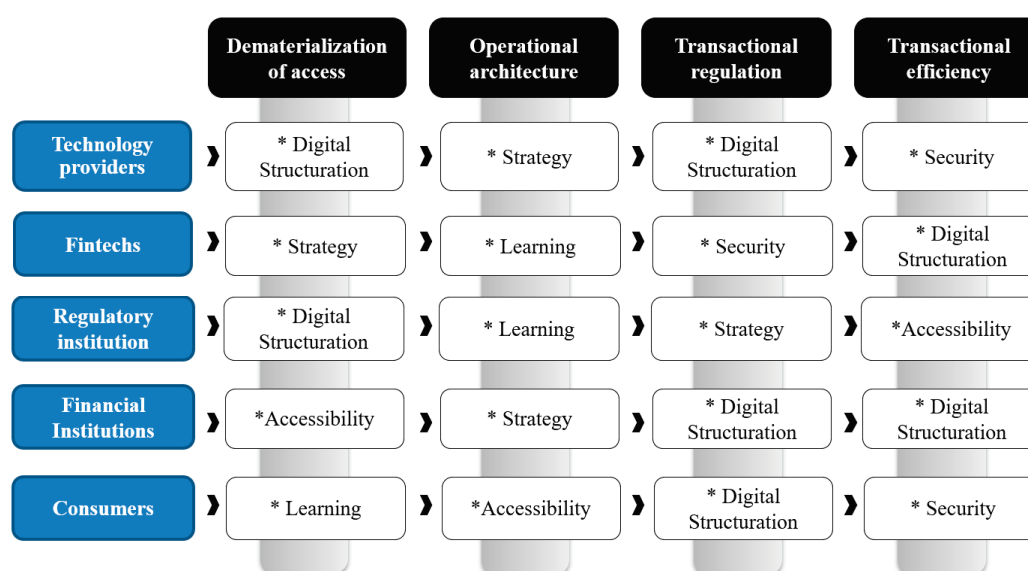


Figure 6. Characteristic traits of the findings from each dimension per agent. Source: Created by the authors.

Regarding the operational architecture dimension, the technology providers presented traits pertaining to strategy when they demonstrated changes in the business environment, digital management, the optimization of contract execution, and operation cryptography. As for the fintechs, their answers contained traits that characterize learning, considering the technological domain, payment digitalization, the use of digital signatures, and changes in the flow of resources. The departments of the regulatory institution also highlighted learning through new operations, new correspondents, and the exploration of new opportunities. The financial institutions exhibited strategic traits in this dimension as they discussed the elimination of paper money, the acquisition of other fintechs, the implementation of the decentralized payment method (PIX), and changes to the operational model. The consumers' answers highlighted traits pertaining to accessibility, such as changes in operational fees, integrity in intermediation, control of financial information, and the economy of material resources.

As for the transactional regulation dimension, the technology-provider firms included in their findings pertain to counter-attack technology, service automation, and improving control of information, with their answers trending towards digital structure. The fintechs' answers showed traits linked to security, with points such as authority management, regulatory chambers, and secure processing. The regulatory institutions exhibited traits tied to strategy, such as the reduction in regulatory costs, information integration (using APIs), platform operation, and the implementation of regtechs and suptechs. The findings connected to the financial institutions show traits linked to digital structure, such as transfer digitalization, as well as processing and structuring for higher latency in operations. The consumers mentioned points such as the use of artificial intelligence in customer service

and biometry for validating operations, with answers that reflected the characteristic traits of digital structuring.

Finally, in the transactional efficiency dimension, the answers given by the technology providers showed traits pertaining to security, with findings tied to data protection, evaluation systems, and anti-leak technology. The fintechs' answers demonstrated characteristic traits of digital structure, including topics such as the improvement of transactional resources and cybersecurity. The Brazilian regulatory institutions' departments exhibited accessibility as the characteristic trait of their answers, discussing points such as open banking, spread optimization, and risk management by regtechs. The financial institutions presented digital structure as the characteristic trait of their answers, encompassing biometry, the presence of robots, traceability, and digital resources for banking secrecy. The consumers' answers showed traits of security, touching upon evaluation programs, data control, traceability, and virtual crime prevention.

In summation, the framework based on the literature review mentioned in Section 2.2 demonstrated coherence with respect to scientific validity. However, the empirical findings presented in Figure 5 characterize the dimensions according to each agent. Based on such factors, it is possible to clarify that all agents underwent a process of institutional change geared towards an increase in the country's economic performance, with characteristic traits exhibited in Figure 6. Based on these findings, we present three propositions pertaining to the process of institutional change analyzed in this study.

5.2. Propositions

Through the framework used for the empirical analysis, this study detected three propositions pertaining to the evolutionary process of the institutional system caused by fintechs. Firstly, due to the fintechs' accelerated growth, which was strengthened during the pandemic, there was an increase in the flow of user migration from the traditional market to the digital one (Carlos et al., 2024; Conlon et al., 2020; Hassan et al., 2020; Ji et al., 2020; Kim et al., 2025). This growth flow put the institutions in a responsive position regarding the innovations promoted by the fintechs. Thus, we identified a difficulty faced by the institutions in behaving as the protagonists in light of the fintechs in the context of an emerging country, due to their regulatory standards.

Within this study, we noted that the regulations that govern institutions in the financial system are restrictive and, many times, make abrupt changes to their manner of operation impossible. On the other hand, fintechs are included in more flexible regulatory standards, which brings about a series of innovations in the market. Anagnostopoulos (2018) points out that institutions still take perfunctory measures to adapt to fintech growth. However, to the market's benefit, competition can be encouraged by incorporating technology into financial market institutions. Tarkhanova et al. (2018) state that the automated economy fosters institutional changes. Thus, these findings and references serve as base for the following proposition:

Proposition 1. *The financial system's institutions must evolve at the same rate as financial technology.*

Additionally, fintechs have made the financial system's *modus operandi* more dynamic and accessible. In this sense, the offer of financial products is modified, bringing new concepts to the market and to the institutional matrix, especially after COVID-19 (Kim et al., 2025; Chang et al., 2020; Qian et al., 2020; Sahay et al., 2020). These new concepts brought by fintechs force the institutional matrix to operate based on the market's precepts and not on formal regulations (Pazarbasioglu et al., 2020; Zveryakov et al., 2019). These services provided to clients by the fintechs bring about concepts such as self-service

and branchless operations. These concepts are supported by technological tools such as artificial intelligence, biometry, and blockchain, which bring about a change in financial service models (Adamyk et al., 2025; Vives, 2019). This change caused by technology has aspects that are beneficial to consumers, such as inclusion and competitiveness regarding financial services (Xie & Zhu, 2022).

Thus, due to the offer of financial services by fintechs not having to follow such a rigid regulatory model in emerging countries, fintechs can incorporate digitalized operational technologies faster in the financial market (Hassan et al., 2022). These digital resources incorporated by the fintechs have an impact on institutions in the financial market, forcing the regulatory institutions to adapt their statutes to the new model of operation. After this adaptation, these resources arrive at the financial institutions so that they can promote them to their customers. In rigid regulatory contexts, this adaptation only occurs after these operations are formalized by financial system authorities. In this sense, the offering of digital products by fintechs to consumers in an emerging country tends to occur in accordance with Figure 7.

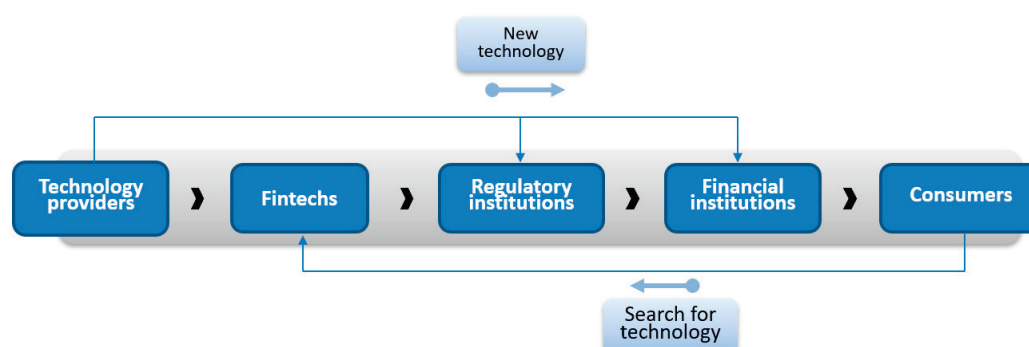


Figure 7. Technology incorporation movement in emerging countries. Source: Created by the authors.

Considering this structure, it is possible to substantiate the following proposition:

Proposition 2. *Consumers of fintech services in emerging countries have access to digitalized products before consumers in the traditional market.*

Finally, it is possible to understand that the financial market has grown and become plural due to this institutional change brought on by fintechs. This study reports that the evolutionary process of institutional change occurs through the dimensions of dematerialization of access, operational architecture, transactional regulation, and transactional efficiency. Stemming from these dimensions, new findings were cited that support the next dimension. These products showed a correlation with the dimensions presented in Figure 1 based on the analyses of North (1990, 1991, 2005), which are based on a structure of incentives, institutional learning, new informal rules, formal rules in the market, and the improvement of economic performance (see Figure 8).

This cycle is presented in Figure 8, demonstrating that the dematerialization of access to financial products occurs based on a structure of incentives. This dematerialization sparks a process of institutional learning in the financial market. The financial system's operational architecture is modified based on this learning structure, generating new, informal rules in the market. These rules undergo the process of formalization through transactional regulation. These formal rules focus on increasing transactional efficiency, leading to an improvement in the country's economic performance. Based on this performance improvement, the institutions will have more resources to structure new incentives in this market. Thus, the cycle repeats itself, and the following proposition appears:

Proposition 3. *The process of institutional change caused by fintechs is cyclical in nature, repeating itself with the introduction of each new technology.*

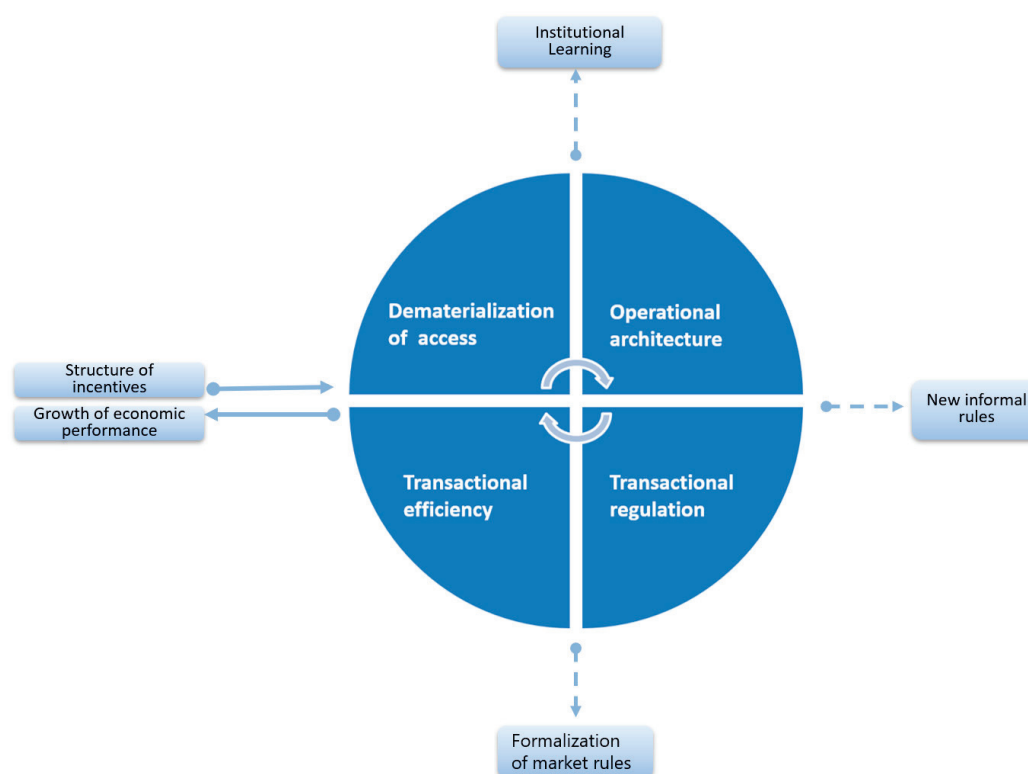


Figure 8. “Evolutionary process” of institutional change brought about by fintechs. Source: Created by the authors.

With new incentives for the introduction of new technologies, the dimensions of the process of institutional change caused by fintechs repeat themselves, interacting with the process described by North (1990). In summation, the different evolutionary dimensions described in this study demonstrate their coexistence with North’s institutional analysis (North, 1990, 1991, 2005). The process of institutional change brought on by the fintechs and geared towards an increase in the financial system’s performance and its dimensions presented important requirements to the institutions in question. Similarly, they involve the institutions’ adaptations to guarantee the financial system’s health. In this sense, this document projects a future research line discussing the topic of fintechs and institutions.

6. Final Considerations

This study aimed to empirically demonstrate the interaction between fintechs and institutions of the financial system in an emerging country, Brazil. To this end, a case study was conducted with different agents of the financial system with the goal of understanding the fintech phenomenon’s impact on the institutional environment.

The first contribution consisted of the empirical validation of the framework proposed by Tello-Gamarra et al. (2022), which describes the change to the institutional model proposed by the fintechs. Since this model evaluates the agents of the financial system from an adaptive viewpoint, this study analyzed how the dimensions appear to each of the agents. This study empirically validated the dimensions and highlighted that for each agent of the financial system, the dimensions exhibit different characteristic traits. These dimensions evolve at the same rate as the financial sector’s technology, which may present new guidance pertaining to the characteristics of each dimension.

The second contribution is the improvement and discussion of the proposed framework. This new discussion used institutional documents in corroboration with semi-structured interviews, conducted until saturation and convergence with technology providers, fintechs, regulatory institutions, financial institutions, and consumers to evaluate the impact of fintechs on their institutionalized activities. Thus, this study highlights evidence of how fintechs can be the vectors for change in each agent's service provision and in consumer experience. Through new technological concepts incorporated by the fintechs, it is expected that this market's evolution will reach unknown levels in the next few years.

Finally, the third contribution was the formulation of three theoretical propositions that substantiate the institutions' behavior in face of the fintechs' evolutionary process. This process is described in detail, identifying the need for a reformulation of the financial system's institutional model due to the incorporation of these technologies. For this reason, the propositions mentioned modifications to the financial system regarding the process of incorporating fintechs into the market and its relationship with the current institutional theory. This study is unprecedented and provides a broad view of how scientific literature has been describing this evolution.

Concerning this study's practical implications, in digital finance, we pointed out implications for public policy and management. Regarding the implications for public policy, digital finance is the fusion of digital technologies and traditional finance, permitting a wider reach that includes populations that had previously been ignored in the financial sector, through a model that is closer, more transparent, efficacious, and efficient (Rao et al., 2022; Jain & Gabor, 2020). In this sense, fintechs can play a central role for sectors that are usually excluded from the system to benefit from the financial system, consequently reducing social inequality. Thus, policymakers can design and implement regulations to encourage the emergence of more fintechs that mitigate the traditional financial exclusion of the lowest economic classes. Furthermore, policymakers can dictate regulations to increase the financial system's transparency and efficiency, which will benefit all agents regarding costs, efficiency, supervision, and regulation.

As for the management implications, and since digital finance allows people and businesses to access payment, savings, and credit services through the internet (online) (Ozili, 2018), (1) fintech administrators can develop strategies to improve their customers' digital financial experiences. As such, they can provide them with services that are more accessible, secure, and inexpensive. On the other hand, (2) financial institution administrators need to learn from fintechs, so that consumers can have broader and better access to their products and services. This decentralized access accelerates the market in a manner that directly affects the liquidity of financial institutions on the market. In this sense, this study helps regarding market positioning, since it reveals that if a financial institution does not advance towards the modernization of its processes, it loses a market share to the fintechs. As for the management issues, (3) this study demonstrates that the legal flexibility fintechs experience in their markets is favorable to the evolution of operations and processes, and it is up to financial administrators to implement strategies to equalize this market.

Regarding this study's limitations, the findings that are presented are related to the adopted research criteria. Consequently, the theoretical base used to formulate the questionnaire was based only on agents that fulfilled the criteria, which may vary in contexts with different criteria. Furthermore, the responses were those of managers and consumers and may have been biased based on the activities performed by the respondents. Another limitation is that the findings are contingent upon the present state of the Brazilian economy, subject to potential shifts in institutional dynamics at the researchers' discretion. Therefore, it is advisable to replicate this study in other emerging economies. Consequently, the

outcomes presented in this research are specific to a particular context and may vary across global regions. Substantiating these data in developed countries may bring up different behaviors. These behaviors may explain more aspects of this new institutional structure. Thus, the suggestion is to compare the proposed framework in different institutional contexts, beginning with an emerging economy and going on to developed economies. Based on this new framework, exploratory and descriptive studies can generate implications for different sectors of the economy.

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Conflicts of Interest: The authors declare no conflict of interest.

Notes

- ¹ In this document, the concept of institutions is directly linked to the rules of the market. As North (1990) defines institutions as “the rules of the game”, the game is the market, in this case, the financial market.

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Article

Corporate Governance and FinTech Innovation: Evidence from Saudi Banks

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Abstract: The rising adoption of FinTech is changing the financial sector. However, the determinants of FinTech have not been examined thoroughly. The purpose of this paper is to examine whether corporate governance is related to FinTech products in the banking sector, given that governance may influence the quantity and quality of innovation. Specifically, we investigate the association between the size of the board of directors, the percentage of independent directors on the board and FinTech services. Furthermore, we show how the composition of the board can influence the association between FinTech services and a bank's performance. Using a sample of 12 Saudi banks for the period 2014–2019, we find that board size is significantly and negatively associated with a bank's FinTech score. We further show that independent members on the board contribute to performance by bringing more FinTech services (innovation development) to the banks. As the first study examining the determinants of FinTech in the Saudi banking sector, this paper may help regulators to better understand the drivers of FinTech and its quality in the banking sector.

Keywords: corporate governance; FinTech services; FinTech firms; Islamic banks; conventional banks; financial performance

JEL Classification: G20; G21

1. Introduction

The importance of FinTech in the banking industry has increased since 2008 as new companies have begun to provide financial services to customers directly, raising the competition for the banking industry (Thakor 2020). In fact, Phan et al. (2020) suggests that emerging FinTech companies could replace banks since they are more effective and efficient. This has pushed the banking industry to give more attention to FinTech, increasing the number of FinTech products over time (Wang et al. 2020; Hornuf et al. 2020). In spite of these developments, the determinants of FinTech quality in the banking industry are hardly understood. To this end, the purpose of this paper is to examine whether corporate governance is related to the quality of FinTech products. Corporate governance is one of the most important mechanisms to assure sustainable development in firms. This includes investing more in innovation, including financial innovation. Many countries, including Saudi Arabia, have updated their corporate governance codes to enhance corporate governance practices and assure that managers act in the best interests of shareholders.

Existing studies suggest that corporate governance mechanisms could reduce agency costs and improve decision making. One of the most important corporate governance mechanisms is the board of directors. Resource dependency theory holds that the board of directors may bring more knowledge and experience to firms, allowing them to manage uncertainty in the external environment and obtain access to important resources (Hillman et al. 2009; Pfeffer and Salancik 2003). In this regard, the board of directors may help banks to develop rapidly in the market, leading them to achieve better FinTech quality.

Alternatively, agency theory focuses on the role of directors in monitoring management and reducing conflicts of interest that may arise from the separation of ownership and management. From this point of view, the board of directors may lead to excessive monitoring, which hinders FinTech quality. To better investigate these possibilities, we focus on two important factors in the composition of boards of directors, namely board size and board independence.

Previous studies argue that the board of directors can bring and influence firms' innovation (Jaskyte 2009; Wu and Lee 2007). King (1992) states that leadership brings new innovation to firms. Members on the board may plan for strategic changes (including initiating innovation) to improve the firm's performance and to compete in the market (Davis 1991). In this regard, the board of directors might appreciate new FinTech products and facilitate financial technology as a response to the rapid changes in the financial sector.

Even though prior studies assert the importance of the board of directors, there is still a gap in the literature examining the relationship between the board of directors and innovation in banks. Empirical studies on innovation have ignored the characteristics of the board of directors (Markman et al. 2001; O'Sullivan 2000). One of the unexplored areas in this field is the influence of the board of directors on FinTech quality. Therefore, we contribute to the existing literature on innovation by filling this gap, as innovation is well known to be key to firm survival, alongside the fact that a capable board that governs for innovation can bring a competitive advantage to a firm (Miozzo and Dewick 2002).

In this study, we use a hand-collected dataset from 12 listed banks in Saudi Arabia covering a period of 6 years, ranging from 2014 to 2019. Saudi Arabia is rapidly adopting FinTech, as evidenced by the new cryptocurrency "ABER" set between the Saudi Arabia Monetary Authority (SAMA) and the United Arab Emirates Central Bank (UAECB), which requires further examination on the various aspects of FinTech within the region.¹ A number of initiatives have been provided to support the FinTech sector in Saudi Arabia. For example, the Fintech Saudi initiative was launched by the Saudi Central Bank in partnership with the Capital Market Authority in April 2018 to act as a catalyst for the development of the financial services technology (FinTech) industry in Saudi Arabia. The ambition of this initiative is to transform Saudi Arabia into an innovative FinTech hub with a thriving and responsible FinTech ecosystem. Regulators have released a number of amendments to improve the corporate governance codes in Saudi Arabia. These amendments started in 2006, with the last amendment released in 2023.

We find that board size has a negative association with FinTech services, suggesting that a large board may focus on the outward environment rather than the internal environment. Furthermore, this paper shows that independent members on the board contribute to the bank's performance by improving its FinTech quality.

This paper makes several contributions to both the corporate governance and the FinTech literature. First, prior studies have shown an association between corporate governance and R&D performance (Chung et al. 2003), bank performance (Grove et al. 2011) and risk-taking (Aljughaiman and Salama 2019), yet we extend this body of literature by showing the association between corporate governance and FinTech service quality. Second, FinTech studies mainly concentrate on the implication of FinTech for bank performance (Al-Matari et al. 2022; Arena et al. 2023) or risk-taking (Deng et al. 2021). We extend this by examining the determinants of FinTech and show that board characteristics are associated with FinTech services. Finally, this paper extends the analysis by investigating the board of directors' effectiveness in innovation-related decisions.

Our findings have several implications for regulators and banks, as they contribute to the innovation policies and regulation in the financial sector. In particular, and to the best of our knowledge, this is the first paper that empirically shows the association between board characteristics and FinTech services and products in the Saudi banking sector. Such findings may highlight for policy makers and investors the importance of governance as a driver of FinTech in banks, which can be crucial for the competitiveness of banks and the financial sector in the country as a whole.

The rest of the paper is structured as follows: Section 2 reviews the literature and develops hypotheses. Section 3 presents the data and the methodology. Section 4 presents the empirical evidence, and the conclusion is presented in Section 5.

2. Literature Review and Hypothesis Development

2.1. FinTech and Corporate Governance

FinTech relates to the usage of technology to deliver better financial services (Thakor 2020; Goldstein et al. 2019). This innovation should provide a more effective and efficient method to deliver these services. Furthermore, the usage of this technology in the financial sector allows firms in the market to create new financial products such as digital payments, online money transfers, crowdfunding, micro-lending, digital accounts, robo-advisory services, online wealth management solutions and blockchain-based cryptocurrency.

However, empirical studies provide contradicting views on the impact of FinTech on bank performance. This is because innovation is not always productive as many new technologies fail to achieve the goal of providing better financial services.

On the one hand, some studies suggest that FinTech has a positive impact on bank performance. For example, Ky et al. (2019) find a positive relation between FinTech and bank performance. Moreover, Deng et al. (2021) found that the adoption of FinTech reduced risk-taking in banks, which in part came from an increase in a bank's efficiency and improvements in their governance. Similarly, Al-Matari et al. (2022) studied whether board characteristics and FinTech impact corporate performance. They also examined whether or not FinTech moderates this relationship. Examining the financial sector of Saudi Arabia, they found that FinTech is positively associated with corporate performance and that it does not moderate the relationship between performance and board characteristics.

Moreover, Mohd Haridan et al. (2023) argue that the adoption of FinTech enhances the ability of the Shariah Board to provide timely assurance with respect to a bank's compliance with Sharia considerations. This can potentially lead well-governed firms to adopt more FinTech solutions to aid in their governance role in addition to improving performance. Further, Almahadin et al. (2023) argue that the adoption of FinTech may improve the performance of a company through channels such as efficiency improvements and cost saving, enhanced transparency, faster payouts and a reduced likelihood of fraud. Also, Arena et al. (2023) find that FinTech improves a bank's performance, and that better governance reduces the negative relation between FinTech and the riskiness of banks, which may point to a decline in the conflicts of interest. These arguments may suggest that effective boards may accelerate the adoption of FinTech products.

On the other hand, Almulla and Aljughaiman (2021), Beccalli (2005), Alber (2011) and Jalal-Karim and Hamdan (2010) find a negative relationship between FinTech and a bank's performance. More recently, Zhao et al. (2022) found that FinTech has a negative impact on a bank's performance and the quality of their assets, especially in large, state-owned commercial banks.

These conflicting findings highlight the importance of understanding the determinants of FinTech and the factors that can potentially impact the nature of the relationship between FinTech and a bank's performance. One of the possible factors that may control FinTech quality is corporate governance mechanisms. Corporate governance refers to a set of internal and external mechanisms that reduce agency conflicts stemming from the separation of ownership and management (Baysinger and Hoskisson 1990; Shleifer and Vishny 1997). These mechanisms might relate to innovations and high technologies. Davis (1991) argues that corporate governance has an important impact on bringing innovation to a firm. Prior studies report that higher insider ownership and institutional ownership are positively associated with R&D investments (Baysinger et al. 1991). Further, He and Tian (2013) find that stronger analyst coverage is associated with fewer patents and patents with lower impacts, in line with the view that analyst coverage fosters short-termism. In contrast, other studies find that while analyst coverage leads to lower R&D investments, it

pushes firms to make better investments in R&D, leading to better innovations and patents (Guo et al. 2018).

According to resource dependence theory (Hillman et al. 2009; Pfeffer and Salancik 2003), the external environment may affect firm behavior. In detail, firms need to bring in experts to compete with external threats and be able to access external sources. Board members have experience, knowledge, skills, reputation and social relationships. Consequently, an effective board of directors may be able to improve a firm's ability to access critical resources and may bring the most innovative tools to help the firm to compete with their competitors. Therefore, an effective board of directors might be able to enhance a bank's financial technology due to their experience and ability to access outside resources. FinTech can be classified as innovation products that allow banks to meet customer needs, which in turn enhances the bank's reputation and performance. Thus, an effective board of directors might be associated with higher-quality FinTech products.

2.2. Board Size

Board composition contributes to the differences in the amount of environmental uncertainty (Pfeffer 1973; Pfeffer and Salancik 2003). While a large board may concentrate on the firm's goals, objections and strategies, it is also possible that it might be less concerned with these areas and focus on the firm's internal activities. Large boards seem to be more outwardly focused (Alexander et al. 1993). The empirical literature shows that conflicting views exist on the relationship between board size and agency problems and performance. On the one hand, it is possible that larger boards are associated with lower FinTech quality because they can be influenced by the CEO and are slower at making decisions (Cheng 2008; Jensen 1993; Yermack 1996) and coordinating within the firm (Cheng 2008; Wintoki et al. 2012). This is because larger groups may struggle in their internal communication and in reaching the consensus needed to reach critical decisions. Staikouras et al. (2007) find that larger boards are associated with lower profitability in European banks. The same is also found to be true in Chinese banks (Liang et al. 2013).

On the other hand, board members are resources to the firm (Kiel and Nicholson 2003) and increase its pool of expertise (Grove et al. 2011). Arguably, having more resources on the board (i.e., directors) may provide the firm with a wider network, which it can tap into to obtain the required talent and information. Thus, larger boards may lead to better FinTech quality.

As the literature supports two possible directions for the influence of board size on FinTech quality, we suggest a non-directional hypothesis as follows:

H01. *There is a significant association between board size and FinTech quality.*

2.3. Board Independence

Prior studies provide conflicting arguments on whether board independence improves corporate performance. One strand of the literature suggests that independent directors might be related to better FinTech quality as they prevent managers from pursuing their private agendas and short-termism. Lu and Wang (2015) find that independent directors are associated with lower capital investments and higher R&D investments, consistent with the view that independent directors reduce agency problem related to free cash flow. Moreover, board independence could lead to better monitoring and control of myopic cuts to innovation, which are required for improvements in FinTech (Rodrigues et al. 2020). Liang et al. (2013) find that board independence is related to better bank performance and asset quality, while Staikouras et al. (2007) do not find a systematic relationship.

Another strand of the literature suggests that independent directors may know less about the nature of the business, leading to a negative association between board independence and FinTech quality. This possibility might be more pronounced in the banking industry due to its complexity (Grove et al. 2011). This complexity is likely to be greater around FinTech products given their innovative nature.

H02. *There is no relationship between board independence and FinTech quality.*

3. Data and Methodology

3.1. Sample

This study consists of a sample of 12 listed banks in Saudi Arabia, 4 of which are Islamic banks (IBs) and 8 are conventional banks (CBs), for the period 2014 to 2019.² We followed the previous literature to filter the sample (e.g., Aljughaiman and Salama 2019; Beck et al. 2013) as follows: the banks need to (1) have FinTech data; (2) be fully fledged commercial banks; and (3) have three years of data. The final sample includes 60 bank–year observations. Table 1 presents the sample distribution.

Table 1. Sample distribution.

Year	Freq.	Percent
2014	10	16.67
2015	10	16.67
2016	10	16.67
2017	10	16.67
2018	10	16.67
2019	10	16.67
Total	60	100

We obtained the consolidated financial data from the Bloomberg database. The corporate governance and bank FinTech services data were collected manually from the banks' annual reports available on their official websites.³ GDP and inflation variables were collected from the World Bank databases.

3.2. Measurement of Variables

To measure our dependent variable, we used a new approach to assess the quality of the banks' FinTech services. Following Almulla and Aljughaiman (2021), we examined the banks' reports and websites and the previous literature to determine the common FinTech services provided. We obtained a total of 7 FinTech services provided by banks in Saudi Arabia during our testing period: consumable micro-lending, digital payments, digital savings associations, crowdfunding, robo-advisors, blockchain and robo-portfolio management. Consequently, we created 7 dummy variables that represent each FinTech service provided by a bank in a certain year. Finally, we summed up the score for each bank in each year to find a score that expresses the banks' development of new FinTech services every year (2014–2019). For instance, if a bank has a FinTech score of 4 out of 7 in 2015, it means that the bank developed 4 FinTech services in 2015.

For our main explanatory variables, we used board size and board independence to represent the effectiveness of the boards of directors. Following Aljughaiman and Salama (2019) and Mollah and Zaman (2015), we measured board size by taking the total number of board members. We also calculated the percentage of independent members by dividing the total number of independent members in the board by the total number of board members. We controlled for firm-specific variables following existing FinTech studies (Ky et al. 2019; Phan et al. 2020). These include firm size measured using a natural logarithm of total assets (size); bank performance measured by taking the return on total assets (ROAs); the capital ratio, i.e., total capital to total assets (CAP); the market risk measured using the CAPM model (beta);⁴ and Islamic banks by creating a dummy variable that takes the value of 1 if the bank is Islamic, and 0 otherwise (Islamic). The reason we included firm size and performance in our model is that small-sized firms might have limited fund resources, restricting their ability to invest in innovation. Bank financial performance is also one of the important factors that can influence firms' ability to invest in innovation. The capital ratio

and market risk can provide a picture of the level of risk taken by firms, which could affect their investment in innovation. Furthermore, we controlled for country-specific variables, namely the gross domestic product growth rate (GDP) and inflation rate (INF). Please look at Table 2 for more information regarding variable definitions.

Table 2. Definitions and abbreviations of variables.

Variables	Description	Abbreviation
Dependent variables		
FinTech services	Score of bank's usage of FinTech	FS
Independent variables		
Board size	The number of members on the board	BS
Independent directors	The percentage of independent directors on the board	IND
Control Variables		
Banks' performances	Net profit to total assets	ROA
Bank size	Natural log of total assets	SIZE
Capital ratio	Total capital to total assets	CAP
Islamic bank	A dummy that takes the value of 1 if the bank is Islamic, and 0 otherwise	Islamic
Beta	The market risk, computed using the CAPM model using the prior 3 years of returns (monthly)	BETA
GDP	Annual GDP growth rate	GDP
Inflation	Annual inflation rate (consumer price index, CPI)	INF

Note: this table presents the definitions and abbreviations of all variables.

3.3. Estimation Models

We used Pooled Ordinary Least Squares (OLS) to examine our hypotheses. We also controlled heteroscedasticity by taking robust standard errors. Furthermore, we re-ran our model using an ologist approach as our main dependent variable has a restriction value between 1 and 7 and to control for the ordinal nature of the dependent variable (Aljughaiman et al. 2023). It is argued that when dependent variables are ordinal rather than continuous, it is better to use an ordered logit model. We used different classifications of control variables such as firm-specific variables to test the sensitivity of the results. We also controlled for the year fixed effect. Furthermore, we re-estimated our model using the lagged approach to control endogeneity problems.

We used the following models:

$$Fintech\ Services_{it} = \alpha_{it} + \beta_{it}X_{it} + \epsilon_{it}$$

where:

$Fintech\ Services_{it}$ is the bank FinTech score i at time t ;

i refers to an individual bank, and t refers to the year;

α_{it} is a constant;

X_{it} is the independent and control variables;

ϵ_{it} is an error term.

$$Fintech\ Services_{it} = \alpha_0 + \beta_1 BSize_{it} + \beta_2 IND_{it} + \beta_3 CAP_{it} + \beta_4 Size_{it} + \beta_5 ROA_{it} + \beta_6 beta_{it} + \beta_7 islamic_{it} + \beta_8 GDP_{it} + \beta_9 INF_{it} + \epsilon_{it}$$

4. Main Results

4.1. Descriptive Statistics and Correlation

Table 3 presents the descriptive statistics for all the variables used in our model.⁵ The mean value of the FinTech score is 4.61, which means that on average banks provide around five types of FinTech services. The boards of banks in Saudi Arabia consist of

approximately 9 members, and the maximum number of members on a board is 13. The results in Table 3 show that the mean value of the full sample for the independent member percentage is around 45%. Furthermore, the range of this sample is between 11% and 91%. Also, the mean values of the bank size, bank performance, bank capital ratio and bank beta are 10.3, 1.3%, 27% and 1.6, respectively. In addition, 45% of the banks in our sample are Islamic banks.

Table 3. Descriptive statistics.

Variable	N	Mean	p50	sd	Min	Max
FS	60	4.617	5.000	1.786	1.000	7.000
BoardS	60	9.242	9.000	1.868	3.000	13.000
IND	60	0.452	0.429	0.142	0.111	0.909
Size	60	10.393	10.509	1.828	6.391	13.619
ROA	60	1.346	1.580	0.988	−1.833	2.756
CAP	60	0.275	0.253	0.123	0.053	0.796
BETA	60	1.649	0.844	4.606	−6.661	18.825
Islamic	60	0.450	0.000	0.499	0.000	1.000
GDP	60	2.711	2.434	1.471	−0.742	5.106
INF~e	60	1.625	2.018	1.699	−2.093	4.070

Table 4 presents the correlation matrix for all the variables in our model to investigate any multicollinearity problems. The table reveals that there is no strong association between the explanatory variables as there is no coefficient value higher than 80%.

Table 4. Correlation matrix.

	1	2	3	4	5	6	7	8	9
BoardS (1)	1								
IND (2)	0.0674	1							
Size (3)	0.0409	−0.057	1						
ROA (4)	−0.0209	−0.0061	0.4523 *	1					
CAP (5)	−0.1375 *	0.1696 *	−0.4445 *	−0.1006	1				
BETA (6)	0.1138 *	0.0075	−0.0171	0.0603	0.0913	1			
Islamic (7)	−0.1981 *	−0.0018	−0.3055 *	−0.1436 *	0.2043 *	0.0695	1		
GDP (8)	−0.0894	0.0223	−0.2221 *	0.011	0.0733	0.048	0.021	1	
INF (9)	−0.0509	−0.0282	−0.1977 *	−0.0066	0.0805	−0.0688	0.018	0.6109 *	1

Note: Heteroscedasticity—robust standard errors are in parentheses. * $p < 0.1$

4.2. Multivariate Analyses

We regressed the composition of the boards of directors on the quality of the banks' FinTech services. Table 5 presents the results for the association between board size, board independence and FinTech services. Column (1) shows the results using the OLS estimation method, while column (2) shows the same relationship using the Ologit method. Both estimation methods reveal that there is a significant negative association between board size and FinTech service quality. This means that a larger board may negatively affect a bank's innovation by restricting its development of FinTech products. It is possible that larger boards struggle to communicate and reach the consensus needed to make complex decisions. They may also face the free-rider problem as board members over-rely on their peers. Smaller boards are more effective in improving firm innovation and thus developing FinTech services. This is consistent with the study by Alexander et al. (1993). The results also show that the presence of independent members on the board is not related to FinTech services. This is consistent with H02.

Table 5. Regression results: association between BOD and FinTech.

Variables	(1) OLS	(2) Ologit
BoardS	−0.279 *** (0.103)	−0.484 *** (0.185)
IND	−2.035 (1.275)	−2.876 (1.952)
Size	0.0535 (0.276)	−0.0710 (0.514)
ROA	−0.201 (0.372)	−0.313 (0.858)
CAP	−2.631 (5.174)	−0.973 (10.78)
BETA	−0.0162 (0.0322)	−0.0234 (0.0691)
Islamic	0.865 ** (0.377)	2.089 ** (0.823)
GDP	−2.211 *** (0.550)	−4.110 *** (1.195)
INF	0.768 ** (0.331)	1.246 * (0.748)
Constant	12.74 *** (4.123)	−20.74 ** (8.876)
Year effects	YES	YES
Observations	58	58
R-squared	0.666	0.313

Note: Heteroscedasticity—robust standard errors are in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

For the control variables, the bank size, performance, capital ratio and beta show no significant association with FinTech services. Interestingly, the table shows that Islamic banks in Saudi Arabia adopt more FinTech services than conventional banks. Furthermore, GDP growth has a significant negative impact on FinTech services, while inflation is positively related to the latter.

4.3. Additional Test

For a robustness check, we re-ran our model using the lagged approach. This was to control the endogeneity problem that can be created as a result of reverse causality. Therefore, we lagged out the main variables (board size and board independence) for one previous year. The results are presented in Table 6. Nevertheless, we tested the boards' effectiveness in managing bank development and innovation. In other words, we investigated whether the boards of directors' decisions for improving the banks' FinTech services are associated with positive performance. To this end, we assessed the moderating effect of the board of director variables on the association between FinTech services and bank performance. Specifically, we created two additional variables by taking the interaction between the composition of the board of directors and FinTech. We present the results of these tests in Table 7. We find that board size has no influence on the association between FinTech and performance. However, we discovered that the presence of independent members could enhance banks' FinTech quality, and thus increase their performance.

Table 6. Lagged approach.

Variables	(1) FS
l.BoardS	−0.234 *** (0.0766)
l.IND	−1.563 (1.072)
Size	-7.66×10^{-6} (0.295)
ROA	0.0398 (0.393)
CAP	−1.227 (4.263)
BETA	−0.0107 (0.0289)
Islamic	1.141 *** (0.375)
GDP	−1.188 *** (0.265)
INF	0.359 * (0.192)
Constant	10.53 *** (3.759)
Year effects	YES
Observations	49
R-squared	0.674

Heteroscedasticity—robust standard errors are in parentheses. * $p < 0.1$; *** $p < 0.01$.

Table 7. The moderating effect of the board on the association between FinTech and performance.

Variables	(1) ROA
FS	−0.251 (0.352)
BODS_FS	−0.0197 (0.0348)
IND_FS	0.923 ** (0.350)
BoardS	0.0466 (0.153)
IND	−3.554 ** (1.457)
Size	0.496 *** (0.120)
CAP	0.0244 ** (0.0113)
BETA	0.247 (0.156)
Islamic	0.442 ** (0.214)

Table 7. Cont.

Variables	(1) ROA
GDP	−0.230 * (0.127)
INF	−3.583 ** (1.709)
Year effects	YES
Observations	58
R-squared	0.582

Note: Heteroscedasticity—robust standard errors are in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

5. Conclusions

In this study, we investigate the association between the corporate governance and FinTech service quality of banks. Specifically, we examine the association between board size and independence and FinTech services in banks. The growth of FinTech services in Saudi Arabia specifically and the world more generally has motivated this study. The previous literature does not cover the influence of FinTech services on the banking sector. We also extend our analysis to examine the effectiveness of boards in attracting successful FinTech services. Our sample covers 12 Saudi banks for the period 2014 to 2019. We find that the board size has a significant negative effect on the quality of FinTech services. We also show that the presence of relevant members on the board may enhance the bank's performance by adopting new FinTech services.

This study contributes to the existing literature by moving one step beyond the association between FinTech and bank performance. To the best of our knowledge, this research is the first to examine the association between the composition of the board of directors and FinTech services. Our study also examines the board's effectiveness in introducing good-quality FinTech. This paper has implications for regulators and banks, as it is linked to the financial industry.

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Notes

¹ <https://www.sama.gov.sa/en-US/News/Pages/news29012019.aspx>, accessed on 12 June 2022.

² This period was chosen due to the significant increase in FinTech in Saudi Arabia during the past decade (FinTech Saudi 2020). Furthermore, we tried to exclude the effect of COVID-19, starting from 2020. Most firms have been influenced by the pandemic, which might affect their innovation investments.

³ Examples of FinTech services that are provided by banks: consumable micro-lending, digital payments, digital savings associations, robo-advisors, blockchain and wealth management.

⁴ We used the prior 3 years of returns (monthly) to calculate standard deviation.

⁵ We windsorized all variables at 5–95% to eliminate skewness or kurtosis problems.

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Article

FinTech Adoption of Financial Services Industry: Exploring the Impact of Creative and Innovative Leadership

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Abstract: This paper examines the link between creative and innovative leadership and FinTech adoption through the transmission mechanisms of perceived ease of use (PEOU) and perceived usefulness (PU). This study used a questionnaire survey method to collect data from a sample of 721 employees working in the Indian financial services sector. The data were analyzed using structural equation modelling. The study results revealed a significant and positive influence of creative and innovative leadership, PEOU, and PU on FinTech adoption. Moreover, PEOU and PU mediated the link between creative and innovative leadership and FinTech adoption. This study proposes a new vision for managerial procedures to understand the critical aspects regarding FinTech adoption. The study advises that engineering managers should offer simple and user-friendly technology to enhance the adoption rate. Additionally, the results suggest the importance of creative and innovative leadership for competitively exploiting novel technologies. Given India's digital revolution and huge market potential, the FinTech sector could prove a game-changer, especially in generating employment for the young and technologically qualified population. Tech-driven organizations could use the study findings strategically in this digital era.

Keywords: innovation; leadership; technology adoption; perception; survey data; structural equation modeling

1. Introduction

Today's volatile business environments demand that organizations respond proactively in order to survive. Creativity and innovation are effective stimuli to sustain business volatility and remain competitive. Irrespective of the level of competition, a firm's efficiency and success heavily depend on creativity and innovation (Slåtten and Mehmetoglu 2015). Moreover, creativity and innovation (Baker et al. 2016) spur superior corporate growth. Accordingly, researchers have identified and acknowledged many predictors of individuals' creative and innovative behaviour. However, leadership behaviour appears to be the most influential predictor (Shin and Zhou 2003; Nusair et al. 2012; Jyoti and Dev 2015). Therefore, studying creativity and innovation from a leadership perspective becomes imperative.

The role of leadership becomes essential in encouraging creativity and innovation at the individual or group level or generating and implementing a new idea (Csikszentmihalyi 1997). Leadership produces a risk-tolerant environment wherein the organization accepts novel and practical tactics (Simmons and Sower 2012). As well as the successful adoption and implementation of innovation and technology, leaders help to draw out innovation from individuals' creative thoughts (De Jong and Den Hartog 2007). Although researchers have acknowledged the trickle-down effect of leadership on employees' creativity and innovation (Shin and Zhou 2003; Nusair et al. 2012; Jyoti and Dev 2015), relatively less

is known about the relationship between creative and innovative leadership and technology adoption.

Technology forms the backbone of the success of modern businesses. Along with challenging the traditional financial services set-up (McWaters et al. 2015), technology, including financial technology (FinTech), has successfully enhanced the overall performance of organizations (Chen et al. 2021; Liu et al. 2021). Researchers have primarily examined the attributes affecting FinTech adoption from the perspectives of individual users/customers (Cheng et al. 2006; Tan and Leby Lau 2016; Leong et al. 2017). However, the research about the predictors driving organizations' FinTech adoption needs to be more conclusive. The factors driving organizations' FinTech adoption may be internal and external. For example, creative and innovative leadership (the internal perspective) may drive the organization to adopt novel tactics like FinTech.

On the other hand, engineering management (the external perspective) may also be crucial to determining the adoption of FinTech. From the standpoint of engineering management, product specifications become vital in enhancing product attractiveness. Similarly, Singh et al. (2020) have argued that perceived usefulness drives the intention to use FinTech services. Again, ease of use—another product specification—determines the customer's willingness to use a tech product (Davis 1989; Esen and Erdogmus 2014).

The requirements imposed by customers can influence the engineering management process in terms of adding value to the technology, such as FinTech. These requirements are related to user–interface issues, such as ease of use and usefulness. Such factors have forced engineering managers and their respective staff to review production strategies to stimulate end-user acceptance. Accordingly, Opaluch and Tsao (1993) devised ten ways to improve a product's ease of use. These methods include easy maintenance and ease of learning, which also comprise the essential requirements of FinTech users. Furthermore, Opaluch and Tsao (1993) remarked that product engineers and designers can maximize a technology's end-user acceptance by focusing on its usefulness through the identification and validation of the product feature list, the negotiation of interface agreements and reaching a consensus on system requirements and, finally, building software or technology. Enhancing technology adoption and extending the customer base can influence FinTech design and priorities, thus justifying engineering efforts towards achieving user-friendly technology.

Accordingly, Rogers (1983) argued that potential users' willingness to adopt and use a technology determines its success. The limited research has focused on a comprehensive model for highlighting the critical motivations for organizations to adopt FinTech. Accordingly, this study adopted well-established technology adoption theories to examine the relationship between FinTech adoption and its predictors, specifically creative and innovative leadership. We included age and gender as controls based on the prior technology adoption literature (Venkatesh and Morris 2000; Boonsiritomachai and Pitchayadejanant 2019).

Moreover, FinTech has received significant recognition due to its enhanced and efficient client experience, higher risk aversion, and inclusive growth potential (RBI Report 2018). FinTech has seen an enormous adoption rate, i.e., 87%, in developing countries like India, much higher than the global adoption rate of 64% (EY 2019). Moreover, the adoption and awareness of FinTech have significantly increased since 2015 (EY 2019). Regarding finance app downloads, India led the list of the top ten nations in the world in 2020 (EY 2021).

Moreover, innovative technologies like FinTech have brought a disruptive structural change to the financial service industry (McWaters et al. 2015). They have attracted both service (FinTech) providers and users due to their enhanced and efficient user experience. Given these attributes of financial technology, customer demand is significantly growing (see EY 2021). The PWC Report (2017) suggests that FinTech has achieved the easy delivery of financial services and high personalization and flexibility, which ensures a higher reach, efficiency, and profitability (EY 2016).

Because of the above advantages, FinTech has witnessed an enormous increase in user awareness and adoption (EY 2019). Accordingly, the two FinTech potential giant

markets, India and China, witnessed an 87% adoption rate against a 64% global rate (EY 2019). Thus, the tremendous adoption rate renders India an apt example for examining the drivers of FinTech. Moreover, Ernst and Young's (2017) FinTech adoption index claimed that 84% of users knew FinTech services in the 20 markets surveyed, including India. Therefore, this study uses the Indian financial services industry to study the hypothesized relationships. The main objective of this article is to investigate the influence of creative and innovative leadership on FinTech adoption in the financial services industry. The research will also analyze the influence of creative and innovative leadership on perceived ease of use and usefulness of FinTech adoption. A well-structured questionnaire was adopted to accomplish the study objectives. Referring to the statement of investigation above, the following research questions were formulated:

- Q1. Does creative and innovative leadership influence FinTech adoption in the financial services industry?
- Q2. Does creative and innovative leadership influence the perceived ease of use of FinTech?
- Q3. Does creative and innovative leadership influence the perceived usefulness of FinTech?
- Q4. Do the perceived ease of use and perceived usefulness of FinTech mediate the relationship between creative and innovative leadership and FinTech adoption?

The next section of this research study comprises a literature review concerning the effect of various prognosticators on FinTech adoption. The literature review provides the basis for the research framework and hypothesis formulation. It is followed by the section dealing with the methodology and descriptive statistics of the study sample and its variables. After that, the findings are discussed, followed by the implications, conclusion, limitations, and future research directions.

2. Literature Review and Hypothesis Development

FinTech refers to technological innovations concerning financial services (RBI Report 2018) and is an umbrella term representing the delivery and digital assessment (via media) of financial services (He et al. 2017). "FinTech is any technology-enabled financial innovation resulting in new business models, applications or processes or products, affecting financial markets and institutions and provisioning financial services" (Financial Stability Board 2017).

FinTech is an essential medium for measuring the developments in financial systems and institutions. It has offered novel applications for delivering services relating to payments, savings, borrowing, risk management, and financial guidance to make financial services accessible and convenient for customers (He et al. 2017) and, consequently, sought solutions to financial problems based on technology (Saal et al. 2017). Manyika et al. (2016) assert that the cost efficiency of FinTech pushes the acceptance of FinTech across sectors and firms, such as banking, investment, retail, and telecoms operators, among others (Gefen and Straub 2003; Birch and Irvine 2009; Gogus et al. 2012; Zhu et al. 2012; Alalwan et al. 2018; Boonsiritomachai and Pitchayadejanant 2019). Irrespective of the advantages, FinTech adoption is selective (Singh et al. 2020). This gap paves the way for exploring the prognosticators, unexplored transmission mechanisms, and boundary conditions that drive individuals and organizations to FinTech adoption. Accordingly, this study investigates the impact of innovative and creative leadership on FinTech adoption, which is believed to be the significant determinant of technological adoption.

Considering the existing literature using the TAM model for technology acceptance (Davis 1985; Davis et al. 1989; Yang et al. 2012; Kim et al. 2016), this study also uses the TAM model as a theoretical basis (Davis 1985; Davis et al. 1989) to investigate the relationship between innovative and creative leadership and FinTech adoption. Researchers (e.g., Davis et al. 1989; Adams et al. 1992; Gefen and Straub 2003; Sujana 2008) assert that TAM effectively predicts the acceptance of technology and information systems based on the internet, e-services, and online shopping. Again, this signifies the appropriateness of the TAM model for this study.

Further, this study investigates the relationship between innovative and creative leadership and FinTech adoption through the transmission mechanism of perceived ease of use (PEOU) and perceived usefulness (PU). The mediating mechanism of PEOU and PU in technology is chosen as these comprise the basic elements of TAM and influence favourable attitudes towards technology adoption and use (Davis 1985).

Some theories have become standard for the acceptance of technological models. For example, the popular TAMs, such as the TAM 2 or revised TAM model (Venkatesh and Davis 2000) and the unified theory of technology acceptance and use of technology (UTAUT) (Venkatesh et al. 2003). However, TAM 2 and UTAUT found a basis in the theory of reasoned action (TRA) (Fishbein and Ajzen 1975) and the theory of planned behaviour (TPB) (Ajzen 1985, 1991). Thus, these studies further highlight the importance of PEOU and PU in technology concerning technology acceptance/adoption. These technology specifications demand attention from engineers for improved customer acceptance/adoption. Theories like the theory of reasoned action (Fishbein and Ajzen 1975) and planned behaviour (Ajzen 1985, 1991) help engineering managers and designers bridge the gap between customer needs and product specifications. Again, usability engineering can facilitate improved technology adoption through improved product specifications, such as ease of use and usefulness (e.g., Opaluch and Tsao 1993).

Moreover, the TAM model provides the basis for the adoption attributes of behaviour intention (innovative and creative leadership) to adopt FinTech services. Adding prognosticators, such as independent and mediating variables or, specifically, the predictive power of TAM, would enhance the practical implications of the present study (Venkatesh and Davis 1996; Ha and Stoel 2009). Therefore, this study uses TAM and UTAUT to explore the predictors of FinTech adoption through the mediating mechanism.

The TAM model explains how users adopt a technology by evaluating its PU and PEOU dimensions (Abu-Dalbouh 2013). In line with the TAM, researchers (e.g., Davis 1989; Doll et al. 2010; Susanto and Aljoza 2015) assert that PU and PEOU drive technology adoption. Renny and Siringoringo (2013) argued that internet acceptance mostly depends on TAM testing, considering its validity in predicting technological acceptance (Jahangir and Begum 2008). Regarding the weaker side of the TAM, Wallang (2018) posited the model's low explanatory power.

UTAUT offers a candid representation of the drivers facilitating technology acceptance (Wallang 2018) and the comprehensive improvement of the TAM (Venkatesh et al. 2003). Researchers (e.g., Jackson et al. 2013) argued that the theory of planned behaviour is extended via UTAUT, which also acts as an effective instrument to predict technology adoption (Algharibi and Arvanitis 2011; Venkatesh et al. 2016). Thus, the TAM and UTAUT form the basis for the present research model.

2.1. Creative and Innovative Leadership and FinTech Adoption

Creativity implies producing novel ideas, and converting these ideas into actions means innovation (Mumford and Gustafson 1988). To ensure superior performance, organizations focus on creativity and innovation (Drazin et al. 1999). However, Van de Ven (1986, p. 592) asserted that the “foundation of innovative thoughts is creativity”, which signifies that innovation depends on creativity (Amabile et al. 1996; Madjar and Ortiz-Walters 2008). Accordingly, this study takes creativity to be the individual's behaviour(s) in producing new and useful ideas/thoughts and innovation implies implementing creative ideas at the individual level.

The existing literature highlights the significant association between individuals' creativity, innovation, and leadership theories. Generating and implementing novel thoughts in an organization highly depends on leadership (Mumford and Licuanan 2004). Furthermore, the extant literature signifies the role of leadership, specifically transformational and authentic leadership (Howell and Avolio 1993; Avolio and Gardner 2005; Sarros et al. 2008; Al-edenat 2018) and leader-member exchange (Mascareño et al. 2020), in catalyzing creativity and innovation. However, despite the researchers' acknowledgement of leader-

ship as the predictor of creative and innovative behaviour in individuals and employees, less is known about the creativity and innovation of leaders. Along with the creativity and innovation of the group/team members, those of the leadership are essential to business success. Hence, this study examined the impact of leaders' creative and innovative behaviour on technology adoption, specifically FinTech adoption.

Researchers have asserted the significant role of leadership in technology adoption (e.g., Kristianto et al. 2012; Spencer et al. 2012; Liu et al. 2018). Additionally, leadership encourages ways to support innovative thinking (Gil et al. 2005). Technological innovations offer a plethora of affordable, secure, and convenient services, such as the services provided by FinTech (Leong et al. 2017). These technical specifications can prove to be a game-changer for an organization or an economy. For example, Manyika et al. (2016) argued that FinTech could contribute USD 3.7 trillion to emerging economies by 2025.

Similarly, technology is the main focus of the modern financial services industry. Leadership encourages technology adoption in the services sector, such as banking (Naicker and Van Der Merwe 2018). In support of this, Lee et al. (2013) asserted that leadership and imitation quicken technology adoption. Their study attests that leadership can influence employees' attitudes towards adopting the technology. Von Solms and Langerman (2021) argued that a lack of good leadership could lower digital technology adoption in banks. Furthermore, Arifin (2015) argued that entrepreneurial leadership is a significant determinant of technology adoption. The existing literature asserts that technological leadership influences customers' use of technology, specifically online banking services (Salem et al. 2019).

Similarly, leadership is the key driver of technology adoption in other sectors, such as small, owner-managed travel firms (Spencer et al. 2012) and SMEs (Jalil et al. 2022). Bach (2014) argued that innovative leaders are the fastest at utilizing ICT. In addition, leadership is a significant predictor of perceived ease of use and perceived usefulness (Schepers et al. 2005; Kuo and Lee 2011), eventually facilitating technology adoption (Aziz et al. 2020). Accordingly, we hypothesize:

H1. *Creative and innovative leadership significantly influences FinTech adoption.*

H2. *Creative and innovative leadership significantly influences the perceived ease of use of FinTech.*

H3. *Creative and innovative leadership significantly influences the perceived usefulness of FinTech.*

2.2. Mediating Role of Perceived Ease of Use and Perceived Usefulness

Perceived ease of use (PEOU) implies one's perception that operating technology requires less input (Davis et al. 1989) and the extent to which operating technology is easy or free from effort (Venkatesh and Davis 2000). The TAM model asserts that the perceived usefulness (PU) is the magnitude of the belief that technology enhances individual/organizational performance (Davis et al. 1989). Moreover, PEOU and PU have a bearing on individuals' intentions to reuse technology (Davis 1993; Venkatesh and Davis 2000; Venkatesh et al. 2003; Amin 2007). These two constructs significantly influence technology adoption (Venkatesh and Morris 2000; Gefen et al. 2003; Chen and Barnes 2007; Gounaris and Koritos 2008; Tan et al. 2014). In support of this, Venkatesh et al. (2016) argued that the UTAUT model has been mainly used to explore only direct effects and indicated the need to explore the presence of mediating and moderating effects in this context. Again, the literature highlights areas for improvement in the UTAUT model regarding missing factors and the presence of only a few studies that examined the boundary conditions of technology acceptance models (Venkatesh et al. 2016; Wallang 2018).

Davis (1989) asserted that PU and PEOU are central to technology adoption. Esen and Erdogmus (2014) also proposed that PU and PEOU act as a transmission mechanism in the connection between innovativeness and intention to use. Again, Schepers et al. (2005) suggested that leadership styles positively and indirectly impact technology usage through the mechanism of PU and PEOU, which, consequently, prompts technology adoption (Singh et al. 2020). Further, some studies have proposed the indirect effect of PEOU on technology

usage (Schepers et al. 2005), behavioural intention to use (Terzis and Economides 2011; Chen and Aklikokou 2020; Huang and Teo 2020), and technology adoption (Calisir and Calisir 2004) through perceived usefulness. Moreover, PEOU significantly and positively facilitates the perceived usefulness of technology (Calisir and Calisir 2004; Susanto and Aljoza 2015; Abdullah and Ward 2016; Alalwan et al. 2018; Joo et al. 2018). Thus, PU and PEOU are significant mechanisms for facilitating the adoption of technological innovations, such as FinTech services (Jahangir and Begum 2008; Tan and Leby Lau 2016; Laukkanen 2017; Singh et al. 2020). Based on the above discussion, and the proposed study model (Figure 1), we hypothesize:

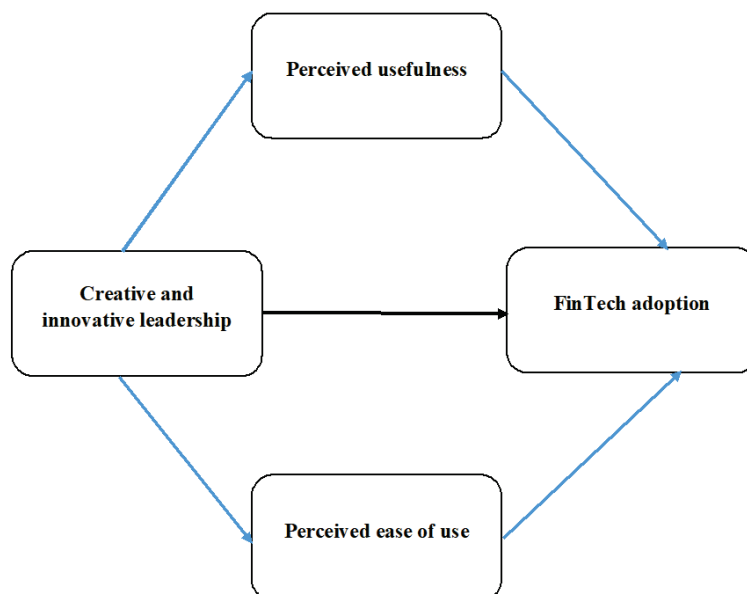


Figure 1. The study model.

H4. *Perceived ease of use significantly influences FinTech adoption.*

H5. *Perceived usefulness significantly influences FinTech adoption.*

H6. *Creative and innovative leadership has a positive and significant indirect effect on FinTech adoption through perceived ease of use (PEOU) (H6a) and perceived usefulness (PU) (H6b) in the financial services industry.*

H7. *Perceived ease of use significantly influences perceived usefulness in FinTech.*

H8. *Perceived ease of use (PEOU) positively and indirectly affects FinTech adoption through perceived usefulness (PU) in the financial services industry.*

In addition, this study involves controls such as age and gender. The existing literature asserts that individual decisions regarding technology adoption vary across age and gender. For example, social pressure less influences older people (Boonsiritomachai and Pitchayadejanant 2019; Tan and Leby Lau 2016), and females are more influenced by others' opinions. Thus, these factors may influence the link between the prognosticators and FinTech adoption.

3. Methodology

3.1. Population and Sample

This study is cross-sectional and was conducted using a questionnaire survey. The data analysis was mainly based on structural equation modelling (SEM), which provides a graphical representation of the study relationships simultaneously via a two-step approach, including measurement and structural models (Anderson and Gerbing 1988). This study was conducted between October 2020 and September 2021. The Indian financial services

sector comprises a variety of financial firms like banks, lenders, finance companies, investment houses, insurance companies, and real estate brokers. Given its wide acceptance in social sciences, we used convenience sampling, ensuring timely accessibility and availability, geographical proximity, and respondents' willingness (Etikan et al. 2016). Convenience sampling was adopted due to the absence of an appropriate sampling frame, on account of which researchers gathered data that was only possible to obtain if it had been. The target population was employees working in different banks and insurance companies in North India. It was not easy to access such a diverse population of interest, so a snowball sampling technique was used to collect responses. The researchers mailed questionnaires to several contacts, who were close relatives of authors, across India, and they helped to organize and administer the survey process across many locations. Before the survey was conducted, participants were informed about the study's intent. This study involved 757 respondents from different banks and insurance companies. Out of 757 questionnaires, 36 were excluded from the analysis as some were missing responses. Therefore, only 721 responses were fit for the data analysis.

3.2. Research Design

The survey questionnaire included two parts: the first collected respondents' demographic information, and the second included the data about the study constructs. A detailed view of these two sections is presented below:

The first section gathered information regarding the participant's age and gender. The second section involves:

Creative and innovative leadership

This construct was measured using Khalili's eight-item scale (Khalili 2017). A sample item from this scale is, "In this organization, leaders encourage employees to develop their ideas".

FinTech adoption

A four-item scale was adapted from Ryu (2018) to measure the FinTech adoption construct. A sample item from this scale is "I would prefer FinTech".

Perceived ease of use

A four-item scale adapted from Davis (1989) was used to assess the perceived ease of use construct. A sample item from this scale is, "I find it easy to get technology to do what I want to do".

Perceived usefulness

We adapted a four-item scale from Davis (1989) to measure the perceived usefulness construct. A sample item from this scale is "Using technology is useful in my job".

This study used a 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree to record the respondents' opinions regarding the study items.

We confirmed the study constructs using two pilot studies before the final data collection—each study included 31 respondents. An exploratory factor analysis (via SPSS 23.0) is followed by a confirmatory factor analysis (via AMOS 21.0) to study the relationships among the study variables. Additionally, the reliability and validity of the study constructs were confirmed using the average variance extracted, CR, and squared correlations.

3.3. Reliability and Validity

The reliability was assessed using composite reliability (CR) and convergent validity using average variance extracted (AVE) (Table 1). The result signifies reliability as the composite reliability estimates exceed 0.70 values, i.e., the minimum threshold (Zafiropoulos et al. 2012). This study prioritized CR values over Cronbach's alpha to assess reliability, as the latter is subjected to biased results (Peterson and Kim 2013; Şimşek and Noyan 2013). Moreover, the CR has the edge over Cronbach's alpha for assessing reliability. The results

also indicate convergent validity, as the AVE values exceed the 0.50 level, i.e., the minimum threshold level (Fornell and Larcker 1981).

Table 1. The average variance extracted (AVE), composite reliability (CR), and shared variance estimates.

	AVE	CR	CIL	PEOU	PU	FA
<i>CIL</i>	0.627	0.845	0.627			
<i>PEOU</i>	0.642	0.894	0.311	0.642		
<i>PU</i>	0.661	0.947	0.252	0.579	0.661	
<i>FA</i>	0.515	0.863	0.285	0.366	0.374	0.515

Note: CIL, creative and innovative leadership; PEOU, perceived ease of use; PU, perceived usefulness; FA, FinTech adoption.

To ensure the discriminant validity, we followed Fornell and Larcker's (1981) recommendation that the AVE estimates of any two constructs exceed the shared variance estimate (squared correlations). The results show discriminant validity, as the AVE estimates for all the factors exceed their corresponding squared correlations (Table 1).

Therefore, the above results indicate the reliability and validity of the dataset.

4. The Descriptive Statistics of the Study Sample and Its Variables

4.1. Respondents Demographic Profile

Most respondents were male, i.e., 67%, followed by females, 33%. Regarding age, 68.09% of the respondents were under 40, followed by those above 40 (31.90%) (see Table 2).

Table 2. The demographic information.

Category	Frequency	Percentage
<i>Gender</i>		
Male	483	66.99%
Female	238	33.01%
<i>Age (in Years)</i>		
Less than 40	491	68.09%
Above 40	230	31.91%

4.2. Exploratory and Confirmatory Factor Analysis

Exploratory factor analysis (EFA) used principal components with varimax rotation to explore the study constructs. The EFA results showed that all the items were loaded on their respective factors with loadings of more than 0.6. Furthermore, Ford et al. (1986) argued that factor loadings greater than 0.4 reduce subjectivity in data interpretation. Therefore, the EFA results signify the validity of the study constructs.

Further, we performed confirmatory factor analysis (CFA) to confirm the factor structure extracted from EFA. Higher model-fit values are essential for sound results (Mosleh-pour et al. 2018). The results show that all the fit indices satisfied the recommended threshold levels (see Table 3). Therefore, the proposed model of this study fits well with the empirical data.

Table 3. The model-fit summary.

Fit Index	Resultant Value	Recommended Value (Source)
<i>CMIN/df</i>	1.317	≤3.00 (Carmines et al. 1981)
<i>GFI</i>	0.948	≥0.90 (Hair et al. 2010)
<i>AGFI</i>	0.941	≥0.90 (Hair et al. 2010)
<i>NFI</i>	0.965	≥0.95 (Blunch 2012)
<i>CFI</i>	0.984	≥0.90 (Hair et al. 2010)
<i>RMSEA</i>	0.045	<0.05 (Hair et al. 2010)
<i>RMR</i>	0.021	<0.08 (Hair et al. 2010)

4.3. Common Method Bias

The common method bias (CMB) was checked in SPSS using Harman's single-factor test. An EFA with no rotation was also used (Verrijika and De Wet 2018) to complement Harman's test. The results show that the highest variance explained by a single factor is less than 50% (Baabdullah et al. 2016), indicating no presence of common bias (Table 4).

Table 4. Harman's single-factor test results in EFA.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	14.618	43.446	43.446	14.618	43.446	43.446
2	8.953	26.715	70.161			
3	2.003	7.113	77.274			
4	1.729	4.084	81.358			

Note: The extraction method was principal component analysis.

4.4. Hypothesis Testing

We tested the study's proposed hypotheses using structural equation modelling (SEM). SEM is used as Tobbin (2010) asserts that it verifies the research model's compatibility and evaluates causal relationships. The standardized betas (β) represent the path coefficients in the structural model (Saadé and Bahli 2005). Further, there were no multicollinearity issues, as the correlations between the independent variables were less than 0.8.

The results show that the model explains 51.09% of the variance in PEOU, 57.49% in PU, and 48.17% in FinTech adoption. The results supported the proposed relationships concerning H1, H2, H3, H4, H5, and H7 (Table 5).

Table 5. Summary of the hypothesis testing.

Hypothesis	Path	Standardized Beta (β)	Result
H1	CIL $\rightarrow$ FA	0.399 ***	Supported
H2	CIL $\rightarrow$ PEOU	0.513 ***	Supported
H3	CIL $\rightarrow$ PU	0.357 ***	Supported
H4	PEOU $\rightarrow$ FA	0.338 ***	Supported
H5	PU $\rightarrow$ FA	0.317 ***	Supported
H6a	CIL $\rightarrow$ PEOU $\rightarrow$ FA	0.193 ($p = 0.014$)	Supported
H6b	CIL $\rightarrow$ PU $\rightarrow$ FA	0.128 ($p = 0.003$)	Supported
H7	PEOU $\rightarrow$ PU	0.436 ***	Supported
H8	PEOU $\rightarrow$ PU $\rightarrow$ FA	0.256 ($p = 0.006$)	Supported

Note 1: CIL, creative and innovative leadership; PEOU, perceived ease of use; PU, perceived usefulness; FA, FinTech adoption. Note 2: *** implies $p < 0.001$.

The direct and indirect effects analysis was used to evaluate the mediation test. The significance of the mediating results was assessed following a two-tailed (BC) step-by-step bootstrap method. The results show significant indirect effects of creative and innovative leadership on FinTech adoption through (a) PEOU and (b) PU, supporting H6a and H6b (Table 6). Furthermore, PEOU significantly predicts FinTech adoption through PU, supporting hypothesis H8 (Table 6).

Table 6. The mediation results.

Hypothesis	Mediator(s)	Antecedent(s)	Direct Effect without Mediator	Direct Effect with Mediator	Indirect Effect	Result(s)
H6a	PEOU	CIL	0.385 ***	0.097 ($p = 0.092$)	0.193 ($p = 0.014$)	Supported
H6b	PU	CIL	0.385 ***	0.152 ($p = 0.006$)	0.128 ($p = 0.003$)	Supported
H8	PU	PEOU	0.436 ***	0.395 ***	0.256 ($p = 0.006$)	Supported

Note 1: CIL, creative and innovative leadership; PEOU, perceived ease of use; PU, perceived usefulness; FA, FinTech adoption. Note 2: *** implies $p < 0.001$.

Moreover, the magnitude of the predictors' influence on FinTech adoption was assessed, controlling for age and gender. A multigroup analysis was used to explore the moderating effect of age. Using the FinTech adoption index (EY 2016), the respondents were divided into two groups, i.e., young or less than 40 years old (491) and older or more than 40 years old (230). The results show no significant difference between the young and older respondents (leaders) concerning FinTech adoption. This can be attributed to the fact that when a technology is user-friendly and easy to use, leaders encourage its adoption, irrespective of being young or older leaders.

Similarly, we used a multigroup analysis, i.e., males ($n = 483$) and females ($n = 238$), to examine the moderating role of gender. The results show no significant difference between male and female leaders concerning FinTech adoption. This could be due to the fact that FinTech services are utilitarian, wherein decision-making exclusively depends on prior knowledge and experience. Thus, the results highlight that age and gender do not influence the relationship between creative and innovative leadership and FinTech adoption.

5. Findings and Discussion

This study explored the FinTech adoption process through the perceived usefulness and ease of use transmission mechanisms. The study constructs were incorporated from the existing models. The constructs comprised creative and innovative leadership as the antecedents, perceived usefulness and ease of use as the intermediary variables and FinTech adoption as the outcome variable. Additionally, our results enrich the technology adoption theory by examining the direct influence of predictors (creative and innovative leadership, PEOU, and PU) on FinTech adoption. The addition of technological attributes, i.e., PEOU and PU, in the proposed model, enhances the robustness of the study's implications, as individuals' technology adoption is significantly influenced by responsiveness and security attributes (Parasuraman et al. 1985; Cronin and Taylor 1992; Barnes and Vidgen 2002).

Our results support H1, i.e., a significant positive relationship between creative and innovative leadership and FinTech adoption ($\beta = 0.399$; $p < 0.001$). This finding supports prior studies (Howell and Avolio 1993; Avolio and Gardner 2005; Sarros et al. 2008; Arifin 2015; Al-edenat 2018; Liu et al. 2018; Mascareño et al. 2020) and signifies that the more leaders are creative and innovative, the more compatible they are with technology adoption. Moreover, creative and innovative leaders' passion for embedding novelty into company offerings pushes them to accept technological advancements. Further, H2, a significant and positive association between creative and innovative leadership and perceived ease of use, is also supported ($\beta = 0.513$; $p < 0.001$). This finding supports the existing literature (Kuo and Lee 2011; Aziz et al. 2020). It may be because leaders encouraging creativity and innovation create a team of quick learners who are also used to experimenting with new procedures and technologies (Schepers et al. 2005). Thus, with their know-how and experience with previous innovations, new technology, such as FinTech, appears more accessible. H3, a significant and positive relationship between creative and innovative leadership and FinTech adoption, is also supported ($\beta = 0.357$; $p < 0.001$). This finding also aligns with the literature (Schepers et al. 2005; Kuo and Lee 2011; Aziz et al. 2020). This indicates that the perception of FinTech being useful can be built when creative and innovative leaders clearly state its benefits, such as easy accessibility and the availability of financial services.

The study results show a significant and positive relationship between perceived ease of use and FinTech adoption ($\beta = 0.338$; $p < 0.001$), supporting hypothesis H4. This relationship indicates the user-friendly compatibility of FinTech in terms of compilation-free and easy-to-use technology. It also signifies that the more creative and innovative leaders perceive FinTech services to be, the more they would prefer FinTech adoption. The literature also asserts that adopting an information system depends on its technical capabilities and ease of use (Veeramootoo et al. 2018). This finding supports prior studies (Alryalat et al. 2013; Martins et al. 2014; Molina and Carter 2014; Alalwan et al. 2016, 2018; Baabdullah et al. 2016; Mensah and Mi 2018). Further, our results depict a significant and positive

relationship between perceived usefulness and FinTech adoption ($\beta = 0.317$; $p < 0.001$), supporting H5. The benefits, such as easy accessibility, user-friendliness, time-saving, easy usage, and less confrontation with organizational bureaucracy, reflect the usefulness of FinTech. This finding suggests that creative and innovative leaders' likelihood of adopting FinTech increases with their increased perception of FinTech benefits. This result supports the prior literature (Horst et al. 2007; Leong et al. 2011; Mou et al. 2017). This also highlights the importance of spreading the word regarding the benefits of technology to ensure its increased adoption (Baganzi and Lau 2017).

Moreover, the results show the significant and positive indirect influence of creative and innovative leadership on FinTech adoption through both the perceived ease of use ($\beta = 0.193$; $p = 0.014$) and perceived usefulness ($\beta = 0.128$; $p = 0.003$), supporting hypotheses H6a and H6b. PEOU and PU fully mediate the relationship between creative and innovative leadership and FinTech adoption. The leaders' passion for and know-how around creative and innovative procedures and technologies, along with their openness to adopt new technologies, also influences their perception of the technology's ease of use and usefulness. In line with this finding, Aziz et al. (2020) asserted a significant and positive association between leadership, perceived ease of use, usefulness, and technology acceptance in organizations. This further indicates that leaders' perceptions regarding the usefulness and usage of technology, such as FinTech, depend on their compatibility with such innovative technology.

Hypothesis H7, a significant and positive relationship between PEOU and PU, is also supported ($\beta = 0.436$; $p < 0.001$). A lower complexity of FinTech services leads to a higher usefulness perception among users. This finding also supports the theory in the existing literature that PEOU improves PU (Gefen and Straub 2003; Calisir and Calisir 2004; Tobbin 2010; Susanto and Aljoza 2015; Abdullah and Ward 2016; Baabdullah et al. 2016; Alalwan et al. 2017; Joo et al. 2018). Additionally, the results show that PU acts as a transmission mechanism in the relationship between PEOU and FinTech adoption ($\beta = 0.256$; $p = 0.006$), supporting H8. This means that effortless FinTech means a higher adoption and higher usefulness perception. Furthermore, the literature also confirmed the indirect effect of PEOU on end-user satisfaction through perceived usefulness (see Calisir and Calisir 2004). Leaders, especially creative and innovative leaders, are easily acquainted with technological innovations that facilitate their apparent usefulness and will eventually increase their usage.

6. Implications

6.1. Theoretical Implications

This research study proposed and tested a FinTech adoption model in the Indian context. This study explores the relationship between creative and innovative leadership and FinTech adoption through the perceived usefulness and ease-of-use transmission mechanism. This study makes some commendable contributions to the TAM literature. Firstly, we unravel the black box of technology acceptance theories by providing empirical evidence for the links between creative and innovative leadership, PEOU, PU, and FinTech adoption in the Indian financial services industry. We confirmed the importance of considering creative and innovative leadership, PEOU, and PU, which is rare in existing technology adoption studies.

Moreover, our results advance the TAM and UTAUT models (Davis 1989; Venkatesh et al. 2003) to understand and explain the prognosticators of technology adoption, specifically FinTech adoption. Based on the study results, we demonstrated that organizations should focus on creative and innovative leadership to ensure FinTech adoption for superior performance, which supports the existing literature (Arifin 2015; Al-edenat 2018; Liu et al. 2018; Mascareño et al. 2020), thereby highlighting the creative and innovative leadership and FinTech adoption relationship. Thus, technology adoption models can be an effective medium for building leadership theory (Van Wart et al. 2017).

Secondly, the study results show a significant and positive association between creative and innovative leadership, PEOU, PU, and FinTech adoption, signifying the role of leadership, PEOU, and PU in FinTech adoption in the financial services sector in India. Additionally, this study suggests the importance of PEOU and PU not only as the main predictors of FinTech adoption but also as transmission mechanisms. Our results show that PEOU and PU significantly mediate creative and innovative leadership and FinTech adoption. The intellectual simulation phenomena back this finding well. In simple terms, when leadership is creative and innovation-centric, i.e., encouraging problem-solving from different viewpoints, the technology adoption level within the organization is enhanced (mediated by PEOU and PU). Additional analysis illustrates that PEOU and PU are essential predictors for enhancing technology adoption within organizations and are important transmission mechanisms for ensuring a superior link between creative and innovative leadership and FinTech adoption.

Thirdly, our results show that PEOU indirectly affects FinTech adoption through PU. To further elaborate on this finding, it may be asserted that the user's perception of technology as applicable depends on the following three factors: firstly, the user's acquaintance with novel technologies reduces the complexity of technological innovation or new technology (or they become easy to use) and they appear helpful to him/her, which eventually leads to higher technology adoption; secondly, the user-friendly characteristics of new technology increases usefulness perception among the users concerning new technology, thus ensuring higher technology adoption; and, thirdly, the accumulation of the first and second points, i.e., the user's acquaintance with novel technologies and less complex technology (or easy-to-use technology) provides usefulness perception among users and, thus, higher adoption.

Furthermore, our study suggests that organizations should fully exploit proactive leaders, specifically creative and innovative leaders, to promote innovation within the organization via accepting and implementing novel technologies, which eventually will be reflected in the firm's market offerings and, thus, bestow a competitive advantage and a superior performance.

6.2. Practical Implications

Our results also have some implications for managers and policymakers regarding technology (FinTech) providers and users, such as the Indian financial services industry. Additionally, this study provides insights into leaders' fundamental priorities regarding FinTech adoption. The results of this study highlight the decisive role of PEOU and PU in FinTech adoption.

This study offers commendable implications for engineering management practice. For example, this study emphasizes that engineering managers should reduce the complexity of FinTech products to enhance the adoption rate by designing the products so that they become easy to use and valuable to users. Moreover, our study signifies that engineering managers need to focus on technology, specifically FinTech, specifications for stimulating tech adoption. Such specifications include the perceived ease of technology usage and usefulness, which become the primary facilitators for technology adoption (refer to hypotheses H6a, H6b, and H8 in Table 5). Furthermore, engineering managers should prioritize simplicity and added value in FinTech. The simplicity perspective can include enhancing the user-friendliness of technology, reducing time wastage, and enhancing transaction speeds (in the case of FinTech), which can be related to the added value perspective.

Additionally, if engineering managers in the FinTech industry ecosystem, including its sub-segments, such as Payments, Lending, Wealth Technology (WealthTech), Insurance Technology (InsurTech), Regulation Technology (RegTech), and Personal Finance Management, want to effectively tap into the needs of tech-savvy customers, they have several options. The first is to focus on customer evaluation while adopting the technology. For example, Abu-Dalbouh (2013) argued that TAM models unveil how customers evaluate technology while adopting it. Accordingly, researchers (e.g., Davis 1989; Doll et al. 2010;

Abu-Dalbouh 2013; Susanto and Aljoza 2015) have proposed that customers' black box focus is on PU and PEOU during technology evaluation and adoption. Therefore, if a company succeeds in incorporating these specifications into its offerings, it could create a competitive differential in the FinTech industry and stimulate the adoption rate of its offerings. The second is that technology providers can focus on enhancing their offerings' general user interface (UI) to facilitate easy-to-use products. Accordingly, Opaluch and Tsao (1993) offered ten methods to improve usability engineering, benefiting project managers, system developers, and human factor engineers. These methods include knowing end-users, assigning a UI designer early on, and enumerating end-user tasks.

Furthermore, FinTech providers can raise awareness concerning its benefits and capabilities, facilitating its (FinTech's) adoption. Awareness of a novel technology becomes essential as the user's (organization or individual's) information regarding how simple (easy to use) and valuable the technology is precedes its adoption. Accordingly, internal marketing campaigns should focus on positive word-of-mouth promotion to attain the required purpose(s). This means that facilitating FinTech adoption will require users to be conscious of its benefits and capabilities. Thus, the organizations/entities offering FinTech may influence organizations and individuals to take up its services by focusing on the user priorities highlighted in this study.

This study puts forth some practical implications from the user's (financial services providers) perspective. Firstly, our study suggests that organizations, such as creative and innovative leaders, should focus on attaining and retaining quality talent. Such leaders act as strategic talent for an organization on many fronts, such as technology adoption or ensuring a competitive advantage (Pereira and Gomes 2012). Additionally, this demands that the organization produce creative leaders or employees to ensure a higher innovation capability. Investment in human resources is closely associated with the firm's innovative capacity and superior financial performance (Renaud and Morin 2020), especially in the fourth industrial revolution era (Pastore et al. 2021). In support of this, our study also confirms the crucial role of creative and innovative leadership in adopting novel technologies, such as FinTech.

Additionally, adopting any technology by an organization is easy; however, the proper and fruitful utilization of that technology is more critical. In this respect, a leader's creativity and innovation can benefit the organization. Such leaders not only enhance the productivity of the novel technology but also allow their subordinates to become acquainted with it, which leads to superior organizational performance.

Furthermore, this study explains that ease of use and usefulness should be the priorities when adopting any technology. The easy use of technology reduces human effort, enhancing its compatibility with employees/individuals. When all individuals are operating technology, productivity is enhanced. Furthermore, using technology leads to greater individual attention, thus ensuring higher productivity. Additionally, this study highlights that the ease of use of technology strongly drives its perceived usefulness, eventually facilitating a higher level of technology adoption.

Moreover, FinTech needs to be encouraged at both the government and private levels to help India attain the aim of financial inclusion, as FinTech has been seen as a promising factor in this arena. Moreover, it provides an attractive means to leave the clutches of poverty (Lagna and Ravishankar 2022).

To summarize, our study offers a candid view for organizations on how FinTech adoption can be enhanced through creative and innovative leadership, perceived ease of use, and perceived usefulness.

7. Conclusions

Though the research concerning technology adoption has received significant government/organizational funding (Agarwal and Chua 2020; Singh 2020; Yadav et al. 2020; Baporikar 2021), the exploration of its predictors is in the nascent stage (Shiau et al. 2020). This has led to higher research attention to unpacking technology adoption factors.

This study is the first to explore the role of creative and innovative leadership, perceived ease of use, and perceived usefulness in the research framework to investigate leaders' FinTech adoption intention. The results suggest the addition of leadership, specifically creative and innovative leadership, to PEOU and PU (TAM variables) in predicting FinTech adoption in the Indian financial services sector. This study enriches the literature concerning TAM/technology acceptance theories by including the role of leadership in FinTech adoption. It also justifies to technology providers that leaders' creativity and innovation, PEOU, and PU are decisive in FinTech adoption. Further, this study demands significant organizational investment towards employee development to facilitate creative and fruitful decisions (regarding technology adoption) to bestow a solid strategic position to a firm.

8. Limitations and Future Research Directions

Despite its significant contributions, this study is also associated with some limitations. Firstly, this study collected data from self-reported questionnaires, which are more prone to bias caused by respondents hiding their true feelings, thus limiting the quality and validity of the data (Fan et al. 2002). Future studies can focus on objective data to overcome this limitation. Secondly, this study focused on one sector, limiting the results' generalizability. Moreover, the results associated with PEOU and PU might differ across contexts (Igbaria et al. 1997). Future studies could focus on different countries and sectors to make more assertive statements. Thirdly, given that the present study is based on TAM and UTAUT, including respondent characteristics, such as their computer self-efficacy, can provide candid results regarding technology adoption and use (Teo 2009, 2011).

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Article

Empowering Self-Help Groups: The Impact of Financial Inclusion on Social Well-Being

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Abstract: Financial inclusion (FI) relates to the access and availability of financial services to society, especially in low-income groups. FI is pivotal in achieving 7 of the 17 Sustainable Development Goals (SDGs). This paper explores the level of FI in the rural areas of Maharashtra and measures the impact of FI on the social conditions of Self-Help Groups (SHGs) prevalent in these areas. The study is based on a 424 SHGs survey conducted in the Pune, Thane, and Palghar districts of Maharashtra, India. The impact of FI on SHGs is evaluated using a Structural Equation Model (SEM). The results of the study show that physical banking services, Business Facilitators (BFs), and Business Correspondents (BCs) improve the social conditions of rural SHGs. Additionally, BCs and BFs mediate the relationship between physical banking services and social conditions. The study also reveals an insignificant association between BCs and BFs and insurance services. The present study highlights the importance of increasing the awareness of insurance policies through financial literacy programs and making timely availability and accessibility of BCs and BFs to enhance financial inclusion in rural areas.

Keywords: financial inclusion; social condition; self-help groups; business correspondents and facilitators; sustainable development goals; structural equation modeling; financial literacy

1. Introduction

Financial development is considered a fundamental prerequisite for achieving poverty alleviation, reducing income inequality, promoting gender equality, and fostering overall social progress (Kaur and Kapuria 2020; Abosedra et al. 2021; Barik et al. 2022; Singh and Jha 2023; Jha and Kırşanlı 2023). Financial inclusion takes precedence as a primary objective in the economic policies of developing and least-developed nations (Ahmad and Law 2022). It functions as a catalyst by providing diverse financial services and government schemes to vulnerable segments of society, particularly in developing countries like India. A crucial step towards attaining financial inclusion is the establishment of bank accounts, reflecting the key drivers of the availability, ease of access, and utilization of banking financial services. Numerous empirical investigations have substantiated the positive correlation between these three dimensions and financial inclusion (Kuri and Laha 2011; Raman 2012; Serrao et al. 2012; Laha and Kuri 2015; Swamy 2014; Goel and Sharma 2017). Financial inclusion serves as a platform for individuals to save surplus funds, which can be subsequently mobilized in the form of loans for small businesses and households. Moreover, it provides access to credit, thereby assisting them in managing their financial crises effectively (Sarma and Pais 2011; Arora 2010; Kumar 2011; Goel and Sharma 2017; Niankara 2022).

Financial inclusion extends beyond the mere provision of bank accounts to encompass a broader array of services and government schemes, resulting in positive externalities. These positive spillover effects transcend immediate impacts and manifest in various domains, particularly in the context of poverty alleviation. Financial inclusion contributes to the effective implementation of poverty alleviation initiatives by facilitating greater awareness and the utilization of government schemes. Consequently, it bestows economic

and social empowerment upon rural households, leading to heightened productivity and an overall enhancement of their living conditions and standards of living (Kuri and Laha 2011; Serrao et al. 2012; Laha and Kuri 2015; Rupa and Uma 2015; Goel and Sharma 2017; Rastogi and E 2018; Sethi and Sethy 2018; Survase and Inumula 2019; Nandru et al. 2021; Lal 2021; Ofoeda et al. 2022; Ozili et al. 2023).

FI plays a pivotal role in achieving 7 of the 17 SDG goals outlined under the 2030 agenda for sustainable development. These goals include no poverty (SDG1), zero hunger (SDG2), good health and well-being (SDG3), gender equality (SDG5), decent work and economic growth (SDG8), industry innovation and infrastructure (SDG9), and reduced inequalities (SDG10) (Survase et al. 2021; Ozili and Iorember 2023; Pushp et al. 2023).

A developed financial system and infrastructure can provide economic growth and achieve development goals if people are included in this financial system. The Government of India introduced Pradhan Mantri Jan-Dhan Yojana (PMJDY) as a national mission of financial inclusion on 4 August 2014. The main objective of this mission is to provide financial services such as deposit, saving, credit, remittance, and insurance services at affordable rates to uplift the poor class of society (PMJDY report, Department of Finance Service Ministry of Finance Government of India 2021; Zouari-Hadiji 2023).

Since the launch of PMJDY in 2014, approximately 52 crore bank accounts have been opened, amounting to INR 217,137 crore deposits and issuing 35.16 crore Rupay Debit Cards to beneficiaries at the national level as of January 2024 (PMJDY report, 31 January 2024). The report also notes that approximately 56% of the total beneficiaries who opened a bank account are females. Waikar and Karmarkar (2017) studied the role of banks through PMJDY in financial inclusion in the Indore District. The study found that schemes such as Atal Pension Yojana (APY), Pradhan Mantri Jeevan Jyoti Bima Yojana (PMJJBY), and Pradhan Mantri Suraksha Bima Yojana (PMSBY) played crucial roles in enhancing financial inclusion.

2. Research Gap, Research Questions, and Hypotheses

Inadequate access to financial services is termed financial exclusion. Rural areas are deprived of financial/banking services since the banking business is not profitable due to the low utilization of financial services (Kolloju 2014; Saxena and Mishra 2016). This has led to financial exclusion in rural areas. Hence, there is a need for a mediator between banks and rural households to connect banking services to rural households. The Business Correspondence Model (BCM) was introduced by RBI in January 2006 (Bhaskar 2006). BCM refers to the banking facilities and services provided through a third party, which acts as a bank agent in unbanked areas. RBI has permitted banks to engage intermediaries such as BFs and BCs as agents of the bank to extend banking services to unbanked areas since 2006.

BCs and BFs play a crucial role in the branchless areas by providing financial services, particularly in the rural areas, which helps to improve the social condition of rural households (Handoo 2010; Ramasubbian and Duraiswamy 2012; Chauhan 2014). Bakshi (2012) has stated that BCs and BFs are other banking channels similar to automated channels (ATMs, debit cards, credit cards, internet banking, mobile banking, and E-wallets). However, BCs and BFs have a human element catering to the needs of low-income groups, unlike automated channels that target the literate population, which mainly includes the upper and middle classes of society.

Kolloju (2014) opined that financial services are of the utmost importance for the socio-economic development of the poor class and unbanked section in rural areas (Rastogi and E 2018). He argued that banking/financial services have not reached these sections as the banking business is unprofitable due to the lesser usage of financial services. He mentioned that BCs and BFs could play a significant role in providing financial services in such areas. Similarly, Saxena and Mishra (2016) state that even after various government schemes/initiatives, a large portion of society in rural areas remains excluded due to the non-availability of basic financial services. BCs and BFs play a crucial role in covering such

classes by providing door-step financial services. The BC and BF model helps in improving the socio-economic conditions of the vulnerable class by providing government schemes and financial services in the absence of bank branches in rural areas. In light of the above background, the study aims to address the following three Research Questions (RQs).

RQ1: Do BCs and BFs substitute banks in branchless areas to provide financial services?

RQ2: Do BCs and BFs enhance the insurance services in rural areas?

RQ3: Do BCs and BFs improve the social conditions of rural households?

Many studies have demonstrated that BCs and BFs can support traditional banks in offering financial services in branchless locations. According to Kumar and Sharma (2017), branchless banking is one of the alternative banking channels that is increasingly important for providing customers with financial services. They also opined that using banking agents can help financial institutions reach more people in remote places by enabling clients to perform simple banking operations without the requirement for a physical branch. Aziz et al. (2022) emphasizes the prospects and challenges for branchless banking in Malaysia while highlighting the advantages of efficiency, time savings, security, and cost-effectiveness. Collectively, these results lend credence to the premise that BCs and BFs may successfully offer financial services in locations without physical bank branches. This is tested through the below hypothesis.

H₁. *BCs and BFs complement physical banks in branchless areas to provide financial services.*

Numerous studies have revealed that the penetration of insurance in rural areas of India is very low (Singh and Naik 2018; Radhika and Satuluri 2019; Murthy and Kumar 2023; Chatterjee et al. 2023). Further, there is a low penetration and poor density of insurance services in rural India, Ahmed (2013). Furthermore, the primary obstacles encountered by insurance businesses include low per capita income, a tame attitude among the populace, indifference by intermediaries to travel to remote locations, and a lack of financial literacy (Cbilamge 2015). The state of insurance service in rural areas is tested through the below hypothesis.

H₂. *BCs and BFs improve insurance services in rural households.*

BCs and BFs play a crucial role in improving the social conditions of rural households by providing financial services in the absence of banks (Sharma and Kukreja 2023). The role of BCs and BFs in improving social conditions is tested through the following hypothesis.

H₃. *BCs and BFs improve the social conditions of rural households.*

PMJDY aims to provide two insurance services viz. PMJJBY and PMSBY to the poor class of society at a minimum premium. PMJJBY provides a two-lakh death cover at INR 330 premium per annum and, PMSBY covers INR 2 lakhs for accidental death and INR 1 lakh for partial disability at INR 12 per annum. In addition, 1.26 Bank Mitras delivers branchless banking services in rural areas. Hence, banking services and insurance play a vital role in protecting rural households from financial crises (Habib et al. 2016; Jütting 2004; Asfaw and Von Braun 2005; Prinja et al. 2017).

Ahmed (2013) argued that there is a low penetration of insurance among the poor class particularly in rural areas in India. His study stated that approximately 8% to 10% of rural households are covered under life insurance. The study concluded that there is a lack of awareness and wrong perception about insurance products. Similarly, Yusuf et al. (2009) opined that people's attitudes toward insurance services are negative due to low awareness and support from the insurance institutions in Nigeria. Khanal (2007) stated that insurance companies failed to undertake long-term investments in Bangladesh, Malaysia, and Nepal. His study found a positive relationship between financial deepening and economic growth in these countries.

Rupa and Uma (2015) revealed a significant impact of financial inclusion on indicators of social conditions such as education expenditure, access to health care, confidence level, skills and empowerment, risk management, and nutritional status. Similarly, Survase and Inumula (2019) explored seven indicators of social conditions of rural households such as sanitation facilities, purified/potable drinking water, electricity, personal care access, social security, the standard of living, and overall social status. Their study showed a significant association between these indicators and financial inclusion. Other studies have also revealed a positive association between financial inclusion and the social conditions of rural households (Pailwar et al. 2010; Kuri and Laha 2011; Serrao et al. 2012; Xu et al. 2022). With this background, the study tried to investigate the role of banking branches in providing insurance services and improving social conditions in rural areas. The study has framed the following research questions concerning physical banking and insurance services.

RQ4: Do physical banks improve insurance services in rural areas?

RQ5: Do physical banks improve the social conditions of rural households?

RQ6: Do insurance services improve the social conditions of rural households?

Though there is less penetration of insurance services in rural areas, the presence of banking services enhances insurance services in rural areas (Demirgüç-Kunt and Klapper 2012; Goel and Sharma 2017; Niankara 2022). Hence, the role of physical banking in providing insurance services in rural areas is tested through the following hypothesis.

H₄. *A positive relationship exists between physical banking services and insurance services in rural areas.*

Previous research has shown that the socio-economic vulnerability of people in rural areas exposes them to financial risk (Murphy and Scott 2014; De Silva and Kawasaki 2018). Financial risk can be mitigated through banks by providing access to credit, saving, and insurance services (Sarma and Pais 2011; Arora 2010; Demirgüç-Kunt and Klapper 2012; Goel and Sharma 2017; Niankara 2022). Hence, the presence of banking facilities and insurance services helps them to mitigate risks and improves their social conditions. This is tested through the following hypotheses.

H₅. *Physical banking services improve the social conditions of rural households.*

H₆. *Insurance services improve the social conditions of rural households.*

Based on the above research questions and hypotheses of the study, the following conceptual model is proposed for the study (Figure 1).

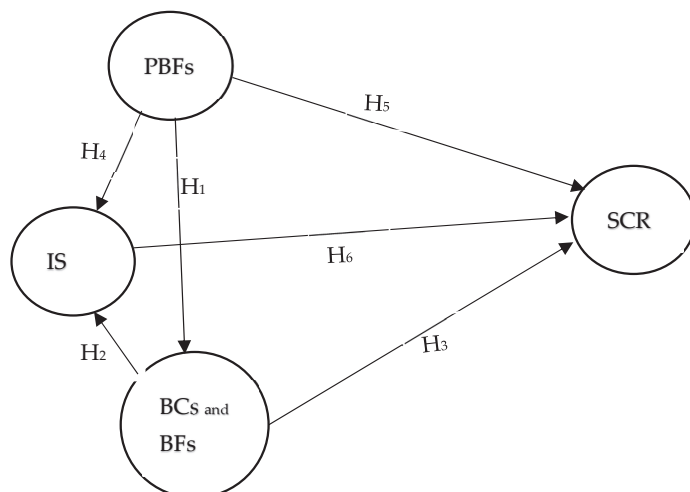


Figure 1. Conceptual Framework.

The study examines the relationship between the presence of PBF and BCs and BFs. It also explores the association between BC and BF and insurance services (ISs) in rural areas. In addition, it assesses the impact of BC and BF on the SCR in rural areas.

It also explores the association between PBF and IS in rural areas. In addition, it assesses the impact of physical banking facilities on the SCR in rural areas. The study measures the impact of insurance services on the social conditions of the SHGs in rural areas.

3. Data and Research Methodology

A questionnaire survey was used to conduct this cross-sectional investigation. The data analysis relied heavily on SEM, which gives a graphical depiction of the research interactions in two steps, comprising measurement and structural models (Asif et al. 2023). The data were collected using the convenient sampling method. The targeted population was SHGs that were selected from 12 villages of the Pune, Thane, and Palghar districts of Maharashtra, India. The survey of 422 respondents of SHG households was conducted using a scheduled questionnaire. We used a five-point Likert scale to record the responses of the respondents on identifying the factors influencing financial inclusion and social conditions of the respondents. The study considered a total of 56 indicators to measure the response of the respondents regarding financial inclusion and social conditions (refer to Appendix A). The study identified thirteen financial services provided in rural areas. The level of financial inclusion is measured by considering the availability, access, and usage of these financial services in rural areas (Sarma and Pais 2011; Myeni et al. 2020). The study considered seventeen indicators of the social conditions of rural households (Serrao et al. 2012; Rupa and Uma 2015; Survase and Inumula 2019). The impact of financial inclusion on social conditions is measured using these indicators.

The study applied an exploratory factor analysis (using SPSS 27.0) and confirmatory factor analysis (using AMOS 24.0) to investigate the associations between the research variables. Furthermore, the Average Variance Extracted (AVE), Convergent Values, and squared correlations were used to confirm the reliability and validity of the research constructs (Hair et al. 2010).

4. Analysis and Results of the Study

The results of the study are presented in five sub-sections viz. descriptive analysis, exploratory factor analysis, measurement model, structural model, and mediation analysis.

4.1. Descriptive Analysis

This section includes the demographic profile of the respondents, a summary of descriptive statistics, and the reliability of the construct. The majority of the respondents, i.e., 87 percent, are below the age of 45 years and 13 percent are over 45 years. The sample comprises respondents from various castes such as the General Category, Other Backward Class (OBC), Scheduled Caste (SC), and Schedule Tribe (ST) category, and the majority of the sample, i.e., 85%, comprises SC, ST, and OBC.

The level of education is low among respondents with only 6 percent of respondents having completed graduation, postgraduation, or a diploma. It is noted that the majority of the respondents, 85 percent, have only completed secondary or higher secondary education and 9% are illiterate.

The survey comprises respondents from various occupations. The majority of the respondents are farmers (47 percent) followed by private sector employees (18.6 percent), daily laborers (15 percent), and self-employed (14 percent). A small portion of respondents are public sector employees (3 percent) and unemployed (2.4 percent). Respondents are selected equally from three districts, Pune, Thane, and Palghar, of the Maharashtra state (Table 1).

Table 2 provides the variable correlation coefficient. The correlation is statistically significant, providing initial support for the hypotheses.

The statistical reliability of the scale is calculated based on Cronbach's Alpha (≥ 0.6) and the factor loading (≥ 0.5) to obtain statistically significant outcomes from the proposed model (Hair et al. 2010). All the variables are statistically significant, indicating the high internal consistency of the scale (Table 3).

Table 1. Demographic Profile.

Demographics	Household Details (N = 426)	% of Respondents
Age	Less than 25 years	13
	26 to 35 years	39.4
	36 to 45 years	34.9
	More than 45 years	12.7
Caste	SC	22.1
	ST	33.5
	OBC	27.9
Education	Secondary and Higher	16.5
	Illiterate	8.7
	Below Secondary	48.3
	Secondary and Higher Secondary	36.8
Occupation	Graduation and Diploma	3.8
	Post-Graduation and above	2.4
	Self Employed	13.9
	Private Sector Employee	18.6
	Public Sector Employee	3.1
	Farmer	46.9
District	Daily Labor	15.1
	Unemployed	2.4
	Pune	36.1
	Thane	30.2
	Palghar	33.7

Source: Author's Compilation.

Table 2. Correlation Matrix.

Construct	SCR	PBF	IS	BCs and BFs
SCR	1.000			
PBF	0.499 **	1.000		
IS	0.256 **	0.577 **	1.000	
BCs and BFs	0.44 **	−0.177 **	−0.129 **	1.000

Source: Author's Compilation. Note: ** significant correlation coefficient at the 0.01 (2-tailed).

Table 3. Reliability of Factors.

Construct	No. Items	Cronbach's Alpha (Reliability)
PBFs	8	0.933
IS	3	0.95
BCs and BFs	3	0.875
SCR	9	0.934

Source: Author's Compilation.

4.2. Factor Analysis

Factor analysis is used to identify the relevant items of the constructs (Hair et al. 2010). The results in Table 4 indicate that a total of four factors have emerged viz. social conditions, physical banking facilities, insurance schemes, and BCs and BFs. The total variance explained by these four factors is 72.34%. The Kaiser–Meyer–Olkin (KMO) value is 0.923, which is higher than 0.6, indicating the adequacy of the sample for factor analysis (Hair et al. 2010). The social conditions factor includes nine indicators, whereas the physical banking

facilities factor consists of eight indicators of financial services. The insurance service factor includes three indicators and the BC and BF factor includes three indicators. Other variables (33 indicators) have less than 0.5 factor loading and, hence, are not considered for further analysis.

Table 4. Exploratory Factor Analysis Results.

Rotated Matrix ^a		
Construct	Items	Factor Loading
SC	SC2—Helped for all Health Access	0.782
	SC3—Improved confidence level	0.661
	SC6—Improved nutritional status	0.744
	SC7—Access to basic sanitation facilities (i.e., lavatory)	0.781
	SC11—Personal care access (i.e., oral, hair, and body care)	0.834
	SC12—Entertainment (i.e., movies)	0.590
	SC15—Helped in Family and Cultural Function	0.768
	SC16—Improved Social Security (i.e., feeling of security in the society)	0.871
	SC17—Improved Overall Social Status	0.876
PBF	AVFS1—The bank branch is available at your place	0.828
	AVFS3—Automated Teller Services (ATMs) is available	0.881
	AVFS10—Deposit/withdrawing cash facility is available	0.699
	ACFS3—Automated Teller Services (ATMs) are easily accessible	0.846
	ACFS6—Cheque book is easily available to you	0.641
	UFS1—Avalied financial services through the bank branch	0.785
	UFS3—Use of Automated Teller Services (ATMs) is frequent	0.842
	UFS9—Avalied overdraft facility of the bank	0.533
IS	AVFS8—Insurance schemes are available	0.882
	ACFS8—Insurance facilities are easily accessible to you	0.886
	USF8—Avalied insurance facilities through the bank/BC/BF	0.872
BC and BF	AVFS2—BC and BF are available at your place	0.744
	ACFS2—BC/BF are easily approachable	0.894
	UFS2—Avalied financial services through BC/BF	0.845
Total cumulative variance: 72.342		
Extraction Method: Principal Component Analysis.		
Rotation Method: Varimax with Kaiser Normalization. ^a		
^a . Rotation converged in 7 iterations.		

Source: Author's Compilation. Note: Eigen Values of all constructs are >1 and KMO is 0.923.

4.3. Measurement Model

The measurement model relates the measured variables to latent variables. In Figure 2, the variables presented in the rectangle are called measured variables (e.g., UFS3, UFS1), and those presented in ellipse are called latent variables (e.g., PBF, SCR). Co-variance numbers are presented on the double-sided arrow connecting the two latent variables. The relationship between latent variables and measured variables is presented in Figure 2. Figure 2 shows the final measurement model and the standardized regression weights associated with each item.

The measurement model was estimated through an iterative process until the regression weights were greater than 0.5. Some co-variances are negative, which is justified by the literature review. Table 5 provide the goodness-of-fit of the initial model and the final model. As shown in Table 5, the initial model failed to meet the acceptable limits and, hence, it was rejected. In the final model, all the indices have met their acceptable limits, indicating that the model is statistically significant.

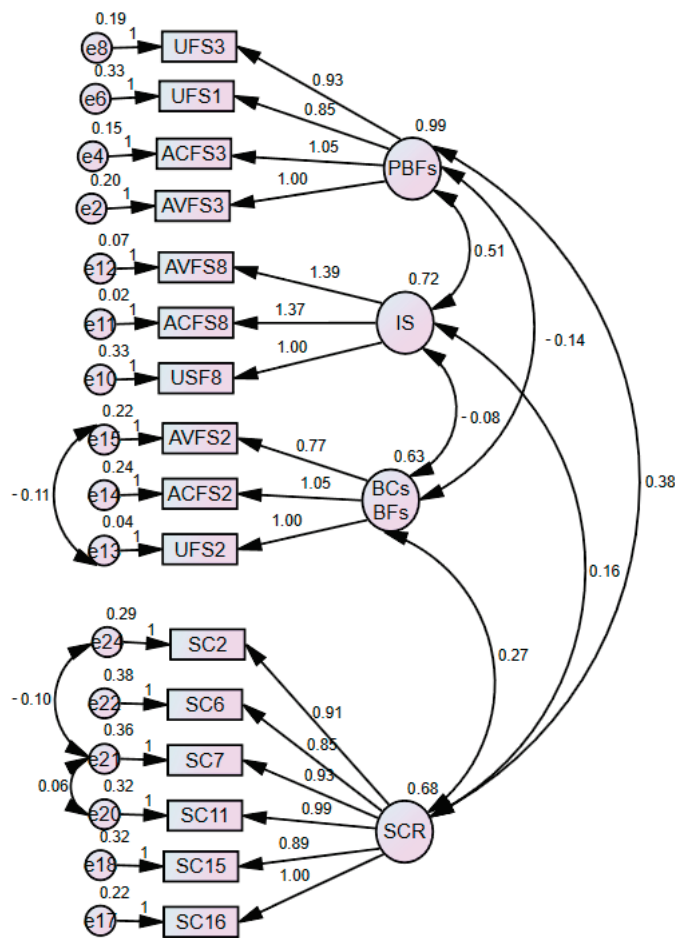


Figure 2. Final measurement model.

Table 5. Initial and Final Measurement Model (Standardized Output).

Measure	Initial Measurement	Final Measurement	Acceptable Fit Criterion
CMIN/DF	3.554	2.675	≤ 3 indicates an acceptable fit ≤ 5 indicates a reasonable fit
CFI	0.956	0.974	≥ 0.90 indicates an acceptable fit ≥ 0.95 indicates an excellent fit
SRMR	0.068	0.0574	≤ 0.05 indicates an acceptable fit
RMSEA	0.078	0.063	≤ 0.05 indicates an excellent fit ≤ 0.08 indicates an acceptable fit
PCLOSE	0	0.012	≥ 0.05 the model is considered to have a close fit

Source: Author's Compilation.

Construct Validity

Construct validity is a test to measure a construct. It is tested using discriminant validity and convergent validity, and they are opposite to each other. The discriminant validity indicates that one construct is different from the other construct and, hence, they are unique in nature. The discriminant validity is tested using the square root of the AVE, which should be greater than the correlations of all the corresponding latent constructs (Hair et al. 2010; Jobson 2012). The results presented in Tables 2 and 6 fulfill the requirement of discriminant validity. The convergent validity shows that all the items designed to measure a construct are the same and correlate with each other. The convergent validity

is tested using the Composite Reliability (CR) value, which should be greater than 0.5. Table 6 indicates CR of all latent variables is greater than 0.5, hence it meets the criteria of convergent validity.

Table 6. Discriminant and Convergent Validity.

Construct	No. Items	AVE	CR
PBFs	8	0.58	0.86
IS	3	0.77	0.88
BCs and BFs	3	0.68	0.82
SCR	9	0.59	0.88

Source: Author's Compilation.

4.4. Structural Equation Model

The SEM relates one variable with another. The SEM provides standardized estimates of all the latent variables (Hair et al. 2010). Table 7 indicates the goodness-of-fit indices. All the indices have met the acceptable limits and, hence, this model is statistically significant (Figure 3).

Table 7. Goodness-of-fit Indices of SEM.

Measure	Estimate	Threshold	Interpretation
CMIN/DF	2.675	Between 1 and 3	Excellent
CFI	0.974	>0.95	Excellent
SRMR	0.057	<0.08	Excellent
RMSEA	0.063	<0.06	Acceptable
PCLOSE	0.012	>0.05	Acceptable

Source: Author's Compilation.

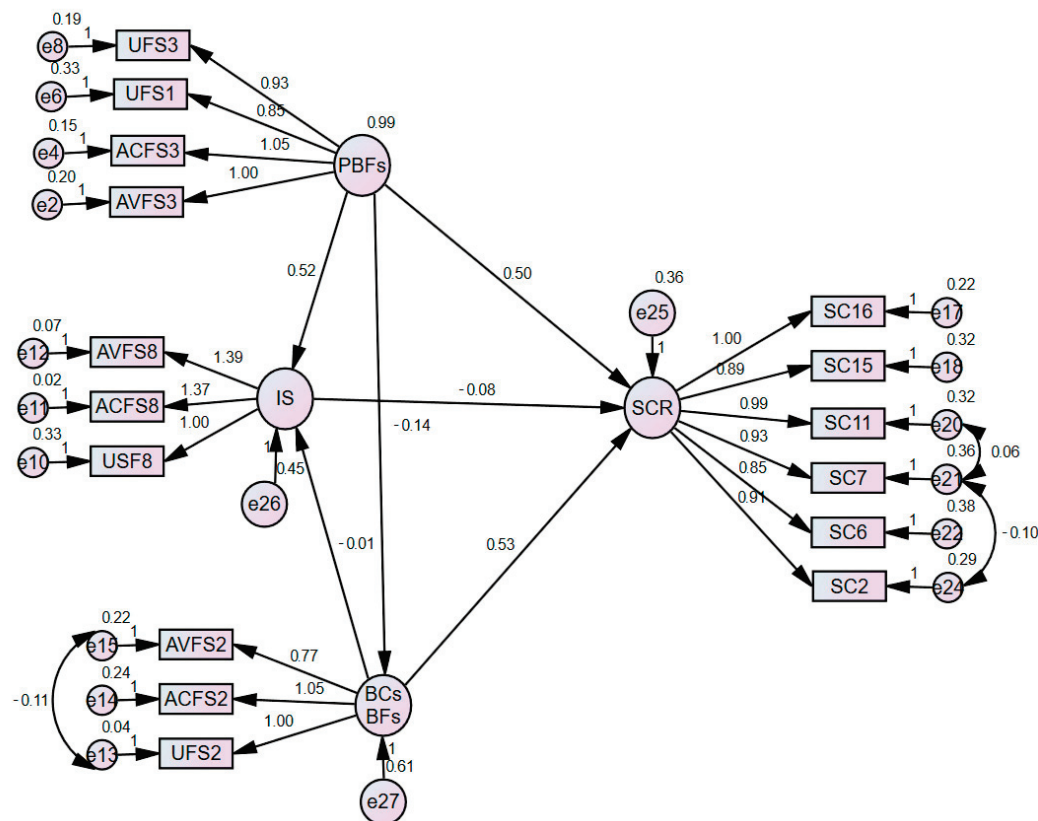


Figure 3. Structural Model.

The hypotheses of the study have been tested in the structural diagram using AMOS. The results are presented in Table 8.

Table 8. Hypotheses Testing from SEM.

Hypotheses	Path	Estimate (β)	p Values ≤ 0.01	Result
H ₁	BCs and BFs $\leftarrow$ PBFs	−0.14	***	Supported
H ₂	IS $\leftarrow$ BCs and BFs	−0.01	0.835	Rejected
H ₃	SCR $\leftarrow$ BCs and BFs	0.53	***	Supported
H ₄	IS $\leftarrow$ PBFs	0.52	***	Supported
H ₅	SCR $\leftarrow$ PBFs	0.50	***	Supported
H ₆	SCR $\leftarrow$ IS	−0.08	0.11	Rejected

*** $p < 0.01$. Source: Author's Compilation.

As shown in Table 8, the SEM analysis revealed the existence of a significant inverse relationship ($\beta = -0.14$; $p < 0.01$) between PBFs and BCs and BFs for SHGs in rural Maharashtra. Hence, hypothesis H₁ is supported. On the other hand, the analysis showed that BCs and BFs influence the SCR of rural SHGs ($\beta = 0.53$; $p < 0.01$) significantly. Hence, hypothesis H₃ is supported. Similarly, PBFs significantly influences the IS (H₂, $\beta = 0.52$; $p < 0.01$) and SCR of the rural SHGs (H₃, $\beta = -0.50$; $p < 0.01$) positively. Therefore, hypotheses H₅ and H₆ failed to be rejected. On the contrary, the relationship between BCs and BFs and IS is statistically insignificant ($\beta = -0.01$; $p < 0.01$). Hence, hypothesis H₂ is rejected. The relationship between IS and SCR is statistically insignificant ($\beta = -0.08$; $p < 0.01$). Hence, hypothesis H₆ is rejected. As hypotheses H₂ and H₆ are rejected, the IS factor is eliminated from the final model. Further analysis is conducted by considering BCs and BFs as a mediator between PBFs and SCR.

4.5. Mediation Analysis

The main objective of the mediating analysis is to examine whether a change in a mediating variable can mediate the effect of the independent variable on the dependent variable (Hair et al. 2010). The study has examined the mediating effect of BCs and BFs direct, indirect, and total effects using Barron and Kenny's mediation analysis in AMOS 23. The mediating model has tested statistically significant, meeting all the thresholds (Table 9 and Figure 4).

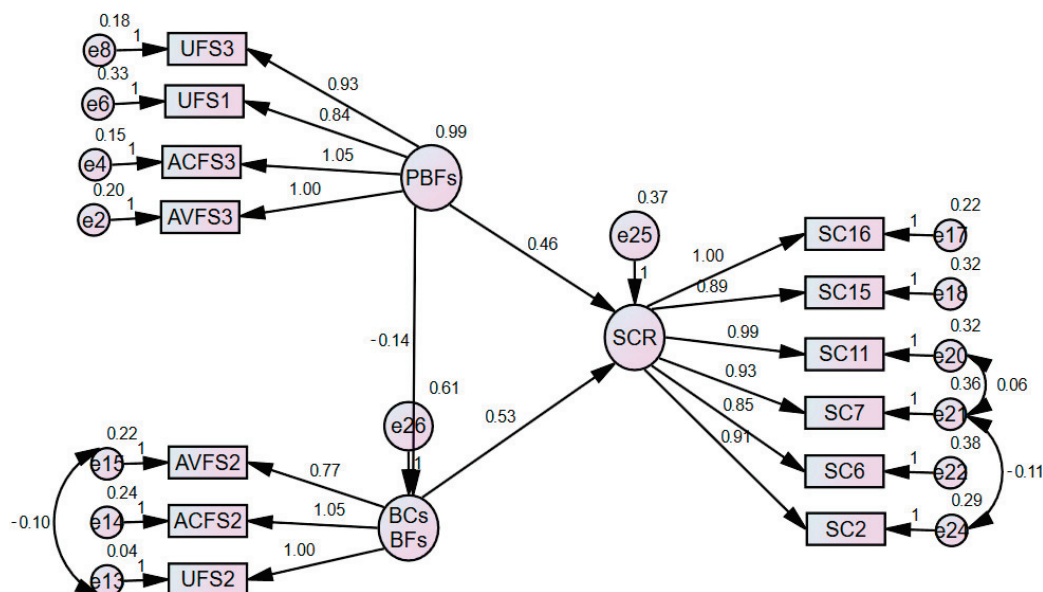


Figure 4. Mediating Analysis.

Table 9. Test of Mediating Analysis: goodness-of-fit indices.

Measure	Estimate	Threshold	Interpretation
CMIN/DF	2.647	Between 1 and 3	Excellent
CFI	0.975	>0.95	Excellent
SRMR	0.057	<0.08	Excellent
RMSEA	0.062	<0.06	Acceptable
PCLOSE	0.015	>0.05	Acceptable

Source: Author's Compilation.

Barron and Kenny's Mediation Model

Table 10 indicates that PBFs significantly influence BCs and BF (s) ($\beta = -0.151$; $p < 0.01$) and SCR ($\beta = -0.378$; $p < 0.01$). However, the relationship between PBFs and BCs and BF (s) is inverse as they complement each other in the branchless rural areas. The BCs and BF (s) also influence the SCR of SHGs in the rural areas of Maharashtra significantly ($\beta = 0.361$; $p < 0.01$).

Table 10. Individual Independent Variable and Dependent Variable.

	Path		Estimate (β)	p Values ≤ 0.01
SCR	$\leftarrow$	PBF	0.378	***
BC and BF	$\leftarrow$	PBF	-0.151	***
SCR	$\leftarrow$	BC and BF	0.361	***

*** $p < 0.01$. Source: Author's Compilation.

As compared to the initial model, the effect of PBFs on SCR has improved significantly ($\beta = -0.55$; $p < 0.01$) by considering BCs and BF (s) as a mediating variable between PBF and SCR (Table 11 and Figure 4). Similarly, the effect of BCs and BF (s) on SCR has also improved significantly ($\beta = 0.51$; $p < 0.01$). Hence, BCs and BF (s) are a partial mediating variable.

Table 11. Individual Independent Variable and Dependent Variable.

	Path		Estimate (β)	p Values ≤ 0.01
SCR	$\leftarrow$	PBF	0.55	***
BC and BF	$\leftarrow$	PBF	-0.18	***
SCR	$\leftarrow$	BC and BF	0.51	***

*** $p < 0.01$. Source: Author's Compilation.**5. Discussion**

Financial inclusion serves as a secure and accessible platform for rural households to engage in saving, depositing, and investing their surplus funds. Additionally, it offers remittance services, facilitates access to credit, and provides a range of financial services tailored to the needs of vulnerable segments of society (Demirgüç-Kunt and Klapper 2012; Adedokun and Ağa 2021). Consequently, financial inclusion assumes a pivotal role in empowering poor groups, with particular relevance to rural populations in developing nations such as India.

The primary objective of this study was to identify factors that contribute to the advancement of financial inclusion in rural areas and to assess its impact on the social well-being of rural households. Three key factors were identified as significant drivers of financial inclusion in rural areas: (1) the presence of physical banking services, including ATMs and brick-and-mortar banking branches; (2) the availability and accessibility of insurance services; and (3) the utilization of BCs and BF (s). These findings complement earlier research, which also explored various outreach channels for financial services (Handoo 2010; Gupta and Singh 2013; Iqbal and Sami 2017).

Regarding the first key factor, the study observed that the availability and accessibility of ATMs and physical banking branches positively influence usage, thereby contributing to

greater financial inclusion in rural areas. The second key factor, insurance services, was found to enhance financial inclusion when made readily available and accessible, resulting in increased service utilization among rural populations. The third key factor, involving BCs and BF, plays a crucial role in expanding financial inclusion in branchless regions, particularly when their timely availability and accessibility are ensured.

In addition to identifying the factors fostering financial inclusion in rural areas, the study also examined its effects on the social conditions of rural households. Notably, financial inclusion exhibited a significant positive impact on various aspects of social well-being. It led to improvements in nutritional status and access to healthcare facilities. Moreover, financial inclusion facilitated enhanced access to basic sanitation facilities and personal care services. Additionally, it was found to facilitate more efficient handling of financial matters, particularly during family and cultural functions, thereby contributing to a heightened sense of social security among respondents. These findings align with earlier studies, which have also underscored the positive influence of financial inclusion on rural social welfare (Rupa and Uma 2015; Survase and Inumula 2019).

The identified factors were confirmed through exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). Subsequently, the SEM was employed to examine the relationships among these factors. The results of the SEM indicated an insignificant relationship between BCs and BF and insurance services, suggesting that BCs and BF have not adequately provided insurance policies in rural areas. Moreover, the SEM also revealed an insignificant relationship between insurance services and the social conditions of rural households, indicating that insurance services did not have a significant impact on the social well-being of rural households. A significant relationship was found between PBF and the SCR, which became more significant when BCs and BF served as mediating variables, suggesting a partially mediating role of BCs and BF. The study further demonstrated an inverse relationship between PBF and BCs and BF, suggesting that BCs and BF are more prevalent in branchless areas where bank branches and ATMs are less accessible. This highlights the crucial role of BCs and BF in providing financial services in rural areas without traditional banking infrastructure. These findings align with the earlier study that the BCs and BF play a crucial role in improving the social conditions of rural households (Sharma and Kukreja 2023).

Additionally, a significant relationship was observed between PBF and IS, indicating that physical banking facilities serve as an effective platform for enhancing insurance services in rural areas. However, the study found an insignificant relationship between BCs and BF and IS, indicating a lack of provision of insurance services by BCs and BF to rural households in Maharashtra. In addition, the study revealed an insignificant relationship between IS and the SCR in rural Maharashtra. This indicates the unsuitability and lack of financial literacy of insurance services in rural areas.

Overall, the study revealed that PBF played a vital role in improving the social conditions of rural SHGs in Maharashtra. Furthermore, the social conditions of rural households improved significantly when BCs and BF acted as mediators between PBF and SC. The relationship between BCs and BF and SC was found to be significant, suggesting that BCs and BF contributed to improving the social conditions of rural households, especially in the absence of physical banking services.

The present study demonstrated a significant impact of financial inclusion on the social conditions of rural households. BCs and BF, along with physical banking services such as bank branches and ATMs, emerged as the main drivers of financial inclusion in rural areas. However, no significant association was found between insurance services and the social conditions of rural households. Likewise, the relationship between BCs and BF and insurance services was also found to be insignificant.

6. Conclusions and Policy Implications

The results of the study reveal that BCs and BF have a significant role in providing financial services in branchless areas. The timely availability and accessibility to BCs and

BFs are imperative to enhance financial inclusion. Frequent visits by the BCs and BFs to their assigned rural areas would lead to improved availability and accessibility. They should be assigned incentive-based monthly targets such as opening bank accounts and loan disbursement. In addition, BCs and BFs should have frequent interaction with rural households to raise awareness of new government schemes and services. The availability of financial services in remote areas can be achieved through the selection of BCs and BFs from the same village. Adequate and necessary training should be provided to BCs and BFs.

The primary reason for financial exclusion among rural households is a lack of awareness of various banking and financial services. Financial inclusion can be achieved through financial literacy programs that aim to educate rural households on the use of various banking and financial services such as ATMs, mobile banking, and E-wallets. The banks should appoint financial advisors to educate and assist rural households in financial investment decisions.

The present study did not find a significant relationship between insurance services and the social development of rural households. The BCs and BFs did not enhance the insurance services in these places. Hence, there is a need to increase awareness among rural households about the benefits of various government and insurance services/schemes such as Prime Minister Jeevan Jyoti Bima Yojana, Pradhan Mantri Suraksha Bima Yojana, and Sukanya Samriddhi Yojana through BCs and BFs and financial literary programs (Ahmed 2013; Waikar and Karmarkar 2017). The awareness regarding insurance services can be improved through financial literacy programs that include putting hoarding in a visible place, painting at the most common place of a visit, and conducting street act play. A local influential individual can also assist in changing the mindset of the rural household towards the use of insurance services.

The study provides policy implications that can assist in improving access to banking and financial services in rural areas. The government policies should aim at providing adequate training to BCs and BFs and increasing the timely availability and accessibility of BCs and BFs to rural households. The government can overcome the limitation of inadequate financial infrastructure in rural areas in the short term, through increased access to BCs and BF. The policies should aim to educate rural households on financial services, insurance policies, and the use of digital technology such as ATMs and E-wallets (Asif et al. 2023). The government should frame policies that aim to provide need-based financial products and improve access to banking services. The policies aimed at building banking services in rural areas would contribute to improved social conditions in rural households.

The study was conducted in the rural areas of Maharashtra, India. Hence, other areas such as semi-urban and urban are not explored in the study. The research is based on the SHGs that are financially inclusive; non-SHG members are not considered in this research. The study has explored the impact of financial inclusion on the social conditions of SHG households. The association between demographic factors viz. caste, education, culture, social condition, and financial inclusion is not considered in the study.

The present study can be extended to assess the impact of financial inclusion not only on social conditions but also on the economic and psychological conditions of rural households. The present study can be extended to other states of India and state-specific factors can be identified that lead to an improvement in social conditions through FI. This study can also be extended to other developing countries to ensure the accuracy and reliability of the present study.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

- AVFS1—The Bank branch is available at your place
- AVFS2—BC and BF are available at your place
- AVFS3—Automated Teller Services (ATMs) is available
- AVFS4—Mobile Banking is available
- AVFS5—Internet Banking is available
- AVFS6—Cheque Book facility is available
- AVFS7—Loan facility is available
- AVFS8—Insurance schemes are available
- AVFS9—Overdraft facility is available
- AVFS10—Deposit/Withdrawing cash facility is available
- AVFS11—Mortgage facility is available
- AVFS12—A financial adviser is available
- AVFS13—NRLM schemes are available
- ACFS1—The Bank branch is easily approachable
- ACFS2—BC/BF are easily approachable
- ACFS3—Automated Teller Services (ATMs) are easily accessible
- ACFS4—You have easy access to Mobile Banking
- ACFS5—You have easy access to Internet Banking
- ACFS6—Cheque Book is easily available to you
- ACFS7—Loan facility is easily accessible to you
- ACFS8—Insurance facilities are easily accessible to you
- ACFS9—The overdraft facility is easily available to you
- ACFS10—Deposit/Withdrawing cash facility is easily available to you
- ACFS11—You have easy access to mortgage facility
- ACFS12—You have easy access to a financial adviser
- ACFS13—NRLM schemes are easily accessible to you
- UFS1—Availed financial services through the Bank branch
- UFS2—Availed financial services through BC/BF
- UFS3—Use of Automated Teller Services (ATMs) is frequent
- UFS4—Use of Mobile Banking is frequent
- UFS5—Use of Internet Banking is frequent
- UFS6—Use of Cheque Book is frequent
- UFS7—Availed loan facility through bank/BC/BF
- UFS8—Availed insurance facilities through bank/BC/BF
- UFS9—Availed overdraft facility of Bank
- UFS10—Deposit/Withdrawing of cash is frequent through bank/BC/BF
- UFS11—Availed mortgage facility through bank/BC/BF
- UFS12—Availed financial advice facility through bank/BC/BF
- UFS13—Availed NRLM schemes frequently
- SC1—Helped Education Expenditure
- SC2—Helped for Health Access
- SC3—Improved confidence level
- SC4—Improved Skills and Empowerment
- SC5—Helped in Risk Management
- SC6—Improved Nutritional status
- SC7—Access to basic sanitation facilities (i.e., lavatory)
- SC8—Access to purified/ potable drinking water
- SC9—Enhanced access to electricity
- SC10—Helped in getting insurance (general, life, and medical)

- SC11—Personal care access (i.e., oral, hair, body care)
- SC12—Entertainment (i.e., movies)
- SC13—Improved consumption of luxurious goods and services
- SC14—Improved traveling and tourism status
- SC15—Helped in Family and Cultural Function
- SC16—Improved Social Security (i.e., feeling of security in the society)
- SC17—Improved Overall Social Status

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