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# Designing a Qualitative Model of Barriers, Challenges, and Influencing Factors in the Implementation of Fourth-Generation Digital Banking in Iran

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## ABSTRACT

The present study aims to design a qualitative model of barriers, challenges, and influencing factors in the implementation of fourth-generation digital banking in Iran. In terms of data type, this research is qualitative; in terms of purpose, it is considered a fundamental and exploratory study, seeking to develop a qualitative model of barriers, challenges, and influencing factors affecting the implementation of fourth-generation digital banking in Iran. The participants of the study consisted of officials and policymakers in the banking sector, as well as senior managers. The data collection instrument in this study was semi-structured interviews, with each interview lasting on average between 45 and 55 minutes. Maximum variation sampling was employed, and efforts were made to select participants from three groups—officials, policymakers in the banking sector, and senior managers—to ensure that different dimensions of the phenomenon were identified. Since sampling continued until theoretical saturation was achieved, the final sample size was determined at the end of the qualitative data collection process, comprising 12 participants. In this study, the grounded theory method with the Glaserian approach was used to design the model based on the challenges and foundations of implementing fourth-generation banking in Iran. In this stage, the model was developed through three phases of coding: open, axial, and selective coding. The frequency of open codes in this study was 805, which corresponded to 99 distinct open codes. In the next step, axial coding was conducted, resulting in the identification of 30 axial codes. Finally, through selective coding, the axial codes were categorized into two main groups: challenges and barriers, and foundations (influencing factors). Based on the results of the qualitative model design, the variables of fourth-generation banking risks, structural challenges, and challenges related to laws and regulations were identified as barriers and challenges. In another part of the model, which focused on identifying foundations and influencing factors, variables such as strengthening the digital ecosystem, assessing the maturity of information technology infrastructure, development and growth of investment, data-driven management based on core data, the banking industry supply chain, leveraging the algorithmic potentials of fourth-generation banking, and innovation in service delivery were identified as key foundations and influencing factors in fourth-generation banking.

**Keywords:** Fourth-generation banking, Fourth Industrial Revolution, barriers and challenges, influencing factors and foundations, grounded theory approach.

## Introduction

The relentless and rapid pace of technological advancement, catalyzed by the advent of the Fourth Industrial Revolution (Industry 4.0), has fundamentally reshaped the landscape of global financial services, altering how economic value is generated, distributed, and consumed [1, 2]. Financial institutions worldwide are currently traversing a massive paradigm shift from traditional, legacy-based banking structures toward dynamic, highly interconnected digital business models [3].

This evolution transcends mere digitization; it represents a comprehensive overhaul of the entire banking ecosystem, demanding unprecedented levels of organizational agility and a profound integration of intellectual capital [4]. Fourth-generation (4G) digital banking represents the current pinnacle of this evolutionary trajectory. It is characterized by the omnipresence of interconnected technologies, data-driven decision-making protocols, and seamless customer experiences that predict and anticipate needs proactively. Furthermore, as the banking industry looks to the horizon, theoretical conceptual models are already bridging the gap toward Industry 5.0, where human-centric approaches and advanced digital interactive spaces, such as metaverse banking, are beginning to take root in pre-adoptive frameworks [5].

At the core of fourth-generation digital banking is the deeply symbiotic relationship between traditional banking operations and highly agile financial technology (FinTech) innovations [6]. The proliferation of FinTech has not merely acted as a supplementary distribution channel but has fundamentally disrupted traditional banking value chains. This disruption demands that incumbent banks adopt intelligent digital banking architectures to remain competitive and relevant [7]. The seamless integration of these multifaceted technologies into next-generation banking platforms requires a rigorous evaluation of digital service quality, system reliability, and modular scalability to ensure uninterrupted value delivery to the end-user [8, 9]. Within this technological nexus, the adoption of artificial intelligence (AI) is particularly transformative, providing the robust analytical backbone necessary for predictive analytics, hyper-personalized customer service, and automated complex decision-making processes in smart banking environments [10, 11].

Advanced AI and Big Data Analytics play a critical role in managing and minimizing credit risk, an essential operational component of modern 4G banking. By employing optimal balancing and efficient feature ranking algorithms, banks can isolate critical risk variables from vast, unstructured datasets [12]. Furthermore, integrating Big Data Analytics dramatically enhances the institution's intellectual capital, acting as a crucial moderating variable that amplifies overall innovation performance within the banking network [13]. The strategic inclusion of distributed ledger technologies, notably blockchain, further secures this digital environment by offering immutable, decentralized transaction records, establishing critical success factors for sustainable and highly resilient operations, particularly during periods of intense business uncertainty [14].

The strategic imperative of implementing these advanced digital architectures is inextricably linked to organizational performance, efficiency, and long-term viability. Banks that successfully design future-ready enterprises inherently cultivate a strong entrepreneurial orientation, utilizing comprehensive digital transformation as a primary driver of high organizational performance [15, 16]. Consequently, the volume of digital bank transactions has surged globally, a metric that directly correlates with enhanced institutional financial performance and broader sectoral growth [17]. The impact of this profound digitization on operational efficiency is undeniable; empirical thematic analyses continually demonstrate that robust digital infrastructures streamline back-office operations, significantly reduce overhead costs, and optimize resource allocation [18]. Moreover, increasing this operational efficiency via digital means serves as a vital mediating mechanism linking a banking institution's environmental and economic sustainability awareness directly to its overall profitability [19]. Consequently, the level of direct financial investment into FinTech capabilities is emerging as a strong predictor of European and global banks' profitability metrics [20]. Strategic technological capability must also heavily align with comprehensive marketing knowledge management; leveraging digital financial innovation effectively acts as a critical mediating factor connecting internal knowledge capacities to external, quantifiable business performance [21].

Beyond internal operational mechanics, the implementation of fourth-generation digital banking drastically alters the bank-customer dynamic, redefining how financial services are consumed. A primary objective of strategic digital transformation is evaluating, understanding, and subsequently maximizing the acceptance rate of e-services among highly diverse consumer demographics [22]. However, navigating this transition requires overcoming significant behavioral and psychological hurdles on the consumer side. The purely digital banking space poses unique, distinct challenges to consumer trust building and long-term retention, necessitating sophisticated digital marketing strategies tailored specifically for FinTech environments [23]. A comparative analysis between traditional brick-and-mortar institutions and purely digital banks highlights that digital entities must deploy highly responsive and integrated complaint management systems to bridge the gap left by the absence of physical customer service and to ensure continuous service improvement [24]. Exploring the complex determinants of technology adoption is crucial, particularly in nuanced financial sectors like Islamic banking and waqf institutions, where strict religious compliance and specialized institutional trust heavily influence the uptake of financial technology [25]. Understanding these digital banking adoption patterns is especially vital in developing economies, where successful market penetration relies heavily on assessing physical infrastructural readiness, advancing digital literacy, and proving perceived usefulness to the public [26].

Despite the immense potential benefits and efficiencies, the global transition towards digital and fourth-generation banking is fraught with systemic barriers, multifaceted structural challenges, and profound operational risks. From a managerial perspective, digital transformation frequently encounters deeply entrenched internal resistance to change, often stemming from risk aversion, deep dependencies on legacy systems, and a lack of a coherent digital vision at the executive policymaking level [27]. Cultural and institutional values play a formidable role in either accelerating or severely hindering the digitalization process; if an institution’s historical culture conflicts with the agile, rapid demands of the digital era, the resulting organizational friction can derail otherwise sound technological initiatives [28]. The sheer economic reality of the digital landscape also presents severe hurdles; for instance, intense market competition and high customer acquisition costs mean many newly established digital banks struggle for extended periods merely to reach the breakeven point, representing a highly volatile evolution wave in the financial sector [29].

Furthermore, aggressive digital transition often brings unintended socio-economic consequences, most notably the exacerbation of the digital divide. The rapid digitalization of banking services frequently leads to physical branch closures, which can inadvertently create severe digital barriers and reshape the landscape of financial inclusion. This phenomenon disproportionately disenfranchises vulnerable, elderly, or rural populations who lack reliable digital access or adequate digital literacy [30]. Finally, the expansive deployment of 4G banking introduces unprecedented and highly complex cybersecurity vulnerabilities. As artificial intelligence and wide-scale digital transformations scale, banks are exposed to sophisticated, automated cyber threats, necessitating the immediate development of comprehensive, multi-stakeholder cognition-driven frameworks to aggressively fortify digital perimeters and definitively safeguard highly sensitive core financial data [31].

Within the context of developing nations, and specifically the Islamic Republic of Iran, the banking sector faces a unique confluence of these global technological imperatives alongside localized, highly specific structural challenges. While contemporary global literature provides extensive, valuable insights into digital banking adoption and challenges in regions such as the BRICS economies, the European Union, and rapidly developing Southeast Asian markets, there remains a critical, undeniable dearth of contextualized, qualitative models that address the nuanced challenges of implementing fourth-

generation digital banking within Iran's distinct regulatory, economic, and technological ecosystem. Iranian banks operate under specific domestic legislative frameworks, face unique macroeconomic conditions and trade complexities that can complicate the procurement of foreign technological infrastructure and international FinTech partnerships, and must navigate a highly localized domestic digital ecosystem. The transition to fourth-generation banking in Iran is not merely a matter of simple technological procurement; it requires a fundamental restructuring of the traditional banking industry supply chain, the establishment of robust data-driven management protocols based on core localized data, and the aggressive stimulation of domestic investment growth despite prevailing economic constraints.

To bridge this significant gap in the current academic literature, it is imperative to move beyond the quantitative assessments of isolated variables and instead develop a holistic, conceptually grounded understanding of the phenomenon as it exists in reality. A qualitative methodological approach allows for a deep, exploratory investigation into the lived experiences, strategic perspectives, and operational realities of policymakers, senior banking executives, and officials who are actively managing this digital transition on the ground. Identifying the specific contextual risks of 4G banking, the rigid structural impediments inherent to the local sector, and the complex web of domestic laws and regulations is absolutely essential for forming actionable, effective policies. Concurrently, identifying the foundations and positive influencing factors—such as assessing domestic IT infrastructure maturity, strengthening the local digital ecosystem, leveraging the algorithmic potentials of 4G banking, and fostering continuous innovation in service delivery—will provide a vital roadmap for successful implementation. Therefore, the present study aims to design a qualitative model of barriers, challenges, and influencing factors in the implementation of fourth-generation digital banking in Iran.

## Methodology

This study is qualitative in terms of data type and is considered a fundamental and exploratory study in terms of its objective, aiming to design a model of fear of missing out (FOMO) in promotional purchasing opportunities using a grounded theory approach. The research participants consisted of officials and policymakers in the banking sector as well as senior managers, and the average duration of the interviews ranged between 45 and 55 minutes. In some cases, interviews were repeated to share preliminary findings, as well as to complete, refine, revise, and adjust the data. Additional probing questions were posed to guide discussions and to achieve categories relevant to the phenomenon under investigation. Maximum variation sampling was employed in this study, and efforts were made to select participants from three groups—officials, policymakers in the banking sector, and senior managers—in order to identify different dimensions of the subject. Since sampling continued until theoretical saturation was achieved, the final sample size was determined at the end of the qualitative data collection process, comprising 12 participants. After each interview, the full text of the conversations was transcribed, and through careful examination, concepts relevant to the research objective were extracted from the interview paragraphs. To enhance the accuracy of concept coding, efforts were made to formulate questions based on the obtained data. Questions such as who, when, where, what, how, and why were instrumental in completing the list of coded concepts. During the process of answering these questions, ambiguities regarding the relationships among data and the research topic were identified, and these ambiguities themselves generated new questions for subsequent interviews. In other words, the coding process of one interview generated questions whose answers were not fully present in the existing data and therefore needed to be addressed in subsequent sessions. This iterative process continued until the interviews reached saturation and

no new concepts emerged. At this stage, two additional interviews were conducted to ensure data saturation, after which the interview process was terminated, and in subsequent coding stages, only brief clarifications were sought when necessary. The characteristics of the qualitative participants are presented in Table 1.

**Table 1**

*Characteristics of Qualitative Participants (Interviews)*

| No. | Gender | Age | Position | Education | Interview Duration |
|---|---|---|---|---|---|
| 1 | Male | 42 | Senior Manager | PhD | 50 minutes |
| 2 | Male | 45 | Board Member | PhD | 55 minutes |
| 3 | Female | 42 | Senior Manager | PhD | 45 minutes |
| 4 | Male | 49 | Board Member | PhD | 55 minutes |
| 5 | Male | 42 | Board Member | PhD | 45 minutes |
| 6 | Female | 49 | Senior Manager | PhD | 50 minutes |
| 7 | Male | 48 | Board Member | PhD | 55 minutes |
| 8 | Female | 42 | Senior Manager | PhD | 55 minutes |
| 9 | Female | 39 | Senior Manager | PhD | 50 minutes |
| 10 | Male | 52 | Board Member | PhD | 50 minutes |
| 11 | Male | 44 | Board Member | PhD | 40 minutes |
| 12 | Male | 38 | Board Member | PhD | 60 minutes |

It should be noted that with the execution of each interview, simultaneous analysis and the emergence of concepts and categories guided the direction of subsequent interviews. Based on the grounded theory method, the analysis of data obtained from participants was conducted using the Glaserian approach. Furthermore, after final coding, test–retest reliability was assessed. To measure the reliability of the instrument, the recoding method and intra-coder agreement percentage were used. Accordingly, the second, fourth, and eighth interviews were selected. Each of these interviews was coded twice within a ten-day interval. It is noteworthy that the number of agreed codes in the first and second coding rounds was identified by both coders and considered as paired codes. The total number of codes within the ten-day interval was 210, and the number of agreed codes was 103. The final reliability test result was 80.15%, and since this value exceeds 60%, the coding demonstrates acceptable reliability.

**Table 2**

*Criteria for Evaluating Research Reliability*

| No. | Interview | Total Codes | Agreed Codes | Disagreed Codes | Test–Retest Reliability (%) |
|---|---|---|---|---|---|
| 1 | First | 64 | 24 | 6 | 75 |
| 2 | Third | 85 | 39 | 11 | 91.7 |
| 3 | Eighth | 61 | 19 | 5 | 62.2 |
| Total | — | 210 | 79 | 22 | 76.3 |

Other criteria for evaluating research validity are presented in Table 3.

**Table 3**

*Criteria for Evaluating Research Validity*

| No. | Criteria | Actions Taken |
|---|---|---|
| 1 | Credibility | To enhance the credibility of the collected data, multiple data collection methods such as note-taking and observation were employed. Participant validation of handwritten notes was conducted to ensure consistency with their experiences. Additionally, the extracted concepts, categories, and classifications were reviewed by researchers to verify the accuracy of the coding process and to achieve consensus codes. |
| 2 | Transferability | To strengthen transferability and applicability, a detailed description of all research steps was provided to enable replication, along with detailed characteristics of participants. Maximum variation sampling was used by selecting participants with the highest level of knowledge and awareness related to the research topic. |
| 3 | Dependability | Reliability was ensured by documenting interviews, including handwritten records, and by recoding the text of three interviews after a three-week interval. The results of the initial coding were compared with the recoding to identify consistent codes. |
| 4 | Confirmability | To assess confirmability, expert opinions from marketing scholars in the field of qualitative research were utilized to achieve consensus on the findings. |

## Findings and Results

The process of analyzing qualitative interview data begins when the researcher focuses on meaningful statements that are considered salient in relation to the research topic. This analysis starts with repeated review and examination of the interview data set, and after meaningful statements relevant to the research topic are identified, they are coded. First, the researcher attempts to provide a detailed view of the various dimensions of the case (facts). In other words, a brief description is initially presented regarding the situation, events, actors, and context of each case study. Subsequently, the data from each case are categorized through open coding; at this stage, the main categories are identified. Then, through axial coding, the categories are reduced to themes, and the core themes in each case study are identified. Coding is part of the knowledge production process and theory generation in grounded theory methodology. This approach begins with one or more research questions and is formed over time through data collection by means of in-depth interviews and reflective observation, continuing through systematic and continuous analysis, and ultimately leading to knowledge production and stabilization through theory development, although it does not end there. A research project based on this method is considered successful when its outcome not only answers the initial research questions, but also generates new questions that provide the basis for future research. This method is one of the forms of qualitative research whose primary objective is to explain social and educational processes and to develop theory. With a distinctive orientation, this method is exploratory in nature and, in data analysis, relies on the constant comparative analysis approach within the framework of three stages: open coding, axial coding, and selective coding. It should be noted that all coding processes were carried out using MAXQDA 2020 software.

In open coding, after each interview and transcription of the data, the text must be reviewed two to three times. To ensure a thorough examination of the data, and by using a maximum coding approach, the text of each interview is analyzed line by line. Each event, idea, and situation is assigned a label that signifies and represents that phenomenon, and by merging similar codes, their number is reduced. In the next stage, through axial coding, concepts with semantic convergence are grouped and integrated, resulting in the extraction of several axial categories. In the subsequent stage, namely selective coding, the identified categories are placed under a limited number of main categories, and the coding process is implemented through a defined procedure. The three-stage coding process is explained in the following sections.

In open coding, open sampling is conducted, meaning that participants are selected as samples who provide the greatest opportunity to collect the most relevant data regarding the phenomenon under study. In principle, in open sampling, the researcher is not yet certain which concepts are theoretically appropriate. Therefore, without considering individual differences, the researcher approaches the process openly and increases the number of interviews until, through daily interviews and their analysis, a primary list of questions and specific individuals who should be interviewed in greater depth is gradually identified. Accordingly, the total frequency of open codes in this study is 805, corresponding to 99 distinct open codes. The results obtained from the open coding stage are presented in Table 4.

**Table 4**

*Analysis of Extracted Open Codes and Their Frequencies*

| Open Codes | Frequency |
|---|---|
| Approval of targeted sanctions for the national banking industry | 7 |
| Government-related risks | 9 |
| Policy and policymaking-related risks | 7 |
| Political risks in attracting foreign investment | 7 |
| Political risks in expanding international activities | 8 |
| Political risks in expanding banking operations | 7 |
| Political risks in increasing the outflow of experts and human capital | 7 |
| Inefficiency in operational risk management | 7 |
| Inefficiency in credit risk management | 8 |
| Inefficiency in liquidity risk management | 8 |
| Increased cost of technology acquisition due to various constraints | 7 |
| Rapid evolution of financial technologies globally | 9 |
| Investment risk in technological infrastructure due to continuous change | 7 |
| Risk of data leakage and failure to protect customer privacy | 8 |
| Challenges related to decentralized identity verification | 8 |
| Risk of inadequate service provision by other supply chain partners | 7 |
| Presence of fintech firms and risk of customer loss and reduced bank revenues | 7 |
| Lack of support from senior banking industry managers | 8 |
| Lack of managerial awareness and knowledge of fourth-generation banking | 8 |
| Migration of employees and skilled workforce in the banking sector | 7 |
| Lack of transformational mindset in human resources toward fourth-generation banking | 8 |
| Shortage of skilled human resources in digital banking | 8 |
| Misalignment between domestic banking system changes and global developments | 9 |
| Inability of banks to attract skilled workforce | 9 |
| Presence of traditional organizational culture in banks | 9 |
| Presence of traditional organizational structure in banks | 8 |
| ضعف در حفاظت و امنیت اطلاعات | 9 |
| Low internet speed and limited bandwidth | 10 |
| Presence of outdated infrastructure in the country | 10 |
| Lack of sufficient resources for infrastructure modernization | 9 |
| Ineffective regulation in areas such as cryptocurrencies | 8 |
| Violation of international regulations | 7 |
| Ineffective regulation of data ownership | 8 |
| Delay in issuing facilitative regulations for fintech activities | 9 |
| Delay in updating financial ecosystem regulations | 8 |
| Delay in updating stock market regulations | 8 |
| Delay in updating insurance regulations | 9 |
| Delay in updating banking regulations | 7 |
| Restrictive domestic laws and regulations | 8 |
| Updating software infrastructure in line with the digital ecosystem | 7 |
| Updating hardware infrastructure in line with the digital ecosystem | 8 |
| Expansion of activities and facilitation of communication within the digital ecosystem | 8 |
| Access to international markets for banks and supply chain firms | 8 |
| Facilitation of relationships among supply chain ecosystem actors | 8 |
| Development of standards aligned with the digital ecosystem | 7 |
| Parallel development of regulators with system developers | 7 |
| Regulation aligned with the digital ecosystem | 9 |
| Increased transparency in stakeholder collaboration regulations | 7 |
| Development of dynamic and up-to-date regulations aligned with the digital ecosystem | 8 |
| Assessment of technological infrastructure maturity in network communications | 9 |
| Assessment of technological infrastructure maturity in banking supply chains | 9 |
| Assessment of technological infrastructure maturity in business intelligence | 8 |
| Assessment of technological infrastructure maturity in cognitive banking | 8 |
| Assessment of technological infrastructure maturity in open banking | 8 |
| Assessment of technological infrastructure maturity in platform banking | 7 |
| Foreign investment inflow through transparent international regulations | 8 |
| Capital allocation based on national economic conditions | 9 |
| Capital allocation based on national income | 9 |
| Increased investment in the domestic digital ecosystem | 9 |
| Allocation of foreign investment in supply chain sectors | 8 |

| | |
|---|---|
| Increased investment in the international digital ecosystem | 8 |
| Development of AI operational capabilities through targeted investment | 8 |
| Establishment of strong databases for AI deployment through targeted investment | 6 |
| Development and investment in AI capabilities | 10 |
| Use of data analytics in developing fourth-generation banking | 9 |
| Optimal use of data to facilitate banking processes | 10 |
| Use of data to enhance efficiency and effectiveness of banking processes | 7 |
| Accelerating decision-making through data-driven approaches | 8 |
| Preventing resource waste through data-driven approaches | 7 |
| Reducing decision-making risk through data-driven approaches | 8 |
| Evaluation of banking supply chain in data collection and storage | 7 |
| Evaluation of banking supply chain in data analysis and utilization | 7 |
| Evaluation of supply chain decision-making based on big data | 8 |
| Assessment of supply chain maturity in digital communication usage | 8 |
| Assessment of supply chain maturity in data utilization | 10 |
| Assessment of supply chain maturity in operational speed | 9 |
| Assessment of supply chain maturity in organizational transformation | 8 |
| Use of open banking in supply chains | 8 |
| Use of platform banking in supply chains | 7 |
| Use of cognitive banking in supply chains | 7 |
| Supply chain agility through stakeholder integration | 10 |
| Supply chain agility through improved interactions | 8 |
| Supply chain agility through process optimization | 9 |
| Collaboration with partners in augmented reality | 9 |
| Enhancing customer experience through location-based services | 8 |
| Strengthening virtual reality marketing for banking services | 9 |
| Use of integrated virtual and augmented reality for banking services | 8 |
| Predicting supply chain failures using big data | 8 |
| Decision-making using big data | 7 |
| Trend analysis and forecasting using big data | 9 |
| Transparency in financial transactions | 8 |
| Asset tokenization | 9 |
| Smart contracts | 10 |
| Leveraging insurtech to increase customers | 10 |
| Leveraging regtech to increase customers | 9 |
| Leveraging lendtech to increase customers | 7 |
| Bank presence in social media for service delivery | 9 |
| Creating specialized financial environments in social media | 8 |
| Designing applications for social media-based service delivery | 8 |

Based on the content analysis of the conducted interviews, a total of 99 codes were identified, which were subsequently used in the axial coding stage. It should be noted that all processes related to open coding were carried out using MAXQDA version 2020.

In this stage of coding, the open codes were categorized through classification and identification of shared conceptual roots, and after clustering, they were labeled with reference to the theoretical foundations. Given that the title of the study is focused on identifying the barriers, challenges, and foundations (influencing factors) of implementing fourth-generation banking, an effort was also made in this section to conduct axial coding in two parts: axial coding for identifying the barriers and challenges of implementing fourth-generation banking, and axial coding for identifying the foundations (influencing factors) of implementing fourth-generation banking. Accordingly, Table 5 presents the results of axial coding for identifying the challenges of implementing fourth-generation banking.

**Table 5**

*Axial Coding for Identifying the Barriers and Challenges of Implementing Fourth-Generation Banking*

| Axial Codes | Open Codes | Axial Codes | Open Codes |
|---|---|---|---|
| Legal risk | Approval of targeted sanctions on the national banking industry | Failure to update the laws and regulations of the national financial system | Delay in updating laws related to various ecosystems of the financial system |
| | Government-related risks | | Failure to expedite the issuance of laws facilitating fintech activities |
| | Risks related to policies and policymaking | | Delay in updating stock market regulations |
| Political risk | Political risks in attracting foreign investment | | Delay in updating insurance regulations |
| | Political risks in expanding international operations | | Delay in updating banking regulations |
| | Political risks in expanding the bank's activities | | Cumbersome domestic laws and regulations |
| | Political risks in the growing outflow of specialists and human resources | Lack of specialized human resources in the field of fourth-generation banking | Lack of support and backing from senior managers in the banking industry |
| Weakness in banking risk management | Inefficiency in operational risk management | | Managers' lack of awareness and knowledge of fourth-generation banking |
| | Inefficiency in credit risk management | | Migration of employees and specialized human resources in the banking industry |
| | Inefficiency in liquidity risk management | | Lack of a transformational perspective in human resources toward fourth-generation banking |
| Technology risk | Increased cost of acquiring technology due to various constraints | | Shortage of specialized human resources in digital banking |
| | Rapid pace of change in financial technologies worldwide | Existence of a traditional structure in the national banking system | Misalignment between changes in the national banking system and global developments |
| | Investment risk in technological infrastructure due to continuous change | | Inability of banks to attract specialized human resources |
| | Risk of information leakage and failure to protect customer privacy | | Presence of a traditional organizational culture in the bank |
| | Challenges related to decentralized identity verification | | Presence of a traditional organizational structure and traditionalist orientation in the bank |
| Collaboration risk | Risk of inadequate service delivery by other partners in the supply chain | Weakness of technical infrastructure in the national banking system | Weakness in information protection and security |
| | Presence of fintechs and the risk of banks losing customers and reduced revenues | | Low internet speed and limited bandwidth |
| Deficiencies in legal mechanisms | Ineffective regulation in various areas, including cryptocurrency | | Existence of obsolete infrastructure in the country |
| | Violation of international laws | | Lack of sufficient resources for infrastructure modernization |
| | Ineffective regulation of data ownership | | |

Subsequently, axial coding was conducted to identify the foundations (influencing factors) of implementing fourth-generation banking, and the results are presented in Table 6.

**Table 6**

*Axial Coding for Identifying the Foundations (Influencing Factors) of Implementing Fourth-Generation Banking*

| Axial Codes | Open Codes | Axial Codes | Open Codes |
|---|---|---|---|
| Infrastructural upgrading within the ecosystem | Updating software infrastructure in line with the digital ecosystem | Evaluation of the fourth-generation banking supply chain | Evaluating the status of the banking supply chain in data collection and storage |
| | Updating hardware infrastructure in line with the digital ecosystem | | Evaluating the status of the banking supply chain in data analysis and application |
| Facilitation of communications within the ecosystem | Expansion of activities and facilitation of communications in line with the digital ecosystem | | Evaluating the status of the supply chain in decision-making based on big data |
| | Possibility of entering the international market for banks and supply-chain companies | Evaluation of supply chain maturity | Measuring supply chain maturity in terms of the use of digital communications |
| | Facilitating relationships among actors in the supply chain ecosystem | | Measuring supply chain maturity in terms of data utilization |
| Regulation or regulators within the ecosystem | Standard-setting in line with the digital ecosystem | | Measuring supply chain maturity in terms of acceleration |
| | Simultaneous development of regulators alongside the system developer | | Measuring supply chain maturity in terms of organizational transformations |

| | | | |
|---|---|---|---|
| | Regulating laws and regulations in line with the digital ecosystem | Application of digital technologies and infrastructure in the fourth-generation banking supply chain | Use of open banking in the banking supply chain |
| Transparency in ecosystem laws | Increasing the transparency of stakeholder collaboration rules in line with the digital ecosystem | | Use of platform banking in the banking supply chain |
| | Establishing up-to-date and dynamic laws in line with the digital ecosystem | | Use of cognitive banking in the banking supply chain |
| Monitoring the maturity of communication infrastructure | Measuring the maturity of technological infrastructure in terms of network communications | Agility of the fourth-generation banking service supply chain | Increasing agility through connecting various stakeholders in the banking service supply chain |
| | Assessing the maturity level of technological infrastructure in the banking supply chain | | Increasing agility through improving various interactions in the banking service supply chain |
| | Measuring the maturity of technological infrastructure in terms of business intelligence | | Increasing agility through various banking service supply chain processes |
| Monitoring the maturity of modern banking infrastructure | Measuring the maturity of technological infrastructure in terms of cognitive banking | Application of metaverse capabilities | Collaboration with business partners active in the field of augmented reality |
| | Examining the maturity of technological infrastructure in terms of open banking | | Improving customer experience through the provision of location-based services |
| | Measuring the maturity of technological infrastructure in terms of platform banking | | Strengthening virtual reality marketing for the delivery of banking services |
| Investment in the field of fourth-generation banking | Inflow of foreign investment through creating transparency in international laws | | Using a combination of virtual reality and augmented reality for the delivery of banking services |
| | Allocation of capital according to the country's economic conditions | Application of big data capabilities | Predicting various failures in the supply chain using big data |
| | Allocation of capital according to national income | | Decision-making and policy formulation using big data |
| Investment in the digital ecosystem | Increasing investment in the domestic digital ecosystem sector | | Analytics and forecasting improvement trends using big data |
| | Allocation of foreign investment in supply-chain sectors | Application of blockchain capabilities | Transparency of financial transactions and exchanges |
| | Increasing investment in the foreign digital ecosystem sector | | Asset tokenization |
| Development and investment in the use of artificial intelligence tools | Developing operational AI capabilities through targeted investments | | Smart contracts |
| | Establishing a robust database for the proper deployment of AI through targeted investments | Online services | Using the potential of insurtech to increase customers |
| | Development and investment aimed at strengthening AI capabilities | | Using the potential of regtech to increase customers |
| Data and information management | Using data analytics in the development of fourth-generation banking | | Using the potential of lendtech to increase customers |
| | Optimal use of data to facilitate processes related to fourth-generation banking | Development of social networks in the banking industry | Bank presence on social networks for introducing and delivering services |
| | Use of data to increase the efficiency and effectiveness of processes related to fourth-generation banking | | Creating a specialized financial environment on social networks for introducing and delivering services |
| Application of data management in the decision-making process | Accelerating policy formulation and decision-making with a focus on data | | Designing applications for presence on social networks to introduce and deliver services |
| | Preventing resource waste through a data focus | | |
| | Reducing decision-making risk through a data focus | | |

Through the process of selective coding, by which a core category emerges, theoretical conceptualization can begin, and the researcher is able to confirm any existing assumptions. In open coding, the analyst focuses on generating categories and their properties and then attempts to determine how these categories vary across specified dimensions. In axial coding, categories are systematically refined and linked to subcategories. At this stage, the grounded theory researcher formulates a theory regarding the relationships among the categories identified in the axial coding model. The process of integrating and refining the theory in selective coding is carried out through techniques such as writing a storyline that connects categories and categorization through personal memos concerning theoretical ideas. In a storyline, the researcher examines how specific

factors influence the phenomenon and lead to the adoption of particular strategies with specific outcomes. In other words, selective coding takes the findings from previous coding stages, selects the core category, systematically relates it to other categories, validates these relationships, and completes categories that require further development and refinement. The results of selective coding are presented in Table 7.

**Table 7**

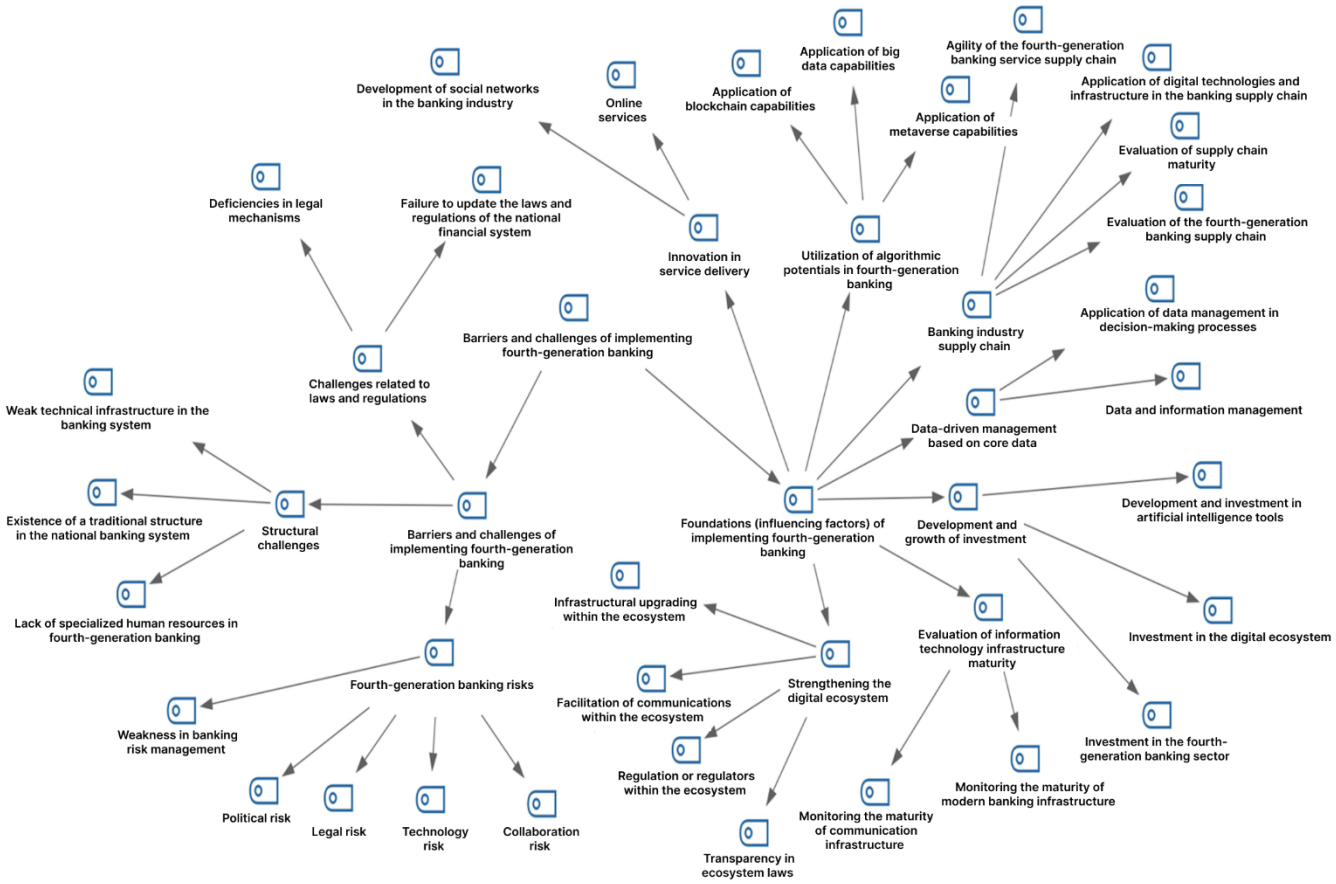
*Selective Coding for Categorizing Barriers, Challenges, and Foundations (Influencing Factors) of Implementing Fourth-Generation Banking*

| Model Dimensions | Selective Codes | Axial Codes |
|---|---|---|
| Barriers and challenges of implementing fourth-generation banking | Fourth-generation banking risks | Legal risk |
| | | Political risk |
| | | Weakness in banking risk management |
| | | Technology risk |
| | | Collaboration risk |
| | Structural challenges | Lack of specialized human resources in fourth-generation banking |
| | | Existence of a traditional structure in the national banking system |
| | | Weak technical infrastructure in the banking system |
| | Challenges related to laws and regulations | Deficiencies in legal mechanisms |
| | | Failure to update the laws and regulations of the national financial system |
| Foundations (influencing factors) of implementing fourth-generation banking | Strengthening the digital ecosystem | Infrastructural upgrading within the ecosystem |
| | | Facilitation of communications within the ecosystem |
| | | Regulation or regulators within the ecosystem |
| | | Transparency in ecosystem laws |
| | Evaluation of information technology infrastructure maturity | Monitoring the maturity of communication infrastructure |
| | | Monitoring the maturity of modern banking infrastructure |
| | Development and growth of investment | Investment in the fourth-generation banking sector |
| | | Investment in the digital ecosystem |
| | | Development and investment in artificial intelligence tools |
| | Data-driven management based on core data | Data and information management |
| | | Application of data management in decision-making processes |
| | Banking industry supply chain | Evaluation of the fourth-generation banking supply chain |
| | | Evaluation of supply chain maturity |
| | | Application of digital technologies and infrastructure in the banking supply chain |
| | | Agility of the fourth-generation banking service supply chain |
| | Utilization of algorithmic potentials in fourth-generation banking | Application of metaverse capabilities |
| | | Application of big data capabilities |
| | | Application of blockchain capabilities |
| | Innovation in service delivery | Online services |
| | | Development of social networks in the banking industry |

Accordingly, the use of these three coding procedures indicates that grounded theory researchers employ systematic procedures to develop their theory. They rely on the analysis of their data to transform them into specific types of categories identified during axial coding and use diagrams to present their theoretical models. Figure 1 illustrates the selective coding based on the grounded theory approach (Glaserian perspective).

**Figure 1**

*Selective Coding (Model Based on Barriers, Challenges, and Foundations [Influencing Factors] of Implementing Fourth-Generation Banking in Iran)*




## Discussion and Conclusion

The primary objective of this qualitative study was to design a comprehensive model identifying the barriers, challenges, and influencing foundations critical to the successful implementation of fourth-generation (4G) digital banking in Iran. Utilizing a grounded theory methodology based on the Glaserian approach, semi-structured interviews with 12 key policymakers, officials, and senior banking managers yielded 99 distinct open codes, which were subsequently refined into 30 axial codes. The results culminated in a selective coding framework bifurcated into two main categories: challenges and barriers (encompassing 4G banking risks, structural challenges, and regulatory hurdles) and foundations and influencing factors (including the strengthening of the digital ecosystem, IT infrastructure maturity, investment growth, core data-driven management, supply chain optimization, algorithmic potential leverage, and service delivery innovation).

The emergence of 4G banking risks as a primary barrier strongly aligns with current literature highlighting the vulnerabilities introduced by expansive digitalization. As banks migrate toward fully interconnected digital frameworks, they inherently expose themselves to severe, complex cybersecurity threats. This finding is supported by researchers who advocate for the deployment of multi-stakeholder cognition-driven frameworks to aggressively mitigate digital risks in the banking sector [31]. Furthermore, economic risks play a substantial role; the transition is highly capital-intensive, and many

digital banking initiatives struggle initially to reach the critical breakeven point, representing a volatile evolution wave that requires careful financial navigation [29].

Structural challenges were also identified as a formidable impediment. The data revealed that transitioning from traditional legacy systems to agile 4G architectures often encounters intense organizational friction. This corroborates empirical findings that highlight how deep-rooted traditional corporate culture and institutional values can severely hinder the digitalization process [28]. From a managerial perspective, overcoming internal resistance to change and establishing a future-ready enterprise requires a fundamental overhaul of internal operational processes [16, 27]. Externally, structural challenges manifest as the exacerbation of the digital divide. As physical branches close in favor of pure digital platforms, vulnerable demographics face heightened digital barriers, reshaping the landscape of financial inclusion in ways that require strategic mitigation [30]. Finally, the regulatory environment in Iran was identified as a critical bottleneck. The rigidities of current laws often lag behind the rapid pace of technological innovation. This necessitates proactive regulatory development to govern digital business models in Industry 4.0, a sentiment echoed globally as regulatory bodies strive to keep pace with FinTech advancements [3]. These regulatory complexities are particularly acute in Islamic finance systems, where digital frameworks must align perfectly with stringent institutional and religious parameters, similar to technology adoption patterns seen in waqf institutions [25].

Conversely, the qualitative model identified critical foundations and influencing factors that act as catalysts for 4G banking implementation. Strengthening the broader digital ecosystem and fostering investment growth are foundational prerequisites. The integration and strategic role of FinTech within the banking industry ecosystem are undeniable drivers of modern financial evolution [6]. Elevated levels of financial technology investment directly correlate with enhanced bank profitability and sustainable market competitiveness [20]. To maximize this profitability, investments must be channeled into assessing and upgrading the maturity of the IT infrastructure. Establishing intelligent digital banking technologies and architectures is no longer optional but mandatory for survival [7]. Within this upgraded infrastructure, resilient operations across the banking industry supply chain can be profoundly secured through the adoption of distributed ledger systems and blockchain technology [14]. Furthermore, building institutional quality through these technological upgrades paves the way for broader national participation in the Fourth Industrial Revolution, a phenomenon similarly observed in rapidly developing BRICS economies [2] and major global players like China [1].

A pivotal finding of this study is the critical reliance on data-driven management and leveraging algorithmic potentials. 4G banking is fundamentally powered by Big Data Analytics and Artificial Intelligence. The empirical data suggests that the capacity to manage marketing knowledge and intellectual capital through Big Data dramatically moderates and enhances overall innovation performance [13, 21]. The adoption of AI is essential for predictive modeling and automating complex decision-making in smart banking environments [10, 11]. For example, utilizing optimal balancing and efficient feature ranking approaches is vital for minimizing credit risk, a core operational necessity [12]. Integrating these advanced technologies transforms traditional operations, vastly improving operational efficiency. The

elevated operational efficiency acts as a mediating role that connects a bank's sustainability awareness to its net profitability [19]. Consequently, the surge in digital bank transactions facilitated by these algorithmic capabilities directly fuels broader sectoral performance [17].

Finally, innovation in service delivery was identified as a paramount influencing factor. The ultimate success of 4G banking relies on how effectively these complex back-end systems translate into a seamless user experience. Evaluating the quality of next-generation banking platforms and measuring the acceptance rate of e-services are critical continuous processes [8, 9, 22]. Developing Asian economies and localized markets demonstrate that adoption hinges on perceived usefulness, trust, and targeted digital marketing strategies [23, 26]. Because purely digital banks lack physical touchpoints, they must innovate heavily in customer relationship management, utilizing advanced complaint management systems to bridge the gap and retain consumer trust [24]. Successfully blending these digital innovations with strong entrepreneurial orientation ultimately serves as the primary driver for achieving high organizational performance in the modern era [15]. Looking forward, building these 4G foundations is critical as the industry begins to transition toward Industry 5.0 concepts, such as metaverse banking, which will heavily rely on the intellectual capital and robust data structures established today [4, 5].

While this study provides an in-depth exploratory model of fourth-generation digital banking implementation, several methodological and contextual limitations must be acknowledged. Primarily, the qualitative nature of the research and the reliance on the grounded theory approach inherently restrict the statistical generalizability of the findings. The sample size, determined by theoretical saturation, consisted of 12 participants. While sufficient for qualitative depth, this small cohort may not capture the total variance of perspectives across all tiers of the Iranian banking sector, particularly middle management and operational IT staff who execute these strategies daily. Furthermore, the findings are deeply contextualized within the specific economic, regulatory, and technological environment of Iran. Factors such as international sanctions, highly specific domestic financial policies, and localized infrastructure constraints mean that the proposed model may require significant adjustment before being applied to other geographical or economic contexts. Finally, qualitative coding processes, despite rigorous adherence to the Glaserian approach, carry an inherent risk of subjective researcher bias during the conceptualization and categorization of open and axial codes.

To build upon the foundational qualitative model developed in this study, future research should prioritize quantitative validation. Developing a comprehensive survey instrument based on the identified axial and selective codes would allow researchers to test the relationships between the barriers and influencing factors using structural equation modeling (SEM) or partial least squares (PLS) across a broad, representative sample of the banking sector. Such quantitative studies could mathematically determine the predictive weight of specific variables, such as how strongly IT infrastructure maturity impacts operational efficiency compared to regulatory challenges. Additionally, longitudinal studies are highly recommended to track how the perception of these challenges and foundations evolves as technological implementation matures over time. Comparative cross-cultural studies would also be highly valuable; juxtaposing the Iranian banking sector's digital transition against those of other developing nations or emerging markets could isolate which challenges are purely systemic to the technology and which are unique to specific geopolitical environments. Finally, as the technological horizon expands, future inquiries should investigate the pre-adoptive frameworks necessary for transitioning from fourth-generation banking into Industry 5.0, focusing heavily on human-machine collaboration and decentralized finance architectures.

For practitioners, senior banking managers, and domestic policymakers, the findings of this model offer a strategic roadmap for navigating digital transformation. It is highly recommended that banking institutions adopt a phased, modular approach to IT infrastructure upgrades rather than attempting monolithic overhauls, thereby mitigating systemic operational risks and managing capital investments more effectively. Banks must aggressively prioritize the development of their

intellectual capital and human resources; investing in advanced training programs focused on big data analytics, artificial intelligence, and cybersecurity is essential to overcome internal structural resistance and build a future-ready workforce. Furthermore, executive leadership must establish highly responsive, digital-first customer relationship frameworks that address the emotional and practical needs of users to prevent customer attrition during the digital transition. From a macroeconomic and regulatory perspective, it is imperative that financial authorities and government policymakers collaborate directly with banking leaders to create “regulatory sandboxes.” These controlled environments would allow for the rapid, secure testing of innovative algorithmic services and blockchain-based supply chain integrations without violating existing legal frameworks, ultimately fostering a more dynamic, supportive, and legally robust digital financial ecosystem.

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## Authors’ Contributions

All authors equally contributed to this study.

## Declaration of Interest

The authors of this article declared no conflict of interest.

## Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Written consent was obtained from all participants in the study.

## Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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