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Constellations of Trust: Where Service Innovation Meets Digital Banking's Heart

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Abstract

This study examines the relationship between service innovation and digital bank performance, focusing on service personalization, security and authentication, system stability, ease of access, and innovation in service delivery. A mixed-methods design was employed. The qualitative phase consisted of grounded theory analysis of semi-structured interviews with specialists in the banking business, supplemented by MAXQDA. In the quantitative phase, questionnaire data were collected from specialists working at banks listed on the Stock Exchange throughout 2023–2024. The relative importance of the identified parameters and their links with digital financial performance were assessed using Friedman ranking tests and regression analysis in SPSS. The findings indicated that service personalization and information security are critical for customer trust and happiness, and that ease of access and system stability were connected with higher operational efficiency. The customer experience, competitive advantage, and overall performance of the digital bank were also examined in relation to service innovation. The study combined the Technology Acceptance Model (TAM), SERVQUAL and Trust Theory to suggest a conceptual framework, "Constellations of Trust". Rather than analyzing these perspectives separately, the framework investigated the dimensions of their relationship with digital banking performance. The empirical regression results indicated that service personalization, security, system stability, and ease of access had statistically significant associations with performance, whereas the direct effect of service innovation was not statistically significant.

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1. Introduction

In recent decades, digitalization has changed the world economy. Advances in artificial intelligence, big data, blockchain and financial technology have altered economic and monetary institutions (Bueno et al., 2024). Digital technologies today shape company structures, information systems and relationships between economic actors. The banking sector has responded by shifting from traditional delivery channels to digital service ecosystems. Digital banking, electronic wallets, open banking infrastructure, and intelligent financial technologies have altered the way services are provided and how banks and clients generate value (Abdurrahman et al., 2024).

The performance of digital banking needs to be understood from multiple complementary theoretical approaches. The Technology Acceptance Model (TAM) explains adoption by perceived utility and ease of use, whereas SERVQUAL describes the effect of service quality qualities such as reliability, responsiveness and empathy on satisfaction. Trust theories highlight security, authentication and integrity perceptions as origins of confidence in digital financial systems. All perspectives are relevant, but they have generally been established independently. Therefore, the relationship between technology adoption, service quality, trust development and banking performance deserves a more integrated assessment.

The assessment of banking performance has also changed as a result of digitalization. Conventional financial statements cannot adequately reflect an operational environment with technological agility, customer experience, security infrastructure, and service innovation (Chen et al., 2023b). Therefore, performance models require financial and non-financial aspects, particularly for banks in competitive and transparent capital markets (Khan, 2022; Desyatnyuk et al., 2024; Firmansyah et al., 2023; Hakimi et al., 2023; Kajla et al., 2024; Bashori et al., 2024).

Although extensive research has examined digital technology and banking performance, the evidence remains fragmented. Some studies consider technology adoption without linking it clearly to financial outcomes; others focus on conventional financial indicators while overlooking the multidimensional nature of digital banking performance (Chen et al., 2023a; Li et al., 2024). Findings on service innovation are also mixed: some studies report positive effects, whereas others identify weak or indirect relationships. Such differences suggest that context, customer trust, and user experience may shape the observed associations (Desyatnyuk et al., 2024; Javaid et al., 2024; Melnyk, 2024).

Service personalization, security and authentication, system stability, and ease of access are widely recognized in practice but have often been studied separately. This limits understanding of how they operate together. The gap is particularly relevant in emerging markets such as Iran, where context-specific empirical models of digital banking performance remain limited. An integrated approach is needed to examine technological, behavioral, and financial dimensions within a common framework.

To remove such restrictions, this study has provided an integrated framework for the assessment of the financial performance of banks listed on the Tehran Stock Exchange in the digital economy. The model, based on well-established theory and conversations with banking experts, consists of data protection, technological agility, customer experience, system stability and service innovation.

The proposed framework brings together TAM, SERVQUAL, and Trust Theory to explain digital banking performance. Its purpose is not to introduce a wholly new theory but to integrate complementary dimensions of existing perspectives within a single model.

The rest of this paper is organized as follows: The literature review and the theoretical background are summarized in Section 2, the research methodology is explained in Section 3, the empirical results are discussed in Section 4 and the study is concluded with some ideas for future research in Section 5.

2. Theoretical issues and literature review

2.1. Theoretical framework

Digital technology has transformed the structure of economic activity. The digital economy is the economic and commercial activity that is enabled by digital technologies, big data, electronic communication, and intelligent tools. Internet-based services, artificial intelligence, blockchain, cloud computing, financial software and data analytics have transformed existing corporate procedures. They are utilized in a variety of applications such as e-commerce, digital marketing, digital content, and financial services and have helped in the economic development of several countries (Mir et al., 2023).

Banking has experienced these changes particularly rapidly. Internet and mobile banking, digital wallets, big data analytics, robo-advisors, and remote services have transformed customer interactions and altered competition among financial institutions. Digital delivery can improve transparency, speed, affordability, and security while creating opportunities for new services (Elmonshid et al., 2024).

These advances also pose challenges to standard methodologies for measuring bank performance. Digitally supplied services are not fully captured by conventional financial reporting. Thus, the performance frameworks must take into account the particular operational and financial aspects of digital banking.

As banks transform their services, identifying the factors associated with performance becomes increasingly important. Success depends not simply on offering digital channels but on using technology effectively and responding to customers' evolving needs. The following dimensions are therefore considered relevant to digital banking performance (Mogaji, 2023).

One dimension is the customization of financial services. Traditional banking has been more standardized; digital channels allow banks to customize services according to the individual's demands and patterns of activity. Financial advice that is appropriate to the customer's situation can be based on behavioral data and analytic algorithms and can increase happiness and loyalty (Ouyang et al., 2023).

Information security and privacy protection are also top priorities. With the increasing online transactions and sensitive information flowing over digital platforms, banks require reliable solutions to prevent unauthorized access, cyber fraud and breaches of confidentiality. "Operational efficiency has to be married to customer data protection.

Another critical factor is the ease of access and enhancement of the user experience. In digital banking, customers expect to be able to access the banking services they need at any time and from anywhere. This expectation makes the design of simple, intuitive, and understandable user interfaces essential. In addition, other prerequisites to build a pleasant user experience are multi-platform access and 24/7 responsiveness to customers' needs (Porfirio et al., 2024).

System stability and scalability are also critical. As user numbers and transaction volumes increase, banks require infrastructure that can keep pace with demand, adjust to market changes and allow development into new geographies. Resilient and upgradeable systems provide service continuity under changing conditions (Rahman et al., 2023).

The competitive position of the banks can be maintained by continuous innovation in the delivery of services. Banks may enhance their visibility and market reach by improving existing services, launching new products, cooperating with fintech startups, and implementing technologies such as artificial intelligence, machine learning, and blockchain (Rahaman and Sur, 2025).

Digital banking performance reflects a combination of structural, behavioral, and technological factors. Understanding these factors can inform policy and strategic planning and support banks'

sustainability in a competitive digital economy (Rodrigues et al., 2023).

Digitalization also affects financial reporting performance in terms of opportunities and threats. An important opportunity is more accurate and timely data analysis (Sari et al., 2023). Big data and advanced analytics can help banks prepare and disseminate financial information more efficiently. Automated reporting and AI-based forecasting may further increase the timeliness and usefulness of information accessible for decision-making (Shah and Shah, 2024).

These opportunities are accompanied by risks (Shanti et al., 2023). Complex analytical systems may introduce errors in processing or interpreting financial information. Data theft, unauthorized access, and cyberattacks threaten both information security and reliable financial reporting. Banks also face the challenge of complying with domestic and international accounting and reporting requirements as technologies and markets evolve (Sun et al., 2024).

Banks that are digitally transforming need to combine the potential presented by new technologies with operational and reporting risks. Financial reporting needs to be fast, accurate and secure and this requires a reliable infrastructure.

2.2. The theoretical issues, literature and hypothesis development

The present study is based on three theoretical frameworks, including TAM (Aydin and Onayli, 2020), SERVQUAL (Sun et al., 2024), and Trust Theory in digital contexts (Czerwińska et al., 2021). The two provide a platform to explore the technological, service-quality and trust-related elements of performance in digital banking (Hair et al., 2021).

The TAM created by Hie (2019) proposes perceived usefulness and perceived ease of use as the key factors of technology adoption and usage behavior. Khanboubi and Boulmakoul (2019) enhanced this model and showed that these elements predict initial acceptance and continued usage trends in information systems. Within the digital banking setting, ease of access and system stability are intimately linked to the key constructs of TAM, with ease of access being the perceived simplicity of use and system stability improving perceived usefulness by providing reliable service delivery (Krasonikolakis et al., 2020). Empirical research has consistently found that perceived simplicity of use and perceived usefulness have a significant impact on customer satisfaction and sustained usage intentions in mobile and internet banking (Lydiana et al., 2022).

The SERVQUAL framework proposed by Vial (2019) outlines five elements of service quality, such as tangibles, reliability, responsiveness, assurance, and empathy. The model has been widely applied in digital service settings, suggesting that its significance extends beyond traditional face-to-face service encounters (Mirković et al., 2019). In digital banking, personalization of services is related to the empathy dimension, as it refers to the bank's ability to offer individualized attention and customized services to consumers through the use of sophisticated data analytics and customer relationship management systems (Pristiyono et al., 2022). Service innovation relates to the responsiveness dimension as it shows the bank's ability to promptly respond to the customers' wants and market dynamics by launching new features, services, and technology solutions (Naimi-Sadigh et al., 2022). The reliability factor of SERVQUAL also overlaps with system stability, highlighting the significance of providing consistent and reliable services to establish consumer confidence (Shanti et al., 2022).

Trust Theory in digital environments is based on the premise that trust development depends on three important factors: ability (competence), benevolence (goodwill), and integrity (adherence to principles) (Vijayalakshmi and Jayalakshmi, 2019). Xie and Wang (2023) extended the model to e-commerce contexts and revealed that trust is a key mediating variable for the relationships between perceptions of service quality and actual usage behaviors in contexts with limited physical encounters. Information security is directly related to the integrity and capability elements of trust, as clients

expect banks to have the capacity and integrity to safeguard their sensitive financial information (Al-Ali, 2020). In digital banking settings where clients cannot physically verify security measures, perceived information security is a basic prerequisite for the creation of trust and long-term involvement (Azmy, 2022). Recent research has also proven that information security issues have a significant impact on user adoption and usage of digital banking services, with security breaches dramatically eroding customer trust and loyalty (Xie and Wang, 2023).

Based on these theoretical frameworks, this study outlines five important pillars for good digital banking performance, which together represent what we refer to as "constellations of trust". Service Personalization, emanating from SERVQUAL's empathy dimension (Badakhshan et al., 2020), denotes the ability to customize financial services to meet individual customer needs through data analytics and behavioral insights. This has been shown to improve customer satisfaction and loyalty in digital banking contexts (Borgogno and Colangelo, 2020). It includes the safeguarding of customer data and prevention of cyberattacks, which directly affects trust formation and sustained usage (Correani et al., 2020). Ease of access, derived from the perceived ease of use concept of TAM (Dubey, 2019), includes intuitive user interfaces, availability around the clock, and cross-platform compatibility, which lower barriers to adoption (Genberg, 2020). System Stability, which includes TAM's perceived usefulness and the reliability dimension of SERVQUAL (Sun et al., 2024), refers to the ability of the technological infrastructure to support a large volume of transactions and to deliver consistent performance (Gerson and Damaske, 2020). The term "Service Innovation," which was taken from SERVQUAL's responsiveness dimension (Greenstein, 2021), refers to the ongoing improvement and development of new financial services that satisfy changing consumer expectations.

The "constellations of trust" idea in this study refers to the interconnected network of these five characteristics that together build and sustain client trust in digital banking settings. Trust in digital banking is established not only by technological reliability (system stability), security assurance (information security), user experience (ease of access), personalized attention (service personalization) and continuous adaptation (service innovation), but also by the synergistic effect of these factors on each other, forming a comprehensive trust ecosystem (PWC, 2022). Unlike traditional banking, where trust is established through face-to-face interactions and physical presence (Lee, 2019). This constellation approach recognizes that trust in digital banking is not unidimensional but rather results from the dynamic interplay of multiple service quality and technological factors, consistent with recent research that emphasizes the complex nature of trust in digital financial services (Riyanto et al., 2019). The combination of TAM, SERVQUAL and Trust Theory in this framework offers a thorough theoretical foundation for studying the cumulative effect of these five pillars on digital banking performance and customer outcomes in the current digital economy (Romero et al., 2019).

2.2.1. Digital economy in banking

The digital economy is a set of activities enabled by information and communication technology that can improve services and economic processes. It is reaching established and developing nations alike, as mobile phones and internet connectivity have created new income opportunities (Yu et al., 2023). Financial technology, or fintech, now enables electronic payments, transfers, lending, and investment, transforming conventional business structures. London, Singapore and New York have emerged as important fintech centers, where technological advancement has helped to create more efficient financial institutions and provide quicker access to services (Wang et al., 2024).

The introduction of digital technologies into banking began in the 1950s and developed through successive decades. Credit cards and automated teller machines marked important steps in the 1960s. Electronic stock exchanges emerged in the 1970s, followed by advances in networking and data

storage during the 1980s. In the 1990s, the wider adoption of the internet and e-commerce, together with online banking and mobile payments, changed the role and operating costs of physical bank branches (Yuan et al., 2021).

Mobile financial services expanded as smartphones became more widespread. Following the 2008 financial crisis, blockchain, artificial intelligence, and big data analytics gained prominence alongside fintech startups. Developments included robo-advisory services, crowdsourcing, and digital wallets (Zaman et al., 2023). These changes influenced service delivery, financial performance reporting, and bank efficiency.

Studying the major factors that affect the efficiency of digital banking can allow people to comprehend these changes and how they affect the operations of banks. The first one is the personalization of financial services. It helps to provide services customised exactly to every individual's requirements by using analytical algorithms and customer behavioral data. This leads to greater client happiness and loyalty. The second is privacy protection and information security, which gains increasing importance with the increase of digital interactions. The primary concerns of digital banks are the security of private consumer data and the war on cybercrime (Shanti et al., 2023). Designing simple user interfaces, 24/7 accessibility and platform compatibility all of which contribute to the third component ease of access and better user experience all of which are crucial in pulling in and maintaining consumers. Also crucial are the sustainability and scalability of systems, which require building technological infrastructures that can handle quick market changes and enormous transaction volumes. Continuous innovation in the delivery of financial services is required because of banks' competitive advantage and experience in maintaining persistent improvements in the quality of services (Zaman et al., 2023).

Digital banking also changes financial performance reporting. Big data and artificial intelligence can improve the speed and quality of analysis, automate the reporting activities and help with financial forecasts (Kitsios et al., 2021). At the same time, the challenge of increasingly complicated analyzes, cyberattacks and compliance with domestic and international reporting criteria has grown. Addressing these risks requires appropriate technical infrastructure and careful management (Haabazoka et al., 2021).

Research also suggests that performance-based reforms alone may not be sufficient to improve banks' financial performance because such reforms often capture only selected dimensions. Deductive chain methods have therefore been emphasized as a way to examine performance more comprehensively (Haabazoka et al., 2021). Management and reporting in the digital era require an understanding of digital economic trends, financial technologies, and aspects related to bank performance.

2.2.2. Dimensions of performance measurement in banks

The many aspects of performance measurement are important for the correct identification of areas of success and areas of development. The first dimension is value, which includes multiple values, such as economic efficiency, effectiveness and impartiality. These principles express the goals and stakeholders in the banking system. Economic efficiency means cost reduction, effectiveness means attaining organizational objectives, and impartiality means the equitable distribution of services (Yuan et al., 2021). The second dimension is orientation and it studies the relation between inputs and outputs. Inputs are the financial and human resources used and outputs are the number and quality of the services delivered. The outcomes, which are the outputs of activities, should not be ignored (Wang et al., 2024). The third dimension is data or information, which involves the balanced use of objective data (quantitative and factual) and subjective data (perceptions and evaluations of users). Focusing only on quantitative data may lead to an incomplete picture of performance, similar to

assessments that rely solely on test scores without fully capturing a student's actual performance (Zheng and Gong, 2024). Finally, in the digital economy, banks are confronted with several opportunities and risks that directly affect the reporting of their financial performance. The application of big data and artificial intelligence technology has allowed improvements to the reporting process with higher accuracy and speed in data analysis (Zhou and Li, 2023). However, the obstacles, including data analysis complexity, security risks, and the requirement to comply with international standards, necessitate precise measurements and new solutions (Zhu and Jin, 2023). Therefore, the careful integration of various dimensions and components helps managers and policymakers to obtain a holistic view of banking performance in the digital realm and to plan its development and improvement more accurately.

3. Methodology

3.1. Sample selection, variable measurement, and research design

Interview participants were selected using purposive and theoretical sampling consistent with grounded theory. The selection criteria were (1) at least 10 years of professional experience in banking, digital finance, or information systems; (2) direct involvement in digital transformation, financial reporting, or fintech-related decision-making; and (3) academic or executive expertise in financial management, accounting systems, or digital technologies. The sample comprised 15 experts. Recruitment ended at theoretical saturation, when additional interviews yielded no new conceptual codes. Table 1 summarizes participant characteristics.

Table 1. Characteristics of interview participants

ID	Organizational Role	Age (Years)	Work Experience (Years)	Education	Relevant Expertise in Digital Banking
M1	CEO, Startup	41	20	MSc	Startup management, digital ownership systems
M2	Deputy CEO	51	22	PhD	Strategy, organizational governance, fintech systems
M3	Chairman of the Board	59	27	MSc	Corporate governance, digital investment systems
M4	Deputy CEO	48	20	PhD	HRM, organizational culture, digital transformation
M5	Board Member	56	28	MSc	Financial management, startup governance
M6	Digital Sales Manager	45	18	MSc	Digital accounting, employee motivation systems
M7	Digital Sales Manager	53	23	MSc	Accounting systems, incentive structures
M8	IT Accounting Manager	56	25	MSc	IT systems, digital accounting platforms
M9	Deputy Digital Accounting	56	27	MSc	Customer relationship systems, accounting
M10	IT Accounting Manager	48	19	MSc	Data analytics, digital finance systems
M11	Deputy Accounting	59	29	MSc	Financial systems, innovation management
M12	Digital Marketer	34	10	MSc	Digital communication systems
M13	Digital Marketer	32	10	PhD Candidate	Consumer behavior, digital accounting
M14	Academic Expert	49	18	PhD Accounting	Fintech, startup governance
M15	Academic Expert	56	20	PhD Accounting	Organizational culture, ownership systems

3.2. Qualitative research design, validity, and reliability

The qualitative phase used grounded theory (Strauss and Corbin, 1998) to develop a conceptual framework suited to the digital banking context. Relevant academic publications informed the initial research materials. Semi-structured interviews were then conducted to obtain insights from specialists in the field.

At the initial stage, the Content Validity Ratio (CVR), based on Lawshe's framework, was used to assess the necessity of the interview questions and preliminary indicators. Items below the acceptable CVR threshold were revised or removed.

The Content Validity Index (CVI) was subsequently used to assess the clarity, relevance, and simplicity of the revised items, drawing on expert judgment. Items that did not meet acceptable CVI standards were modified further.

3.3. Qualitative data analysis procedure

Interview data were analyzed using Strauss and Corbin's grounded theory procedure: open, axial, and selective coding. During open coding, transcripts were examined line by line to identify initial concepts. The constant comparative method supported refinement of those codes and their grouping into broader categories during axial coding. Selective coding then brought the categories together into core themes that informed the final theoretical framework.

3.4. Coding rigor and inter-coder reliability

To ensure consistency and reliability of the qualitative findings, two trained coders assessed the interviews separately. Differences were handled in formal sessions until consensus was obtained.

Inter-coder reliability was tested using an agreement-based measure on a randomly selected sub-sample of interviews. The coefficients varied from 0.820 to 0.962, which were above the stated threshold of 0.70. The total coefficient was 0.892, showing good agreement between coders. The results are reported in Table 2.

Table 2. Inter-coder reliability

Interview ID	Total Codes (Both Coders)	Agreements	Disagreements	Reliability Coefficient
FE_1	54	26	28	0.962
FE_6	42	19	23	0.904
FE_8	39	16	23	0.820
FE_13	33	14	19	0.848
Total	168	75	93	0.892

The inter-coder reliability coefficients ranged from 0.820 to 0.962, with the mean coefficient of 0.892, showing a high level of agreement between the coders (See Table 2).

The qualitative phase comprises 15 semi-structured interviews with experts and is designed to establish a conceptual model of digital banking performance. The data from the interviews were evaluated via open, axial and selective coding (Strauss and Corbin, 1998).

Open coding produced 421 initial concepts from the interview transcripts. These were refined using constant comparison and organized into 49 categories during axial coding. Selective coding then integrated the categories into five core dimensions of digital banking services.

Table 3 presents the five interrelated dimensions identified in the analysis: service personalization, service sustainability, security and authentication, ease of service access, and service innovation. All of them deal with operational or experiential aspects that are relevant to user experience and the effectiveness of the system in digital financial services.

Service personalization is about services suited to individual consumer demands. Service

sustainability is about continuity, reliability, and continual delivery. Security and authentication include data security and transaction security. Ease of service access includes usability and efficient interactions. Service innovation includes new technology and improvements in service delivery that enable digital transformation.

Separate assessment with Cohen's kappa was carried out, yielding $\kappa = 0.87$, indicating strong inter-coder agreement. Theoretical saturation was reached after the 15th interview, and no new categories or conceptual codes emerged in the subsequent interviews.

Cronbach's alpha was used to assess the internal consistency of the questionnaire. As reported in Table 4, all constructs exceeded the threshold of 0.70, indicating acceptable reliability across the measured dimensions.

In conclusion, the qualitative analysis followed a clear and methodical process from raw data to theory building:

421 initial codes → 49 categories → 5 core aspects

This development provides a transparent description of how the interview data informed the conceptual framework.

Table 3 summarizes the five main qualities and their associated service components determined by the qualitative investigation.

Table 3. Classification of digital banking service components

Category	Services
1. Service personalization	
User interface personalization	Customer preference based user interface design
Advisory and planning services	Advisory and Planning Services: Financial guidance and investment planning.
Customer-related information	Consumer-specific information: Information that is relevant to the individual needs of the consumer.
Customer dashboard	Consumer Dashboard: Providing complete and up-to-date information to help consumer decision-making.
Digital payments	Digital Payments: Providing secure and diverse payment services.
Chatbots and interactions	Chatbots and Interaction: Using chatbots for faster and better interaction with customers.
Automated services with scheduling	Automated Scheduled Services: Automating repetitive tasks in a scheduled manner.
Reminder of permissions	License Reminders: Reminding customers to obtain necessary licenses.
Person-to-person (p2p) services	Person-to-Person (P2P) Services: Providing direct and personal money transfer services.
Risk management and financial issue forecasting	Risk Management and Financial Problem Forecasting: Predicting and managing financial risks.
Decision-making simulations	Decision-Making Simulations: Providing financial simulations to assist economic decision-making.
Investment advice	Investment Advice: Advising on suitable investment options.
Purchasing power after transactions	Purchasing Power Post-Transaction: Analyzing customer purchasing power after each transaction.
Local instructions	Localized Instructions: Offering localized services and instructions based on regional needs.
Special services for the disabled	Special Services for Disabled Individuals: Providing specific services and instructions for people with disabilities.
2. Service sustainability	
24/7 access to services	24/7 Access to Services: Services should be available 24 hours a day, 7 days a week.
Online and real-time services	Online and Real-Time Services: Providing continuous and online services.
Access with weak internet	Access with Weak Internet: Ensuring customers can access services even with a weak internet connection.
Failure prediction	Predicting Failures: Alerting customers about service outages before they occur.

Compensation for damages	Compensation for Failures: Offering compensation for damages due to technical issues or service outages.
24-hour service	24-Hour Service: Providing uninterrupted services at all times.
Logout in case of internet disruption	Automatic Logout on Internet Disruption: Automatically logging out if the internet is lost or the transaction ends.
3. Security and authentication	
Unified authentication,	Unified Authentication: Common authentication across all banking channels.
Biometric authentication	Biometric Authentication: Using biometric features like fingerprints and eye recognition.
Security standards	Security Standards: Adhering to appropriate security measures to protect data.
Preventing unauthorized access	Preventing Unauthorized Access: Preventing unauthorized individuals from accessing customer accounts.
Customer data protection	Customer Information Protection: Ensuring the confidentiality and security of customer data.
Logout in case of internet disruption	Logout on Internet Disruption: Automatically log out when the internet connection is lost.
Suspicious transaction management	Monitoring Suspicious Transactions: Monitoring and controlling unusual transactions to prevent fraud.
Password recovery	Password Recovery: Providing secure password recovery options.
Detecting malicious behaviors	Detecting Malicious Behavior: Identifying and managing fraudulent and malicious activities.
Privacy	Privacy: Respecting customer privacy and providing options to manage it.
4. Ease of access to services	
Ease of search	Easy Search: Enabling easy search within banking services.
Service evaluation	Service Evaluation: Making it easy to compare different service options.
Information transfer to the customer	Information Transfer to Customers: Providing clear and understandable information to customers.
Clarity of instructions	Transparency of Instructions: Reducing bureaucracy and ensuring transparency in procedures.
Single sign-on (SSO)	Single Sign-On (SSO) Access: Allowing access to other platforms through a single account.
Use of various symbols	Use of Various Symbols: Using various symbols to clarify transactions.
24-hour service access	24-Hour Service Access: Ensuring quick and easy access to online and phone services.
Ease of use of mobile banking	Easy Use of Mobile Banking: Offering mobile banking services with ease of use.
5. Service innovation	
Open API	Open API: Using Open API to facilitate service delivery and system interconnectivity.
Automated services	Automated Services: Automating services such as payroll management and customer validation.
Machine learning	Machine Learning: Using machine learning to continuously improve services.
New technologies	New Technologies: Implementing technologies such as IoT, blockchain, and wearables.
Services on social networks	Social Media Services: Offering services through social media platforms.
Cryptocurrencies and digital currencies	Cryptocurrencies and Digital Currencies: Enabling the use and exchange of cryptocurrencies.
Online account opening	Online Account Opening: Enabling banking processes such as online account opening.
Business forecasting	Business Forecasting: Using predictive analysis to simulate and predict economic trends.
Robotic services	Robotic Services: Using robots for customer interaction and automated service delivery.

The identified components were organized into five dimensions: service personalization, service sustainability, security and authentication, ease of access to services, and service innovation. This classification provided the basis for developing the questionnaire.

The internal consistency of the questionnaire dimensions is reported in Table 4.

Table 4. Internal consistency of the questionnaire

Row	Indices	Number of Items	Cronbach's Alpha
1	Service Personalization and Information	15	0.940
2	Service Sustainability	7	0.880
3	Security and Authentication	10	0.890
4	Ease of Service Access	8	0.920
5	Service Innovation	9	0.850
6	Total Questionnaire	49	0.840

Cronbach's alpha ranged from 0.850 to 0.940 across the five dimensions (Table 4). The coefficient for the complete questionnaire was 0.840, indicating satisfactory internal consistency.
Figure 1 illustrates the layered architecture of the digital banking ecosystem.

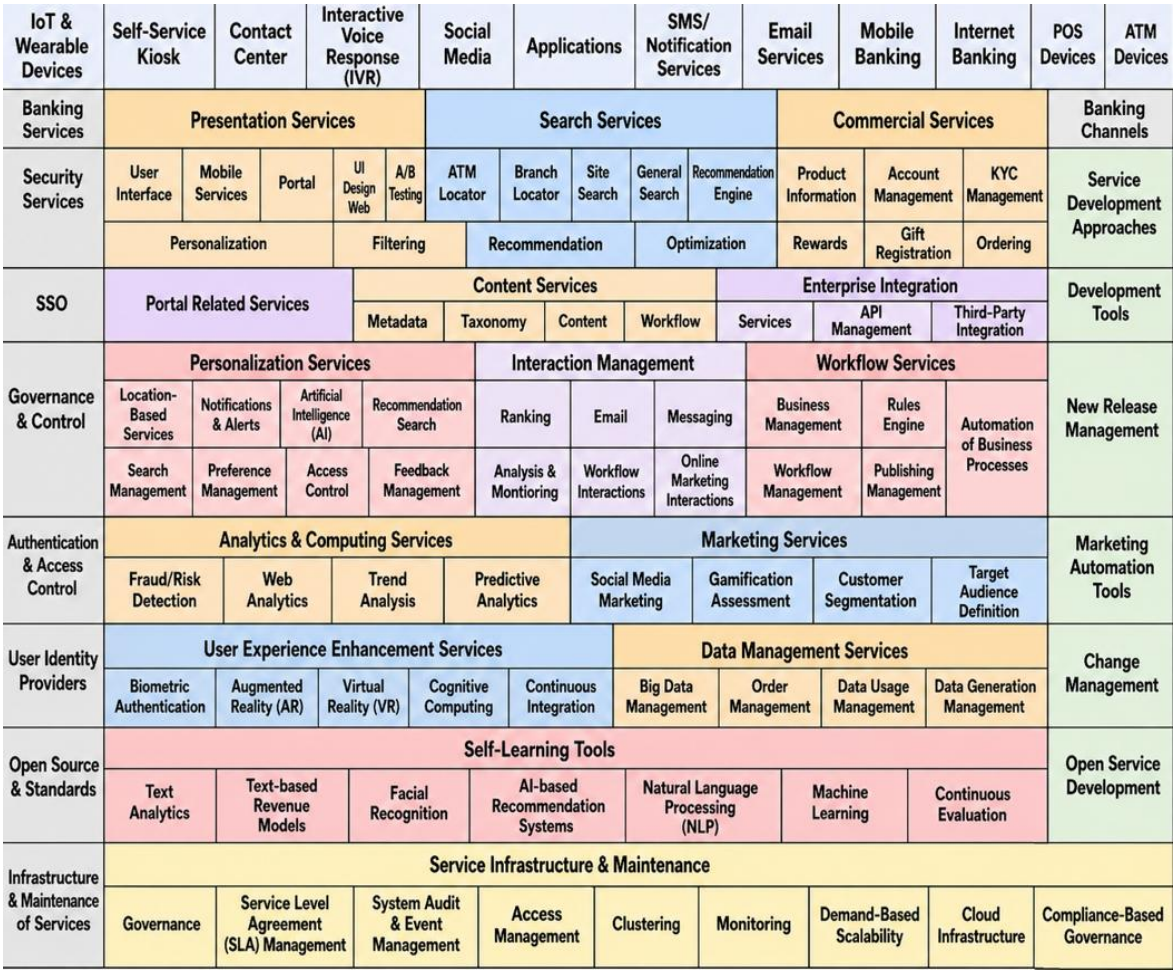


Figure 1. Layered architecture of the digital banking ecosystem

3.5. Sample selection

The study population comprised experts, professors, and managers working in digital banking. Participants were selected purposively because of their specialist expertise (Patton, 2002). The

required sample size was estimated using Cochran's formula for unknown populations (Cochran, 1977):

$$\delta = \frac{5-1}{6} = 0.667$$

$$n = \frac{z_{\alpha/2}^2 \cdot \delta^2}{\varepsilon^2} = \frac{(2.035)^2 \cdot (0.667)^2}{(0.08)^2} = 270$$

A 96% confidence level ($z_{\alpha/2} = 2.035$) was selected for this exploratory study to ensure greater precision. The range/6 heuristic for estimating standard deviation, while approximate, was validated by the observed SD of 0.72 in the collected data.

To acquire the 270 valid responses, 312 banking experts were contacted via email, industry conferences, and institutional partnerships during a period of six weeks (March–April 2024). Of these, 287 were returned (92% response rate). After 17 incomplete questionnaires were excluded, 270 remained for analysis. Early and late respondents were compared to assess non-response bias; no significant differences were reported. The final sample included 94 accountants, 86 auditors, 72 accounting professors, and 18 financial managers (Table 5).$p > 0.05$

The study followed a sequential mixed-methods design. The qualitative phase employed grounded theory (Strauss and Corbin, 1998) and consisted of 15 semi-structured interviews with banking specialists and resulted in five key aspects. Based on these parameters, a 49-item questionnaire was developed and pilot-tested with 15 professionals. In the quantitative phase (March–April 2024), 270 survey respondents were utilized to measure the selected dimensions.

4. Test results

4.1. Descriptive analysis of findings

Descriptive statistics were utilized to describe the replies from the survey. The participants were grouped by gender, age, professional position, education and work experience. The sample comprised 270 individuals with experience in contemporary banking, including university academics, accountants, auditors and financial managers. Frequencies and percentages for each demographic variable are reported below.

The sample included 220 men (81.4%) and 50 women (18.6%), reflecting a predominantly male respondent group.

Regarding age groups, the largest share was held by individuals aged 30 to 40, who comprised 118 individuals, accounting for 43.7% of the total sample, which was followed by the 40 to 50 age group, with 88 individuals (32.6%), and those under 30 years old, with 52 individuals (19.3%). Additionally, individuals aged 50 to 60 made up 10 individuals (3.7%), and those over 60 years old represented just two individuals (0.7%) of the respondents. This distribution indicates the dominance of middle-aged individuals in this sector.

By professional role, the sample comprised 94 accountants (34.81%), 86 auditors (31.85%), 72 accounting professors (26.67%), and 18 financial managers (6.67%). Most participants held a master's degree (194; 71.9%); six (2.2%) had a bachelor's degree, and 70 (25.9%) held a PhD. The sample thus consisted largely of highly educated specialists.

Regarding experience, 88 respondents had worked for less than 10 years (32.59%), 78 for 10–15 years (28.89%), 74 for 15–20 years (27.41%), and 30 for 20–25 years (11.11%).

Table 5. Demographic characteristics of the respondents

Demographic Variable	Category	Frequency	Percentage (%)
Gender	Male	220	81.400
	Female	50	18.600
Age Group	Under 30	52	19.300
	30-40	118	43.700
	40-50	88	32.600
	50-60	10	3.700
	Over 60	2	0.700
Job Position	Auditor	86	31.852
	Accounting Professor	72	26.667
	Accountant	94	34.815
	Financial Manager	18	6.667
Education Level	Master's Degree	194	71.900
	Doctorate	70	25.900
	Bachelor's Degree	6	2.200
Work Experience	Less than 10 years	88	32.593
	10-15 years	78	28.889
	15-20 years	74	27.407
	20-25 years	30	11.111

Table 6 presents descriptive statistics for the five dimensions by gender.

Table 6. Descriptive statistics of the five dimensions by gender

Factor	Gender	*n*	Mean	SD	95% CI
Service Personalization	Male	220	3.970	0.430	[3.91, 4.03]
	Female	50	3.890	0.320	[3.80, 3.98]
Service Stability	Male	220	3.930	0.520	[3.86, 4.00]
	Female	50	3.760	0.480	[3.62, 3.89]
Security and Authentication	Male	220	3.880	0.510	[3.81, 3.94]
	Female	50	3.770	0.490	[3.63, 3.91]
Ease of Access to Services	Male	220	3.760	0.570	[3.68, 3.83]
	Female	50	3.530	0.520	[3.38, 3.68]
Service Innovation	Male	220	3.730	0.690	[3.64, 3.82]
	Female	50	3.430	0.790	[3.21, 3.66]

Note. N = sample size; SD = standard deviation; CI = confidence interval. The 95% confidence intervals for the means were calculated using the t-distribution. Scores were measured on a five-point Likert scale.

Table 6 summarizes the observed mean scores and variability within each gender group. Statistical comparisons are reported in Table 15.

Table 7 presents descriptive statistics for the five dimensions across age groups.

Table 7 summarizes the observed mean scores across age groups. Estimates for respondents aged over 60 should be interpreted cautiously because this group comprised only two participants. Statistical comparisons are reported in Table 16.

Table 8 presents descriptive statistics for the five dimensions by job position.

Table 8 summarizes the observed mean scores and variability across job-position groups. Statistical comparisons are reported in Table 17.

Table 9 presents descriptive statistics for the five dimensions by educational level.

Table 7. Descriptive statistics of the five dimensions by age group

Factor	Age Group	*n*	Mean	SD	95% CI
Service Personalization	Less than 30	52	4.100	0.440	[3.98, 4.22]
	30 to 40 years	118	3.940	0.360	[3.87, 4.00]
	40 to 50 years	88	3.890	0.470	[3.79, 3.99]
	50 to 60 years	10	3.970	0.240	[3.79, 4.14]
	More than 60	2	4.150	0.000	—
Service Stability	Less than 30	52	3.890	0.640	[3.71, 4.07]
	30 to 40 years	118	3.960	0.420	[3.89, 4.04]
	40 to 50 years	88	3.880	0.560	[3.76, 4.00]
	50 to 60 years	10	4.030	0.420	[3.73, 4.33]
	More than 60	2	4.170	0.000	—
Security and Authentication	Less than 30	52	3.830	0.590	[3.67, 4.00]
	30 to 40 years	118	3.820	0.430	[3.74, 3.90]
	40 to 50 years	88	3.840	0.560	[3.72, 3.96]
	50 to 60 years	10	4.020	0.270	[3.83, 4.21]
	More than 60	2	4.670	0.000	—
Ease of Access to Services	Less than 30	52	3.720	0.640	[3.55, 3.90]
	30 to 40 years	118	3.730	0.570	[3.63, 3.84]
	40 to 50 years	88	3.690	0.550	[3.57, 3.80]
	50 to 60 years	10	3.840	0.210	[3.69, 3.99]
	More than 60	2	3.650	0.000	—
Service Innovation	Less than 30	52	3.680	0.850	[3.44, 3.91]
	30 to 40 years	118	3.780	0.630	[3.66, 3.89]
	40 to 50 years	88	3.530	0.730	[3.37, 3.68]
	50 to 60 years	10	3.690	0.610	[3.25, 4.12]
	More than 60	2	4.300	0.000	—

Table 8. Descriptive statistics of the five dimensions by job position

Factor	Job Position	*n*	Mean	SD	95% CI
Service Personalization	Accounting Professor	72	3.960	0.430	[3.86, 4.06]
	Accountant	94	3.960	0.470	[3.86, 4.05]
	Auditor	86	3.970	0.350	[3.89, 4.04]
	Financial Manager	18	4.030	0.360	[3.85, 4.21]
Service Stability	Accounting Professor	72	3.920	0.510	[3.80, 4.04]
	Accountant	94	3.910	0.4900	[3.81, 4.01]
	Auditor	86	3.810	0.590	[3.68, 3.94]
	Financial Manager	18	3.930	0.450	[3.70, 4.15]
Security and Authentication	Accounting Professor	72	3.770	0.470	[3.66, 3.88]
	Accountant	94	3.930	0.520	[3.82, 4.03]
	Auditor	86	3.790	0.560	[3.67, 3.91]
	Financial Manager	18	3.930	0.520	[3.67, 4.19]
Ease of Access to Services	Accounting Professor	72	3.660	0.590	[3.52, 3.79]
	Accountant	94	3.720	0.550	[3.61, 3.84]
	Auditor	86	3.780	0.560	[3.66, 3.90]
	Financial Manager	18	3.710	0.270	[3.57, 3.84]
Service Innovation	Accounting Professor	72	3.560	0.770	[3.38, 3.75]
	Accountant	94	3.670	0.700	[3.52, 3.81]
	Auditor	86	3.670	0.670	[3.53, 3.81]
	Financial Manager	18	3.610	0.590	[3.32, 3.90]

Table 9. Descriptive statistics of the five dimensions by educational level

Factor	Education Level	*n*	Mean	SD	95% CI
Service Personalization	Bachelor's	6	4.030	0.320	[3.69, 4.37]
	Master's	194	3.960	0.410	[3.91, 4.02]
	Doctorate	70	3.940	0.420	[3.84, 4.04]
Service Stability	Bachelor's	6	3.420	0.960	[2.41, 4.43]
	Master's	194	3.880	0.530	[3.80, 3.95]
	Doctorate	70	3.980	0.430	[3.88, 4.08]
Security and Authentication	Bachelor's	6	3.330	0.960	[2.32, 4.34]
	Master's	194	3.810	0.500	[3.74, 3.88]
	Doctorate	70	3.970	0.480	[3.86, 4.09]
Ease of Access to Services	Bachelor's	6	3.300	0.850	[2.41, 4.20]
	Master's	194	3.660	0.580	[3.58, 3.75]
	Doctorate	70	3.890	0.480	[3.77, 4.00]
Service Innovation	Bachelor's	6	3.500	1.040	[2.41, 4.59]
	Master's	194	3.570	0.730	[3.47, 3.67]
	Doctorate	70	3.950	0.580	[3.81, 4.09]

Table 9 summarizes the observed mean scores across educational levels. The wider confidence intervals for Bachelor's degree holders reflect the smaller sample size and greater variability within this group. Statistical comparisons are reported in Table 18.

Table 10 presents descriptive statistics for the five dimensions by work experience.

Table 10. Descriptive statistics of the five dimensions by work experience

Factor	Work Experience	*n*	Mean	SD	95% CI
Service Personalization	< 10 years	88	3.990	0.440	[3.90, 4.08]
	10-15 years	78	3.990	0.350	[3.91, 4.07]
	15-20 years	74	3.930	0.450	[3.82, 4.03]
	20-25 years	30	3.850	0.400	[3.70, 4.00]
Service Stability	< 10 years	88	3.800	0.600	[3.68, 3.93]
	10-15 years	78	3.980	0.530	[3.86, 4.10]
	15-20 years	74	3.940	0.430	[3.84, 4.04]
	20-25 years	30	3.840	0.430	[3.68, 4.00]
Security and Authentication	< 10 years	88	3.790	0.610	[3.66, 3.92]
	10-15 years	78	3.870	0.430	[3.77, 3.97]
	15-20 years	74	3.880	0.420	[3.79, 3.98]
	20-25 years	30	3.850	0.600	[3.62, 4.07]
Ease of Access to Services	< 10 years	88	3.610	0.730	[3.46, 3.77]
	10-15 years	78	3.840	0.540	[3.71, 3.96]
	15-20 years	74	3.750	0.460	[3.64, 3.85]
	20-25 years	30	3.620	0.570	[3.40, 3.83]
Service Innovation	< 10 years	88	3.590	0.830	[3.42, 3.77]
	10-15 years	78	3.850	0.610	[3.71, 3.98]
	15-20 years	74	3.600	0.590	[3.46, 3.74]
	20-25 years	30	3.570	0.860	[3.25, 3.89]

Table 10 summarizes the observed mean scores and variability across work-experience groups. Statistical comparisons are reported in Table 20.

Table 11 reports the sample size, minimum, maximum, mean, and standard deviation for each research dimension.

Table 11. Descriptive statistics of the research dimensions

Variable Name	Number of Respondents	Minimum Value	Maximum Value	Mean	Standard Deviation
Service Personalization	270	2.615	5	3.957	0.412
Service Stability	270	2.083	5	3.896	0.515
Security and Authentication	270	2.500	5	3.848	0.508
Ease of Access to Services	270	1.667	5	3.719	0.563
Service Innovation	270	1.600	5	3.671	0.712

As shown in Table 11, service personalization had the highest mean score (3.957), followed by service stability (3.896), security and authentication (3.848), ease of access to services (3.719), and service innovation (3.671). Service innovation showed the greatest variability in responses (SD = 0.712), whereas service personalization showed the lowest variability (SD = 0.412).

4.2. Inferential analysis of findings

The role of descriptive statistics is to collect, summarize, and describe the quantitative data obtained from samples or populations. However, researchers typically do not stop their work by presenting the data; instead, they aim to generalize the findings derived from examining a sample group to larger, similar groups. On the other hand, in most cases, it is impossible to study all members of a population. Therefore, researchers need methods that allow them to generalize the results obtained from studying small groups to larger groups. The processes through which the characteristics of large groups are inferred based on the measurement of the same attributes in small groups are referred to as inferential statistics.

4.2.1. Examination of data normality

Distributional normality was assessed using the Kolmogorov–Smirnov test, together with skewness and kurtosis. Because the Kolmogorov–Smirnov test is sensitive to sample size, these indicators were considered jointly when evaluating departures from normality. Table 12 reports the results for the five research dimensions.

Table 12. Assessment of distributional normality

Variable	Kolmogorov-Smirnov Test Statistic	Kolmogorov-Smirnov Test Significance	Skewness	Kurtosis
Service Personalization	0.117	0.000	-0.501	1.064
Service Stability	0.066	0.006	-0.467	0.809
Security and Authentication	0.066	0.007	-0.062	-0.427
Ease of Access to Services	0.068	0.004	-0.396	0.786
Service Innovation	0.076	0.001	-0.339	0.065

As shown in Table 12, the Kolmogorov–Smirnov tests were significant for all five dimensions, indicating departures from exact normality. However, skewness ranged from −0.501 to −0.062, and kurtosis ranged from −0.427 to 1.064, suggesting relatively modest distributional departures.

4.2.2. Comparison of the mean of research variables with the average value

To compare the mean of the research variables with the average value, a one-sample t-test was used. This test is applied when there is only one sample of participants, and its purpose is to examine whether the population mean equals the claimed mean (3). The hypotheses of the test are set as

follows:

$$\begin{cases} H_0: \mu = 3 \\ H_1: \mu > 3 \end{cases}$$

If the significance value is less than 0.05, the null hypothesis is rejected, and it can be concluded that the mean differs significantly from 3 and falls within an acceptable range. Otherwise, if the significance value is greater than or equal to 0.05, the null hypothesis is not rejected, and it can be stated that the mean does not significantly differ from 3. Table 13 presents the one-sample t-test results comparing the mean score of each dimension with the scale midpoint of 3.

Table 13. One-Sample t-Test results against the scale midpoint

Variable	Mean	Difference from 3	t-Statistic	Degrees of Freedom	Significance Value
Service Personalization	3.957	0.957	38.199	269	0.000
Service Stability	3.896	0.896	28.615	269	0.000
Security and Authentication	3.848	0.848	27.454	269	0.000
Ease of Access to Services	3.719	0.719	20.965	269	0.000
Service Innovation	3.671	0.671	15.475	269	0.000

As shown in Table 13, the mean scores of all five dimensions were significantly higher than the scale midpoint of 3 (all $p < 0.001$).

4.2.3. Friedman ranking test

In this study, the Friedman test was used to rank the questionnaire indicators. This test was conducted on a sample of 270 individuals. Suppose the significance value of the test is less than 0.05. In that case, the null hypothesis (that the mean ranks are equal) is rejected, indicating a significant difference between at least two groups. In this case, the indicators can be compared based on their mean ranks, and the indicators with the highest and lowest ranks can be identified. Table 14 presents the Friedman test results and the mean ranks of the five dimensions.

Table 14. Friedman test results and ranking of the five dimensions

Variable	Mean Ranks	Rank	Chi-Square Statistic	Degrees of Freedom	Significance Value
Service Personalization	3.504	1			
Security and Authentication	3.233	2			
Service Stability	3.043	3	69.443	4	0.000
Ease of Access to Services	2.657	4			
Service Innovation	2.563	5			

The Friedman test indicated significant differences among the five dimensions ($\chi^2 = 69.443$, df = 4, $p < 0.001$). Service personalization had the highest mean rank (3.504), followed by security and authentication (3.233), service stability (3.043), ease of access to services (2.657), and service innovation (2.563).

4.2.4. Comparison of the mean of research variables across demographic variables

Independent-samples t-tests were used to compare the five digital banking dimensions by gender.

Additionally, to compare these components based on age, job position, education, and work experience, the analysis of variance (ANOVA) test was used. This method, developed by Sir Ronald Fisher, is used for comparing the means of two or more groups. In this analysis, the variance between groups is examined to determine whether the observed differences are due to the influence of

independent variables or simply a result of randomness and error. Table 15 reports the independent-samples t-test results comparing the five dimensions by gender.

Table 15. Comparison of the five dimensions by gender

Variable	Gender	N	Mean	Standard Deviation	t-Statistic	Significance Value
Service Personalization	Female	50	3.893	0.323	-1.397	0.166
	Male	220	3.968	0.429		
Service Stability	Female	50	3.755	0.476	-2.208	0.028
	Male	220	3.932	0.519		
Security and Authentication	Female	50	3.772	0.488	-1.978	0.049
	Male	220	3.877	0.511		
Ease of Access to Services	Female	50	3.529	0.523	-2.625	0.009
	Male	220	3.759	0.566		
Service Innovation	Female	50	3.432	0.794	-2.683	0.008
	Male	220	3.729	0.685		

As shown in Table 15, gender differences were statistically significant for service stability, security and authentication, ease of access to services, and service innovation at the 0.05 level. The difference in service personalization was not statistically significant.

Table 16 reports the one-way ANOVA results comparing the five dimensions across age groups.

Table 16. Comparison of the five dimensions by age group

Variable	Age Group	N	Mean	Standard Deviation	F-Statistic	Significance Value
Service Personalization	Less than 30	52	4.097	0.435	2.253	0.064
	30 to 40 years	118	3.939	0.358		
	40 to 50 years	88	3.893	0.466		
	50 to 60 years	10	3.969	0.244		
	More than 60	2	4.154	0.000		
Service Stability	Less than 30	52	3.886	0.644	1.478	0.209
	30 to 40 years	118	3.961	0.415		
	40 to 50 years	88	3.881	0.555		
	50 to 60 years	10	4.033	0.418		
	More than 60	2	4.167	0.000		
Security and Authentication	Less than 30	52	3.833	0.589	2.474	0.045
	30 to 40 years	118	3.819	0.427		
	40 to 50 years	88	3.842	0.559		
	50 to 60 years	10	4.017	0.268		
	More than 60	2	4.667	0.000		
Ease of Access to Services	Less than 30	52	3.724	0.641	0.214	0.930
	30 to 40 years	118	3.732	0.566		
	40 to 50 years	88	3.685	0.549		
	50 to 60 years	10	3.839	0.208		
	More than 60	2	3.652	0.000		
Service Innovation	Less than 30	52	3.675	0.845	1.856	0.119
	30 to 40 years	118	3.775	0.630		
	40 to 50 years	88	3.527	0.732		
	50 to 60 years	10	3.686	0.608		
	More than 60	2	4.3	0.000		

As shown in Table 16, security and authentication differed significantly across age groups ($p = 0.045$). No statistically significant differences were observed for the other four dimensions at the 0.05 level.

Table 17 reports the one-way ANOVA results comparing the five dimensions by job position.

Table 17. Comparison of the five dimensions by job position

Variable	Job Position	N	Mean	Standard Deviation	F-Statistic	Significance Value
Service Personalization	Accounting Professors	72	3.961	0.434	0.172	0.915
	Accountant	94	3.958	0.473		
	Auditor	86	3.967	0.352		
	Financial Manager	18	4.034	0.362		
Service Stability	Accounting Professors	72	3.922	0.509	0.733	0.533
	Accountant	94	3.912	0.492		
	Auditor	86	3.809	0.592		
	Financial Manager	18	3.926	0.445		
Security and Authentication	Accounting Professors	72	3.774	0.468	1.447	0.230
	Accountant	94	3.927	0.521		
	Auditor	86	3.791	0.561		
	Financial Manager	18	3.931	0.517		
Ease of Access to Services	Accounting Professors	72	3.655	0.590	0.655	0.581
	Accountant	94	3.722	0.552		
	Auditor	86	3.782	0.564		
	Financial Manager	18	3.705	0.269		
Service Innovation	Accounting Professors	72	3.564	0.772	0.367	0.777
	Accountant	94	3.667	0.704		
	Auditor	86	3.669	0.670		
	Financial Manager	18	3.611	0.586		

As shown in Table 17, none of the five dimensions differed significantly across job-position groups (all $p > 0.05$).

Table 18 reports the one-way ANOVA results comparing the five dimensions by educational level.

Table 18. Comparison of the five dimensions by educational level

Variable	Education Level	N	Mean	Standard Deviation	F-Statistic	Significance Value
Service Personalization	Bachelor's	6	4.029	0.322	0.163	0.849
	Master's	194	3.964	0.413		
	Doctorate	70	3.937	0.422		
Service Stability	Bachelor's	6	3.417	0.962	2.776	0.064
	Master's	194	3.877	0.531		
	Doctorate	70	3.978	0.426		
Security and Authentication	Bachelor's	6	3.333	0.962	4.715	0.010
	Master's	194	3.813	0.501		
	Doctorate	70	3.972	0.478		
Ease of Access to Services	Bachelor's	6	3.304	0.853	5.312	0.005
	Master's	194	3.664	0.575		
	Doctorate	70	3.889	0.480		
Service Innovation	Bachelor's	6	3.500	1.039	7.580	0.001
	Master's	194	3.571	0.728		
	Doctorate	70	3.947	0.583		

As shown in Table 18, differences across educational levels were statistically significant for

security and authentication (p = 0.010), ease of access to services (p = 0.005), and service innovation (p = 0.001). Differences in service personalization and service stability were not statistically significant at the 0.05 level.

Table 19 presents descriptive mean differences between educational-level groups for the three dimensions, with significant omnibus ANOVA results reported in Table 18.

Table 19. Descriptive mean differences between educational-level groups

Dimension	Pairwise comparison	Mean difference
Service Innovation	Doctorate vs. Master's	0.380
	Doctorate vs. Bachelor's	0.450
	Master's vs. Bachelor's	0.070
	Doctorate vs. Bachelor's	0.590
Ease of Access	Doctorate vs. Master's	0.230
	Master's vs. Bachelor's	0.360
	Doctorate vs. Bachelor's	0.640
Information Security	Doctorate vs. Master's	0.160
	Master's vs. Bachelor's	0.480

The mean differences in Table 19 were calculated from the group means reported in Table 18. They describe the direction and magnitude of the observed differences and do not establish statistical significance for individual pairwise comparisons.

Table 20 reports the one-way ANOVA results comparing the five dimensions by work experience.

Table 20. Comparison of the five dimensions by work experience

Variable	Work Experience	N	Mean	Standard Deviation	F-Statistic	Significance Value
Service Personalization	Less than 10 years	88	3.99	0.443	1.128	0.338
	10 to 15 years	78	3.989	0.348		
	15 to 20 years	74	3.925	0.451		
	20 to 25 years	30	3.852	0.395		
Service Stability	Less than 10 years	88	3.803	0.597	1.885	0.133
	10 to 15 years	78	3.978	0.528		
	15 to 20 years	74	3.942	0.426		
	20 to 25 years	30	3.838	0.434		
Security and Authentication	Less than 10 years	88	3.788	0.606	0.551	0.648
	10 to 15 years	78	3.87	0.433		
	15 to 20 years	74	3.883	0.419		
	20 to 25 years	30	3.845	0.601		
Ease of Access to Services	Less than 10 years	88	3.614	0.728	2.523	0.058
	10 to 15 years	78	3.837	0.543		
	15 to 20 years	74	3.746	0.457		
	20 to 25 years	30	3.616	0.566		
Service Innovation	Less than 10 years	88	3.594	0.834	2.314	0.076
	10 to 15 years	78	3.846	0.608		
	15 to 20 years	74	3.601	0.589		
	20 to 25 years	30	3.574	0.857		

As shown in Table 20, none of the five dimensions differed significantly across work-experience groups at the 0.05 level.

To ensure clarity regarding the empirical analysis and address potential ambiguity, it is important to specify that this study employs a dual-data framework for examining digital financial performance among banks listed on the stock exchange. Accordingly, two complementary datasets were utilized:

(1) survey-based data and (2) stock market-based financial data. Both datasets were collected for the same set of listed banks and correspond to the same fiscal year (2024), ensuring full temporal alignment and comparability across models. The survey-based dataset captures perceptual and managerial assessments of digital financial performance, while the stock market-based dataset reflects objective financial performance derived from market indicators of listed banks. Based on this structure, two separate but comparable models were estimated: Model 1 (Survey-Based Digital Financial Performance) and Model 2 (Stock Market-Based Digital Financial Performance).

Table 21 presents the regression results for survey-based and stock market-based digital financial performance.

Table 21. Regression results for digital financial performance

Variables	Survey-Based Digital Financial Performance		Stock Market-Based Digital Financial Performance	
	Coefficient	P-Value	Coefficient	P-Value
Service Personalization	0.847	0.038	1.190	0.003
Service Stability	4.793	0.041	2.973	0.000
Security and Authentication	1.621	0.004	0.110	0.001
Ease of Access to Services	1.891	0.029	0.406	0.001
Service Innovation	1.118	0.451	0.649	0.306
Observations (Obs)	16		16	
F-Statistic	4.050	0.000	12.36	0.000
Adjusted R^2	0.5042		0.7911	

The reported regression results indicate positive and statistically significant coefficients for service personalization, service stability, security and authentication, and ease of access in both models. The coefficient for service innovation was not statistically significant in either model.

Table 22 summarizes the reported reliability, validity, and multicollinearity diagnostics for the five constructs.

Table 22. Reliability, validity, and multicollinearity diagnostics

	Factor Loading	CR	AVE	VIF	HTMT	(P-value)
Service Personalization	0.830	0.890	0.650	2.140	0.730	0.038
Service Stability	0.880	0.920	0.690	3.080	0.810	0.041
Security & Authentication	0.790	0.860	0.600	2.710	0.760	0.004
Ease of Access	0.850	0.900	0.670	2.030	0.710	0.000
Service Innovation	0.730	0.820	0.570	1.380	0.640	0.451

Table 23 summarizes the model-level statistics for survey-based digital financial performance.

Table 23. Model-level statistics for survey-based digital financial performance

Indicator	Value	Status
F-Statistic	4.050	Significant (P = 0.029)
Adjusted R^2	0.504	Moderate to High Explanatory Power
Common Method Bias (Harman Test)	0.410	No Evidence of Bias

Table 24 summarizes the model-level statistics for stock market-based digital financial

performance.

Table 24. Model-level statistics for stock market-based digital financial performance

Indicator	Value	Status
F-Statistic	12.360	Significant (P = 0.000)
Adjusted R^2	0.7911	High Explanatory Power
Common Method Bias (Harman Test)	0.410	No Evidence of Bias

The measurement model results show good construct validity and reliability, with satisfactory factor loadings, composite reliability (CR), average variance extracted (AVE), discriminant validity (HTMT), and no multicollinearity (VIF). Overall, the F-tests were significant for both Model 1, $F = 4.05$, $p = 0.029$, and Model 2, $F = 12.36$, $p < 0.001$. Conversely, Model 2 has much higher explanatory power (Adjusted $R^2 = 0.7911$) compared to Model 1 (Adjusted $R^2 = 0.5042$) and better predictive performance by employing market-based financial data of listed banks. Finally, Common Method Bias was assessed using Harman's single-factor test with a value of 0.41, which is below the acceptable threshold of 0.50. This implies that common method bias is not a problem in any model, further validating the robustness of the empirical findings.

5. Conclusion

The outcomes of this study revealed that service personalization, security and authentication, system stability, simplicity of access, and service innovation affect the performance of digital banking collectively. The results were generally in line with the findings of Ahmed and Sur (2023) and Acheampong et al. (2023), who stressed the importance of personalization and information security in improving digital banking success. Thus, the current study validated the concept that customer-centric design and cybersecurity are basic and universal drivers of digital banking effectiveness across settings.

From a theoretical perspective, the results strongly supported the TAM. Consistent with Lydiana et al. (2022), ease of access and system stability significantly influence user acceptance by enhancing perceived ease of use and perceived usefulness. These mechanisms explained how system usability translates into behavioral intention and actual adoption in digital banking environments, confirming the robustness of TAM in explaining technology-driven financial behavior.

Similarly, the results were consistent with the SERVQUAL methodology, notably for service personalization and system stability. These characteristics are consistent with the basic SERVQUAL aspects, namely empathy and reliability, as confirmed by Pristiyono et al. (2022) and Shanti et al. (2022). This means that the quality of digital banking service is not just technical but also experiential, where customization boosts perceived relevance and system stability boosts perceived service reliability.

In terms of Trust Theory, the results provided a more holistic explanation than prior studies, e.g. Vijayalakshmi and Jayalakshmi (2019) and Xie and Wang (2023). Previous research has tended to treat security as a direct antecedent of trust; however, the current results indicated that trust development is a multi-dimensional process. Specifically, security and authentication reduced perceived danger, simplicity of access boosted user confidence through usability, and personalization increased relational engagement. Thus, digital banking trust is a composite outcome rather than a

single-element construct.

A major difference with the existing literature is related to service innovation. Desyatnyuk et al. (2024) and Javaid et al. (2024) revealed that innovation is an important driver of banking performance, but this study showed that its effect is not dominant and depends on the circumstances. Service innovation itself does not have a direct effect on performance, but it acts as an enabler whose effect depends on the existence of sufficient system stability, strong security infrastructure and good usability. It demonstrates that innovation indirectly affects performance improvement and it can be successful only when the basic service environment is mature enough. This view helps resolve contradictions in past studies and emphasizes the significance of contextual circumstances in digital banking ecosystems.

Overall, the comparison revealed that the findings largely align with prior research on the importance of personalization, security and usability, while enriching the literature by redefining the role of service innovation and offering a more complex explanation of trust formation mechanisms. These discrepancies stress the contextual specificity of digital banking performance in the studied setting and help to provide a more comprehensive theoretical explanation of the phenomena.

From a practical perspective, the study has major consequences for managers and policymakers. Improving client experience through personalization Having strong cybersecurity systems Improving system's usability are the key to improve digital banking performance. Effective implementation and impact require the development of innovative strategies to be aligned with infrastructural readiness and service stability.

Future research should further examine the mediating or moderating role of system infrastructure and usability in shaping the effectiveness of service innovation. Additionally, investigating psychological and behavioral dimensions of trust formation, and conducting cross-country comparative studies, may provide deeper insights into contextual differences in digital banking performance and inform more effective policy and managerial strategies.

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