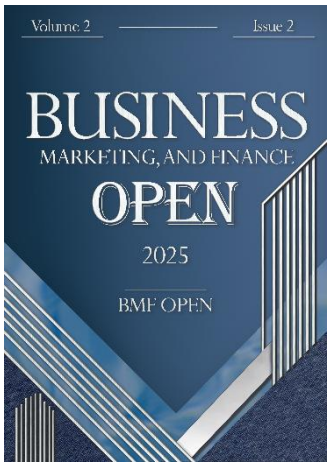
Designing a Model for the Implementation of Fourth-Generation Banking in Iran Using the Fuzzy Delphi Method and Interpretive Structural Modeling



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Abstract: The primary objective of this study is to design a model for the implementation of fourth-generation banking in Iran using the Fuzzy Delphi method and Interpretive Structural Modeling (ISM). This research is applied in terms of purpose and descriptive in terms of nature and methodology. Additionally, this study employs a mixed-methods approach, utilizing the Fuzzy Delphi method in the qualitative phase and Interpretive Structural Modeling in the quantitative phase for analysis. The study participants consisted of university professors and experts in the banking sector. In the qualitative phase, twelve individuals were selected as panel members using purposive sampling. Following the completion of three rounds of the Delphi method, the key variables for implementing fourth-generation banking in Iran were identified. In the quantitative phase, another twelve individuals were selected as the sample, and a questionnaire was distributed among them. Microsoft Excel was used for data analysis in this study. The results of the qualitative analysis, based on the three rounds of the Delphi method, indicated that out of 38 variables initially identified through theoretical foundations and literature review for implementing fourth-generation banking in Iran, 31 variables were ultimately selected by the panel members as the most critical factors. Furthermore, the results of Interpretive Structural Modeling placed these 31 variables into nine levels. Consequently, the model for implementing fourth-generation banking in Iran in this study consists of nine levels. Based on the findings of the model design, it is recommended that special attention be given to the first level (strategic advantages) and the ninth level (information and communication technology infrastructure), as these levels exhibit the highest degree of influence and susceptibility.

Keywords: Banking, Fourth Industrial Revolution, Fuzzy Delphi, Interpretive Structural Modeling

1. Introduction

Digital transformation based on the Fourth Industrial Revolution has emerged as a pivotal force in shaping the banking sector, leading to fundamental changes in banking structures. This transformation continues to evolve alongside rapid advancements in technology and shifting priorities of customers and stakeholders [1]. Over the past few years, traditional banking operations have undergone significant digitalization, encompassing a broad spectrum of functions, from customer interactions to back-end processes. This transformation is driven by various factors, including the proliferation of smartphones, increased internet penetration, and the emergence of innovative financial technologies. Financial institutions and banks increasingly recognize the necessity of digital adoption to remain competitive and relevant in today's fast-paced digital landscape. However, digital transformation is fraught with challenges, as legacy systems, regulatory constraints, and organizational inertia often hinder digitalization efforts, underscoring the complexity of this transition [2, 3].

Digital transformation based on the Fourth Industrial Revolution has become synonymous with the demands of the modern era, where technology plays an increasingly central role in daily life. The digitalization of traditional banking operations extends far beyond mere automation, representing a fundamental shift in how financial institutions engage with customers, manage processes, and deliver value [4]. This evolution is fueled by a combination of factors, including the widespread adoption of smartphones and the internet, which have made financial services more accessible to the public while empowering consumers with unprecedented levels of convenience and choice [5]. Moreover, the rise of innovative financial technologies, often spearheaded by fintech startups, has disrupted traditional banking paradigms, compelling incumbents to embrace innovation [6]. As a result, digital transformation in banking is not merely a technological implementation but a strategic necessity for financial institutions seeking to maintain relevance and competitiveness in an increasingly digital world [3].

Despite the undeniable benefits of digital transformation, banks face significant challenges along the path to digitalization. Legacy systems, characterized by outdated infrastructure and fragmented data architectures, pose a major impediment to progress, limiting agility and interoperability. Overcoming these challenges requires a holistic approach that addresses technological, regulatory, and cultural dimensions while emphasizing the need for strong leadership, strategic vision, and cross-functional collaboration within banking organizations. One of the primary obstacles banks encounter in digital transformation is legacy systems and infrastructure. Many banks still operate on outdated technology platforms, which hinder agility and interoperability, making it challenging to integrate new technologies and adapt to evolving customer demands [7]. Upgrading or replacing these systems requires substantial investment and expertise, creating a significant barrier to digital initiatives. Additionally, cultural resistance and organizational inertia within banking institutions hinder digital transformation efforts. Banks have traditionally been conservative institutions with deeply ingrained processes and risk-averse cultures, making the adoption of innovation and agility a challenge [8].

Overcoming this resistance necessitates strong leadership and effective change management strategies to foster a culture of innovation and adaptability. Moreover, talent shortages and skill gaps pose significant hurdles, as banks struggle to attract and retain specialists in areas such as data analytics and cybersecurity [9]. Addressing these challenges requires a coordinated effort by banks to invest in technology infrastructure, comply with regulatory requirements, cultivate a culture of innovation, and attract and retain digital talent [3]. Despite these obstacles, the era of digital transformation driven by the Fourth Industrial Revolution has introduced numerous

advantages and trends in the banking sector, reshaping traditional banking practices while enhancing overall efficiency and customer experience [7].

Thus, it can be asserted that the emergence of digital transformation based on the Fourth Industrial Revolution has triggered a distinctive paradigm shift in the banking industry, altering the landscape of traditional banking operations and redefining how financial institutions engage with customers [8]. This technological evolution has not only streamlined internal processes but also revolutionized customer interactions through innovative digital channels [2]. As banks embrace digital platforms, the scope and scale of their operations have expanded exponentially, enabling them to offer a diverse range of services, from mobile banking to digital wallets and virtual advisory services [10]. Consequently, the banking sector finds itself at a critical juncture, where the integration of digital tools is essential for enhancing operational efficiency and positioning institutions at the forefront of industry transformation [2].

From a systemic perspective, digital transformation based on the Fourth Industrial Revolution in the banking sector represents a fundamental shift in how financial institutions interact with customers, manage processes, and deliver value [11]. While the transition to digitalization is fraught with challenges—including legacy systems, regulatory constraints, and cultural resistance—banks increasingly recognize the necessity of digital adoption to maintain a competitive edge [9]. Despite these hurdles, the digital era has ushered in numerous benefits and trends in the banking sector, transforming traditional practices while improving overall efficiency and customer experience. From the expansion of digital banking channels to the adoption of innovative technologies such as artificial intelligence and machine learning, banks are poised to leverage digital transformation to drive sustainable growth and competitiveness in the digital age (Bueno et al., 2024).

Indeed, the integration of digital technologies, including Industry 4.0, into the banking sector has marked the beginning of a new era of operational efficiency, redefining how financial tasks are executed, monitored, and optimized [3]. However, evaluating the outcomes of these operations is crucial for banks and the financial services industry, as such assessments carry significant weight for banks and financial institutions by demonstrating their financial efficiency to various stakeholders, including the market, investors, and competitors, while ultimately fostering trust among their customers [12]. As a result, the paradigm shift toward digitalization has not only enhanced the efficiency of individual operational components but has also synergistically aligned various aspects of banking operations, thereby improving the overall operational efficiency of banks' processes [13].

The issue at hand is that with the advent of the Fourth Industrial Revolution in banking processes, many banks initially resisted making fundamental and structural changes, which led to the closure of several banks and financial institutions. Consequently, financial institutions were compelled to adopt appropriate strategies for embracing digital technologies. Following the adoption of digital technology by banks, managers and stakeholders realized that they could enhance resilience and sustainability by mitigating risks, reducing the adverse effects of disruptions, improving flexibility, and shifting business attitudes toward greater satisfaction. Therefore, with the broader adoption of modern digital technologies, the banking sector is continually exploring new ways to conduct banking operations that enhance cost efficiency and ensure long-term sustainability. In this regard, banks can adopt technologies based on the Fourth Industrial Revolution to transform their business models [14].

Accordingly, this article is structured into several key sections. The first section presents the introduction, followed by a review of the theoretical literature. Subsequently, the research methodology is examined. The findings section details the stages of data analysis. Finally, the article concludes with a discussion and conclusion.

2. Methodology

This study falls within the category of applied research based on the classification of research by purpose. According to the classification of research by data collection method, it is categorized as descriptive research. Furthermore, in terms of approach to the problem, this study employs a mixed-methods approach, utilizing the Fuzzy Delphi method in the qualitative phase and Interpretive Structural Modeling (ISM) in the quantitative phase for analysis. The study participants consisted of university professors and experts in the banking sector. In the qualitative phase, twelve individuals were selected as panel members using purposive sampling. In the quantitative phase, the same individuals were used as the sample, and a questionnaire was distributed among them.

The Fuzzy Delphi method is derived from the traditional Delphi method and fuzzy set theory. In the traditional Delphi method, questionnaire items and responses tend to exhibit ambiguity and vagueness. Additionally, a significant challenge in this method is achieving consensus among experts in the framework of group decision-making. Over the past three decades, the Fuzzy Delphi method has been repeatedly revised by researchers to address the issue of ambiguity among experts. This method employs fuzzy numbers or fuzzy set theory, whereby each set has a value ranging from zero to one. By implementing this approach, the costs and time required for evaluating questionnaire items are reduced. Consequently, it decreases the number of research iterations and increases the recovery rate of items, allowing experts to express their opinions without any ambiguous bias and ultimately reach consensus without compromising their genuine perspectives.

Murray et al. (1985) were the first to propose the use of fuzzy theory in the Delphi method. Subsequently, Ishikawa et al. (1993) introduced the application of cumulative frequency distribution and fuzzy scoring of expert opinions. Later, the interval distance of experts for fuzzy scores was incorporated, which led to the development of the Fuzzy Delphi method. The application of the Fuzzy Delphi method in group decision-making can address the issue of the non-fuzzy perception of expert opinions. This method is built upon the collective thinking of specialists to ensure the validity of the gathered information. The Fuzzy Delphi method guarantees that no misinterpretation occurs in the understanding of expert opinions, as it considers the fuzziness of the entire research process. Based on a review of the literature and theoretical foundations, 38 variables were identified as key factors influencing the implementation of fourth-generation banking.

3. Findings and Results

The analysis in the Fuzzy Delphi section was conducted in three rounds. Due to the large volume of tables, only the results of the third round are presented below:

Table 1. Results of the Third Round of the Fuzzy Delphi Method

Row	Identified Variables	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)	L	M	U	Defuzzified Mean	Status
1	Perceived Organizational Governance	6	2	1	3	0	1	1.739589	4	2.119794731	Not Approved
2	Perceived Standards and Structures in Financial Markets	7	2	3	0	0	1	1.477243	3	1.738621566	Not Approved

3	Perceived Environmental Pressure	0	0	3	3	6	3	4.161791	5	4.080895725	Approved
4	Information and Communication Technology (ICT) Infrastructure	0	0	1	1	10	3	4.703344	5	4.351672163	Approved
5	ICT Skills	0	0	0	4	8	4	4.641589	5	4.570794417	Approved
6	ICT Policies	0	0	1	1	10	3	4.703344	5	4.351672163	Approved
7	Strategic Advantages	0	0	0	3	9	4	4.728708	5	4.614354023	Approved
8	Organizational Benefits	0	0	0	2	10	4	4.817462	5	4.65873121	Approved
9	Economic Benefits	0	0	0	2	10	4	4.817462	5	4.65873121	Approved
10	Informational Benefits	0	0	0	2	10	4	4.817462	5	4.65873121	Approved
11	Technological Benefits	0	0	0	3	9	4	4.728708	5	4.614354023	Approved
12	Organizational Performance Improvement	0	0	0	3	9	4	4.728708	5	4.614354023	Approved
13	Business Environment Improvement	0	0	0	4	8	4	4.641589	5	4.570794417	Approved
14	Service Innovation	0	0	0	5	7	4	4.556075	5	4.52803733	Approved
15	Idea Generation for Service Delivery	0	0	0	2	10	4	4.817462	5	4.65873121	Approved
16	Economic Review and Analysis	6	6	0	0	0	1	1.414214	2	1.457106781	Not Approved
17	Technical and Commercial Analysis	5	4	3	0	0	1	1.658149	3	1.829074676	Not Approved
18	Financial Provision	0	0	0	1	11	4	4.907883	5	4.703941325	Approved
19	Project Management System	0	0	1	2	9	3	4.616692	5	4.308346201	Approved
20	New Service and Process Design	0	0	1	2	9	3	4.616692	5	4.308346201	Approved
21	Distribution Channel Design and Development	6	4	2	0	0	1	1.513086	3	1.756542875	Not Approved
22	Entry of a New Generation of Competitors	0	0	0	4	8	4	4.641589	5	4.570794417	Approved
23	Financial Technology Companies (FinTech)	0	0	0	4	8	4	4.641589	5	4.570794417	Approved
24	New Activity Ecosystem and Regulatory Framework	0	0	0	4	8	4	4.641589	5	4.570794417	Approved
25	Market Condition Changes	0	0	0	3	9	4	4.728708	5	4.614354023	Approved
26	Changes in Customer Needs, Behavior, and Expectations	0	0	0	4	8	4	4.641589	5	4.570794417	Approved
27	Financial Capacity	0	0	0	6	6	4	4.472136	5	4.486067977	Approved
28	Competencies and Competitive Advantages	0	0	0	6	6	4	4.472136	5	4.486067977	Approved
29	Organizational Maturity	0	0	0	5	7	4	4.556075	5	4.52803733	Approved
30	Managerial Support	0	0	0	2	10	4	4.817462	5	4.65873121	Approved
31	Willingness to Learn	6	6	0	0	0	1	1.414214	2	1.457106781	Not Approved
32	Communication and Commitment	7	5	0	0	0	1	1.33484	2	1.417419927	Not Approved
33	Willingness to Adopt New Banking Business Models	0	0	0	6	6	4	4.472136	5	4.486067977	Approved
34	Competitive Environment	0	0	0	2	10	4	4.817462	5	4.65873121	Approved

35	Security Risks and Fraud	0	0	0	3	9	4	4.728708	5	4.614354023	Approved
36	Technology Change Speed	0	0	0	3	9	4	4.728708	5	4.614354023	Approved
37	Economic Turbulence	0	0	0	2	10	4	4.817462	5	4.65873121	Approved
38	Banking Service Personalization	0	0	0	3	9	4	4.728708	5	4.614354023	Approved

Based on the results of the three rounds of the Delphi method, 31 variables were ultimately identified as the most critical influencing factors.

In the Fuzzy Delphi section, based on the identified variables, a total of 31 variables were ultimately selected by the panel members as the final influential factors in the implementation of fourth-generation banking in Iran, which are presented in Table 2.

Table 2. Final Influential Variables in the Implementation of Fourth-Generation Banking in Iran

No.	Influential Variables	No.	Influential Variables
1	Perceived Environmental Pressure	17	Entry of a New Generation of Competitors
2	Information and Communication Technology (ICT) Infrastructure	18	Financial Technology Companies (FinTechs)
3	ICT Skills	19	New Activity Ecosystem and Regulatory Framework
4	ICT Policies	20	Market Condition Changes
5	Strategic Advantages	21	Changes in Customer Needs, Behavior, and Expectations
6	Organizational Benefits	22	Financial Capacity
7	Economic Benefits	23	Competencies and Competitive Advantages
8	Informational Benefits	24	Organizational Maturity
9	Technological Benefits	25	Managerial Support
10	Organizational Performance Improvement	26	Willingness to Adopt New Banking Business Models
11	Business Environment Improvement	27	Competitive Environment
12	Service Innovation	28	Security Risks and Fraud
13	Idea Generation for Service Delivery	29	Technology Change Speed
14	Financial Provision	30	Economic Turbulence
15	Project Management System	31	Banking Service Personalization
16	New Service and Process Design		

Next, Interpretive Structural Modeling (ISM) was used to categorize and prioritize these variables. The steps of the ISM approach are presented as follows:

The Structural Self-Interaction Matrix consists of dimensions and indices of the study, comparing them using four types of conceptual relationships. This matrix was completed by experts and specialists focusing on process-oriented analysis. The logic behind Interpretive Structural Modeling is based on non-parametric methods and operates based on the mode of frequencies. In this regard, the causal relationships among variables were determined, leading to the formation of the Structural Self-Interaction Matrix. Due to the large volume of tables, the detailed results are not presented in this article.

The identified relationships were converted into binary values (0 and 1) based on specific rules and incorporated into the reachability matrix. After creating the initial matrix, it was necessary to ensure its internal consistency. For instance, if in the reachability matrix, Variable 1 leads to Variable 2 and Variable 2 leads to Variable 3, then, according to the transitivity rule in mathematics, Variable 1 must lead to Variable 3; otherwise, the matrix should be revised and missing relationships should be included. Mathematical rules for matrix consistency were applied, and the reachability matrix was raised to the power of (K+1), where K≥1. This operation was performed using Boolean algebra.

To determine the level and priority of variables, the reachability set and antecedent set were identified for each variable using the reachability matrix. After defining these sets, the common elements between them for each variable were identified. The results of this analysis are presented in Table 3.

Table 3. Categorization of Model Components for the Implementation of Fourth-Generation Banking in Iran

Level	Influential Variables
Level 1	Strategic Advantages
Level 2	Informational Benefits, Organizational Performance Improvement, Service Innovation, Idea Generation for Service Delivery, Project Management System, Security Risks and Fraud
Level 3	ICT Policies, Technological Benefits, New Service and Process Design, Entry of a New Generation of Competitors, Financial Technology Companies (FinTechs), New Activity Ecosystem and Regulatory Framework, Market Condition Changes, Changes in Customer Needs, Behavior, and Expectations, Organizational Maturity, Willingness to Adopt New Banking Business Models, Economic Turbulence, Banking Service Personalization
Level 4	Perceived Environmental Pressure, ICT Skills, Financial Capacity, Competencies and Competitive Advantages, Competitive Environment
Level 5	Financial Provision, Managerial Support
Level 6	Business Environment Improvement, Technology Change Speed
Level 7	Economic Benefits
Level 8	Organizational Benefits
Level 9	ICT Infrastructure

Finally, based on the categorization of the variables, the model for the implementation of fourth-generation banking in Iran was designed, as illustrated in Figure 1.

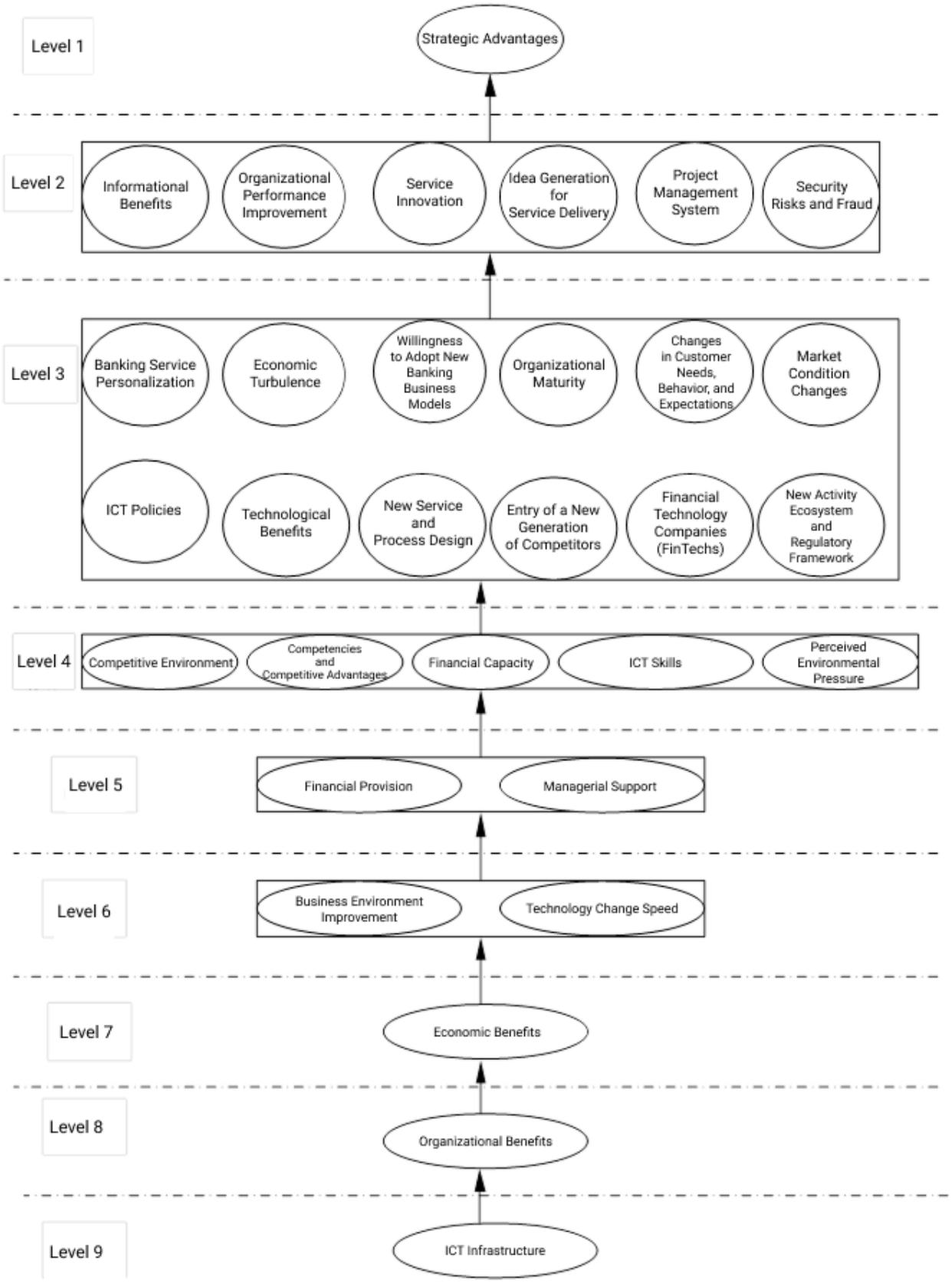

Figure 1. Model for the Implementation of Fourth-Generation Banking in Iran Using the Fuzzy Delphi Method and Interpretive Structural Modeling

4. Discussion and Conclusion

The findings of this study provide a comprehensive framework for the implementation of fourth-generation banking in Iran using the Fuzzy Delphi method and Interpretive Structural Modeling (ISM). The results indicate that 31 variables play a significant role in this implementation, which were categorized into nine hierarchical levels. The first level, which holds the highest priority, is strategic advantages, emphasizing the necessity of aligning banking strategies with digital transformation imperatives. The ninth level, ICT infrastructure, serves as the foundation for implementing fourth-generation banking, highlighting the essential role of robust technological capabilities in digital banking transformation. Other levels include critical factors such as technological benefits, financial capacity, organizational maturity, customer expectations, and regulatory frameworks, which collectively contribute to the successful transition to fourth-generation banking.

The identification of strategic advantages as the highest-priority factor aligns with previous research that underscores the necessity of leveraging digital transformation to enhance banking competitiveness [1, 15]. The ability to integrate new technologies while maintaining strategic differentiation allows banks to gain a competitive edge in the digital banking landscape. Additionally, the emphasis on ICT infrastructure is supported by studies highlighting the role of digital infrastructure in enabling seamless banking services [3, 16]. Without a robust ICT foundation, banks may struggle to adopt new financial technologies and improve service efficiency. The positioning of economic benefits, financial provision, and managerial support at intermediate levels suggests that while these factors are crucial, they act as enablers rather than primary drivers of digital transformation in banking [6].

One of the most critical findings is the impact of environmental pressures and regulatory frameworks on the banking sector. The study found that perceived environmental pressure, regulatory constraints, and changes in market conditions were positioned in the middle levels, indicating that while these factors influence the implementation process, they do not independently drive digital banking transformation. This finding is consistent with previous studies indicating that while regulatory environments shape banking policies, they must be complemented by internal strategic and technological capabilities for successful transformation [4, 17, 18]. Additionally, the study found that customer expectations, behavioral changes, and competitive dynamics play a crucial role in shaping banking innovation, which is supported by studies emphasizing customer-centric digital banking [5].

The study also highlights the growing importance of financial technology (FinTech) companies and the emergence of a new generation of banking competitors, both of which were placed at the third level. This suggests that the traditional banking sector must collaborate with or adapt to FinTech innovations to sustain market relevance. Previous research indicates that FinTech startups have disrupted conventional banking models by offering agile and technology-driven financial services (Sheikh & Anwar, 2023). Banks that fail to integrate these innovations risk losing market share to more adaptive financial service providers.

Another significant finding is the role of technological change speed and security risks in the digital transformation of banking. The study found that these factors were positioned at levels three and six, indicating that while rapid technological advancements offer growth opportunities, they also present significant risks. This finding aligns with studies highlighting cybersecurity threats and fraud risks as major concerns for digital banking operations [9]. Addressing these risks requires banks to invest in cybersecurity measures and digital risk management strategies.

Furthermore, the study found that organizational factors, including financial capacity, managerial support, and business environment improvements, were positioned at intermediary levels. This suggests that while these factors facilitate transformation, they are secondary to technological infrastructure and strategic imperatives. This finding is supported by research emphasizing the importance of aligning organizational capabilities with digital transformation strategies [2]. Banks must ensure that leadership support and financial resources are directed toward sustainable digital banking initiatives.

A key insight from this study is the role of service innovation, idea generation, and customer personalization in enhancing the effectiveness of fourth-generation banking. These factors were placed at level two, indicating their strategic importance in ensuring customer engagement and satisfaction. Previous research suggests that personalized banking services and innovative digital solutions enhance customer loyalty and competitive advantage [11]. Banks that adopt AI-driven customer service models, digital advisory solutions, and mobile banking innovations are more likely to meet evolving customer expectations.

Additionally, the study found that economic turbulence and market fluctuations were identified as influential factors in the implementation of digital banking. This aligns with findings from previous studies that highlight how economic uncertainty influences banking strategies and investment decisions (Dudin et al., 2021). Digital banking transformation must be designed to withstand financial disruptions and economic volatility. Banks that integrate predictive analytics and financial risk management tools into their digital platforms can enhance resilience against market fluctuations.

Overall, the results of this study confirm the multidimensional nature of digital banking transformation, requiring a balanced approach that integrates technological infrastructure, strategic priorities, regulatory adaptation, and customer-centric innovations. These findings align with global studies emphasizing the interconnectedness of technology, strategy, regulation, and competition in banking digitalization [3, 19]. The prioritization of variables into structured levels provides a clear roadmap for banks seeking to implement fourth-generation banking in a structured and systematic manner.

Despite its contributions, this study has several limitations. First, the research was conducted in the context of Iran, and while the findings provide valuable insights into banking transformation, they may not be directly generalizable to other regions with different regulatory environments and technological infrastructures. Second, the study relied on expert panel opinions in the Fuzzy Delphi method, which, while systematic, is inherently subjective and dependent on expert judgment. Additionally, the study did not incorporate quantitative validation through real-world banking data, limiting the empirical testing of the proposed model. Finally, given the rapid pace of technological advancements in the banking sector, the identified variables may evolve over time, necessitating continuous updates and refinements to the proposed implementation framework.

Future research should focus on validating the proposed model through empirical case studies involving real-world banking institutions. Quantitative methods, such as structural equation modeling (SEM), could be employed to statistically test the relationships among the identified variables. Additionally, comparative studies across different banking markets would provide a broader understanding of the global applicability of the model. Future research should also explore the impact of emerging technologies such as blockchain, artificial intelligence, and decentralized finance (DeFi) on the implementation of fourth-generation banking. Moreover, investigating customer perceptions and adoption behavior toward digital banking innovations would provide valuable insights for refining banking transformation strategies.

Banks and financial institutions should prioritize strategic advantages and ICT infrastructure, as these variables play the most influential roles in digital banking transformation. Investments in cloud computing, cybersecurity, and artificial intelligence should be increased to ensure that banking platforms remain secure, scalable, and customer-centric. Regulatory compliance should be streamlined to facilitate the adoption of new technologies without unnecessary bureaucratic delays. Additionally, banks should establish partnerships with FinTech companies to leverage their innovative capabilities while maintaining regulatory oversight. Digital banking transformation should also focus on enhancing customer experiences through personalized banking services, AI-driven financial advisory, and seamless omnichannel interactions. Finally, leadership teams within banks must foster a culture of continuous learning and digital adaptation to ensure long-term sustainability in the evolving banking landscape.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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