

Designing a model to evaluate the effectiveness of the digital transformation of the banking system

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Abstract

Examining the countries' financial systems shows that this field has also been affected by technological developments and has benefited from its advantages and benefits to overcome challenges and create opportunities. Therefore, technology development in the banking sector has meaningful implicit concepts in bank marketing, especially in digital banking, because it affects the standard level of customers. This research aims to design a model for evaluating the effectiveness of the digital transformation of the banking system. Based on the purpose, this research is of developmental and evaluation type, and in terms of method, it is considered descriptive research of mathematical modeling type. In this research, in the quantitative part, two categories of statistical techniques are used using SPSS software. Also, in the second part of the research, content analysis was used to identify the model, dimensions, main categories, and subcategories. In the final part, it was used to analyze the banking system to establish digital transformation based on system dynamics and fuzzy network data coverage analysis method. The research findings showed that identifying and analyzing the practical components in the digital transformation of the banking system is essential for designing a model to evaluate the effectiveness of these transformations.

Keywords: banking system, digital transformation, system dynamics, data mining, fuzzy network data envelopment analysis

1- Introduction

Today, the digital transformation of industries, known as the fourth industry, has become one of the most critical topics in the history of organizational transformation, and its realization in the organization leads to its technological and strategic superiority. Despite these benefits, the uncertain and non-transparent nature of the consequences of investing in digital transformation has prevented a large group of organizations from entering this field. In this regard, the lack of knowledge about the dimensions of this phenomenon and the lack of guidance to guide organizations have been identified as the main reasons for this. The current

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research aims to determine the dimensions and factors affecting digital transformation in the banking industry.

According to the United Nations report 2020, digital transformation is vital to many countries' sustainable national development (UN, 2020). Also, countries are looking to develop electronic services to change obsolete bureaucracies, improve the efficiency and effectiveness of public services, increase the number of services provided to citizens, and promote participation and democracy. The countries' finances indicate that technological developments have also affected this field. Therefore, technology development in the banking sector has meaningful implicit concepts in bank marketing, especially in digital banking, because it affects the standard level of customers (Tsindlin, 2021). Digital banking through telephone, internet, and cell phone is the primary way to deliver multi-channel services to customers, challenging traditional banking models (Kitsuis, 2021). Today, digital transformation is one of the essential topics in the background of organizational transformation, and its realization brings strategic and competitive advantage to the organization, in addition to technological superiority (Aliahmadi et al., 2021). Digital transformation is innovatively implementing new digital technologies to improve the organization's business (Martinchevich, 2019). This term also refers to the use of new technologies for joint creation, joint design, joint production, and distribution of products in interaction with customers and partners, which leads to the organization's competitiveness (Mena et al., 2024).

Studies show that organizations start their digital transformation activities with different goals and perceptions, such as changing customers' views, governmental and governmental coercion, an appropriate response to the emergence of new technologies, and environmental pressure (Vidia, 2021). The diversity of these goals and the place of digital transformation activities in organizations indicate that digital transformation is more than a technological transformation in a specific organization area (nozari &Nahr, 2022). The digital transformation of industries, also known as the fourth industry, is the basis for the realization of various developments in new products, processes, and services (Verhoef et al., 2021). This concept, which has emerged in the last decade due to the development of projector technologies in the industrial sector, changes the outlook of industrial organizations and brings many economic benefits to the users of the mentioned technologies (Trincado-Munoz, 2023). Therefore, many organizations have taken a step in this direction to acquire these developments' benefits. However, despite these potential benefits, studies show that projects based on the fourth industry are not very successful. The turbulent conditions resulting from fundamental changes in the organization, the nature of uncertainty, the lack of transparency of the consequences, and the high investment cost have prevented many organizations from entering this field (Mohammadi et al., 2023). The lack of knowledge about this phenomenon's various dimensions and factors and the lack of guidance to guide organizations are among the reasons organizations have listed for not entering into the activities above (Brown et al., 2022). In this regard, it is essential to use maturity models as a guide. Maturity models play a vital role in successfully establishing business issues and reducing uncertainties by providing a comprehensive guide for strengthening capabilities, targeting, and repeating successes (Teichert, 2019). The study of the background of the maturity of the digital transformation shows that the dimensions and factors considered in the existing models are very general, and, especially in the banking field, there is a gap in university studies that provides a systematic insight into the audience. This doubles the necessity of identifying factors and specific dimensions of digital transformation maturity. Therefore, the current research aims to reduce this gap by using the systematic analysis approach of digital transformation studies in the banking industry to identify the dimensions and present the final digital transformation maturity model. Therefore, in this research, in order to design a model for evaluating the effectiveness of the digital transformation of the banking system, a new approach in the field of the banking system is based on the approach of predicting factors such as the dynamic system

design method, data mining to confirm the prediction model of the model, and the performance evaluation of the designed model will be presented based on the fuzzy data envelopment analysis approach.

2- Literature review

In today's fast-paced world, organizations are trying to get a new competitive advantage by using different methods and patterns to be safe from risks, escape from deterioration, and achieve organizational goals. The sustainability and development of organizations in the 21st century depend on aligning with the rapid global changes. Organizational transformation is a kind of response to transformation. Organizations are located in different environments and rapid environmental changes are significant challenges for their activities. New technology, new products, and changes in people's values and tastes require organizations to transform, and in this regard, Web 4.0 information technology can play an influential role in organizational transformation. It can increase the capabilities of the organization and reduce costs at the same time. Various studies indicate that using information technology has reduced the complexity and concentration of organizational structure and plays a vital role in increasing organizational efficiency. The following section gives some research related to the subject and the research problem.

In his research, Van (2021) stated that digital transformation is the application of technology in all aspects of business. If this process is efficient, it completely transforms business performance, thus increasing business efficiency. This study measures the factors affecting digital transformation and the impact of digital transformation on innovation and company performance. The results of this study, using quantitative methods based on the data of 180 Vietnamese companies in the digital transformation field, show four factors affecting digital transformation: IT capacity, digital business strategy, human resource capacity, and organizational culture. Among these four factors, research findings also confirm that digital transformation directly impacts innovation and company performance. Galeymooa et al. (2021) studied the effect of digital transformation on company performance with the mediating role of digital organizational culture. The data was collected through a questionnaire and analyzed using structural equation modeling. The research findings show that culture is a very effective prerequisite for digital transformation success. Digital transformation through digital organizational culture positively and meaningfully affects the company's performance.

Di (2021), in his research, investigated the set of theoretical foundations related to digital innovation in knowledge management systems (KMS) to understand its role in business management. This research extensively reviews the scientific literature to understand how digital innovation develops new business models by optimizing new knowledge. A bibliometric analysis has been performed on a database, including 46 articles published in the last three decades. The results show that the research published in this field provides interesting concepts about business models and performance. These findings especially highlight the connection between innovation and sustainability and show that digital transformation tools help the value-creation process in the long term.

Revolutionary technologies, including the Internet of Things, cloud computing, social media mobile applications, virtual and augmented reality, data analysis, artificial intelligence, and blockchain, have led to a new approach. This is a digital transformation in the digital age for organizations and societies. (Sousa and Rocha, 2019).

3- Research methodology

The current research topic is dedicated to designing the electronic banking transformation model. According to the mentioned materials regarding the research framework and the extent of variables affecting the research goal, designing such a model requires a regular and step-by-step method. Therefore, it is necessary to rely on the systematic steps of the scientific method in different parts of the current

research process. This research can be considered the first to use the network modeling method of data envelopment analysis to evaluate the evolution of electronic banking. Since no research has been done in network models to provide improvement directions for the evaluated units, in the current research, using approaches based on deficiency and considering undesirable outputs, a new approach will be provided to determine the optimal levels of each Input and output variable and interface. This is the innovation of the present research. Also, based on the goal, this research is of developmental and evaluation type, and in terms of method, it is considered descriptive research of mathematical modeling type.

In the current research, considering that the goal is to present an analytical model for evaluating the development of electronic banking, therefore, its statistical population can be active bank branches that agree with the questions presented for the problem under investigation. In the discussion of the numerical evaluation of the estimated model, a system according to the research questions has been used.

Building the research model for sample selection, a combination of targeted judgment methods and snowball method is used, which is a non-probability method. In this method, the work starts with people who are experts in this field and have the necessary criteria, and along with the research questions, they are asked to introduce other people with opinions in this field. Therefore, except for the first few people who are directly selected by the researcher based on the desired criteria, other experts are also selected by other experts in addition to the criteria of expertise. On the other hand, sampling adequacy will be realized with theoretical sampling method, and in this sampling method, sampling will continue until the model reaches the limit of construction and saturation. In this research, two categories of statistical techniques are used in the quantitative part. In the first part of the research, descriptive statistics analysis is used to investigate the description of demographic variables. This part is done using SPSS software. Also, in the second part of the research, in order to identify the model and dimensions, the main categories and subcategories, content analysis method was used. In the final part, the analysis of the banking system for the establishment of digital transformation based on system dynamics, the deep analysis of the implementation of digital transformation based on data mining and the analysis of the level of effectiveness of digital transformation based on the approach of fuzzy network data envelopment analysis are used.

4- Research findings

Identification of corresponding codes based on semantic units

In this section, the success factors of the digital transformation of the banking system are analyzed. In order to identify the codes, first the conducted interviews, which were in the form of audio files, were written exactly. Then, the content presented in each text was studied line by line in the format of maxqda software, and considering that the content units in this research were text, meaningful concepts related to the main question were extracted in each line and sentence.

Then based on the combination of semantic units that have semantic and conceptual similarity with each other, they were placed next to each other, which were presented in the form of codes. In this stage of the directional content analysis, based on the relationship between the examined codes, as well as the degree of conceptual proximity of the codes and the removal of duplicate codes, it is finally identified by combining these codes and the initial classification of the desired subcategories. Also, at this stage, after identifying the sub-categories, in order to check the validity of the investigated codes and the process of implementing the steps of coding and identifying the sub-categories up to this stage, by referring again to the experts regarding their agreement or disagreement with the extraction sub-categories. A survey has been conducted, and based on the CVR formula, the value of this index was calculated and approved or rejected from the experts' point of view in the form of a percentage of this index.

By referring again to the identified codes and subcategories, the subcategories were re-examined. Based on the semantic and conceptual similarities and also based on the degree of proximity of each of the subcategories to the main categories identified in the initial conceptual model section, the subcategories were classified in the form of the nine cases mentioned in this model.

At this stage, if a subcategory does not belong to any of these categories, a new category is created. In the table below, the concepts associated with each category and the frequency of their repetition are mentioned. Therefore, the 40 identified subcategories were classified into 9 categories, which can be seen in the table below.

Table 1: Selective coding table of qualitative-exploratory study

Row	Title of the category	Repetition of concepts
1	Customer experience and interaction	7
2	Operating efficiency	6
3	Adoption of innovation and technology	9
4	Risk management	10
5	Financial performance	8
6	Analyze data and generate insights	6
7	Compliance with regulations	6
8	Organizational culture and change management	8
9	Market competition	10

So far, two stages have been done to achieve the final research model. First, in the first stage, the researcher identified the variables related to the research topic and the initial model using extensive research literature. Then, in the second stage, the researcher conducted a qualitative study, and based on in-depth interviews conducted with experts, managers, and the relevant assistants, the final model was compiled. In this part of the research, the summary of the two mentioned methods (literature review and qualitative study) is presented in the form of the final research model and all its variables in the table below.

Table 2: Variables of the final research model (combination of thematic literature and qualitative research methods)

Row	Variable Title	Corresponding concepts
1	Customer experience and interaction (C)	User interface design and usability (C1)
2		Personalization of services (C2)
3		Omnichannel experience (C3)
4		Customer satisfaction score (C4)
5		Acceptance rate of digital services (C5)
6		Time to answer customer questions (C6)
7		Automation of processes (O1)

8	Operating efficiency (O)	Saving time and money (O2)
9		Integration of digital tools (O3)
10		Employee productivity levels (O4)
11		Transaction processing speed (O5)
12	Adoption of innovation and technology (I)	Integration of emerging technologies (I1)
13		Investment in research and development (I2)
14		Cooperation with fintech startups (I3)
15		Use of big data analysis (I4)
16		Security measures for digital assets (I5)
17	Risk Management (R)	Cyber security measures (R1)
18		Fraud detection and prevention (R2)
19		Compliance with regulations (R3)
20		Third party risk assessment (R4)
21	Financial performance (F)	channels (F1) Income from digital
22		(F2) Cost-benefit analysis
23		digital services (F3) Profit margin from
24		Market share growth (F4)
25	Analyzing data and gaining insights (A)	(A1) Use of customer data
26		decision making (A2) Predictive analysis for
27		capability (A3) Real-time analysis
28		(A4) Data quality assurance
29	Regulatory Compliance (RE)	regulations (RE1) Compliance with banking
30		requirements (RE2) Regulatory reporting
31		Measures (RE3) Anti-Money Laundering
32		procedures (RE4) Understanding customer
33	Organizational culture and change (CU) management	digital initiatives (CU 1) Leadership support of
34		of employees (CU 2) Training and development
35		(CU 3) Organizational Agility
36		digital strategy (CU 4) Alignment of goals with
37	Market competition (CO)	competitors (CO 1) Benchmarking against
38		digital presentation (CO 2) Differentiation through
39		new demographics (CO3) market penetration in
40		trends (CO 4) Response to market

The final conceptual model of this research is given in Figure 2, based on Table 2.

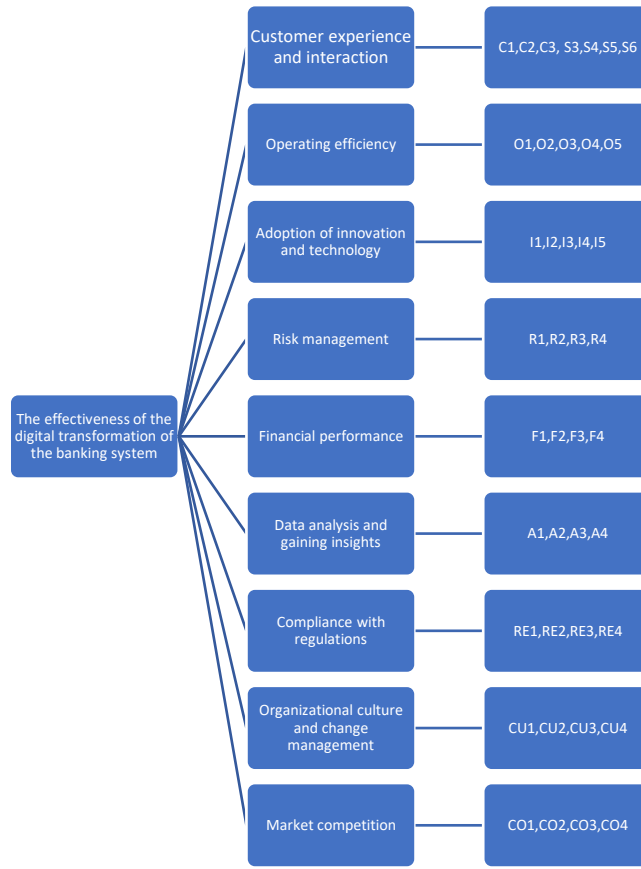


Figure 2: The final conceptual model for evaluating the effectiveness of the digital transformation of the banking system

The arrival of emerging technologies and changes in customer approaches to banking services indicate that digital banking is one of the critical factors in these changes. According to these developments, the improved and flexible banking system must be carefully examined and analyzed using the approaches of system dynamics. The primary purpose of this study is to analyze and investigate the banking system following the establishment of digital transformation. Using system dynamics approaches, we try to understand various factors that effectively transfer this system to a digital structure. In this study, we analyze the process of this transformation in depth by examining input variables and enhancers, as well as output variables and reducers affecting the digital transformation in the banking system. System dynamics approaches are used to design cause and effect diagrams to better understand the patterns and complex relationships between different factors of this evolution. Using these approaches, we intend to get a deeper understanding of the digital transformation process in the banking system and provide solutions and strategies that guarantee the improvement and acceleration of this process. This study is designed as a practical guide for the banking industry, managers, analysts, and policymakers interested in a deeper and more adequate understanding of digital transformations in this industry. Now, based on the components prepared in the previous section, which was based on experts' opinions, this subsystem's cause-and-effect diagram has been designed in the VENSIM software. At first, in this section, experts have been asked to present the input and increasing variables and the output and decreasing variables that are effective in establishing digital transformation for the banking system. Based on this, the following diagram is drawn:

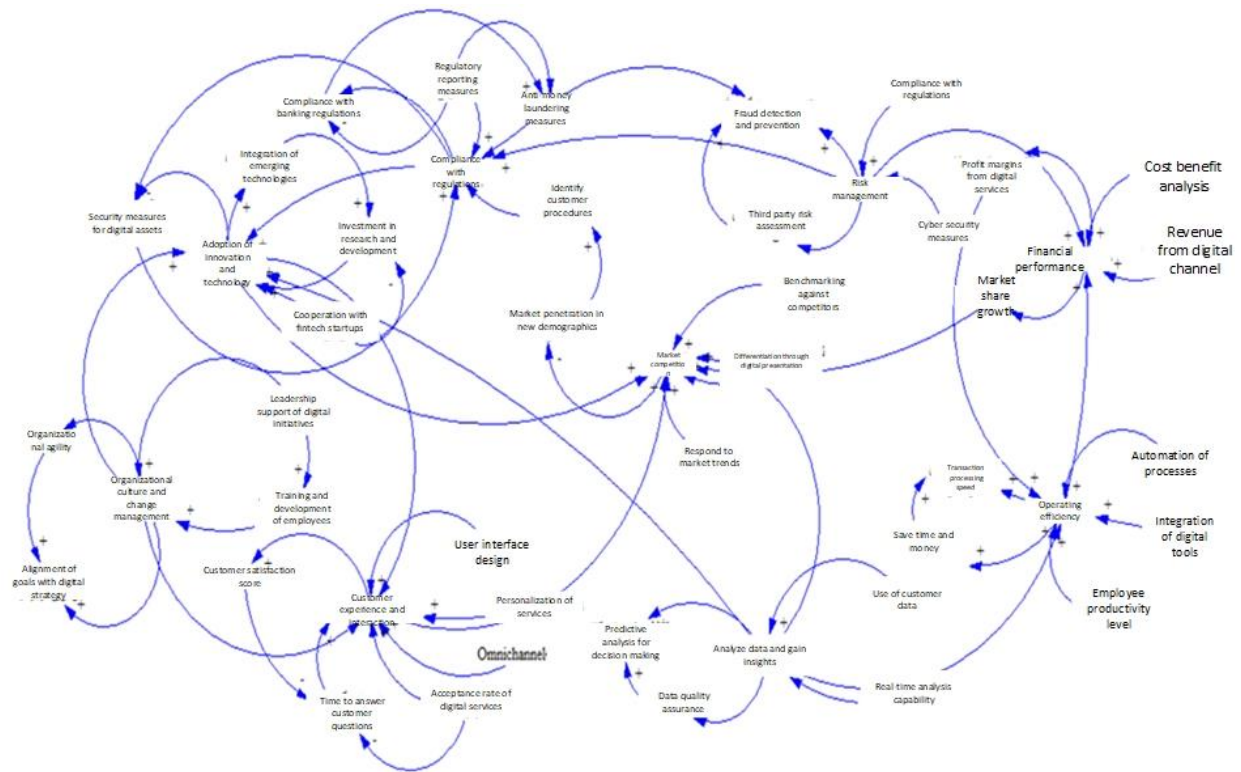


Figure 3: Cause and effect diagram

Flow diagram and mode

By converting level variables to state variables and defining the input and output flows of each state variable, the flow and state diagram is drawn based on the following diagram:

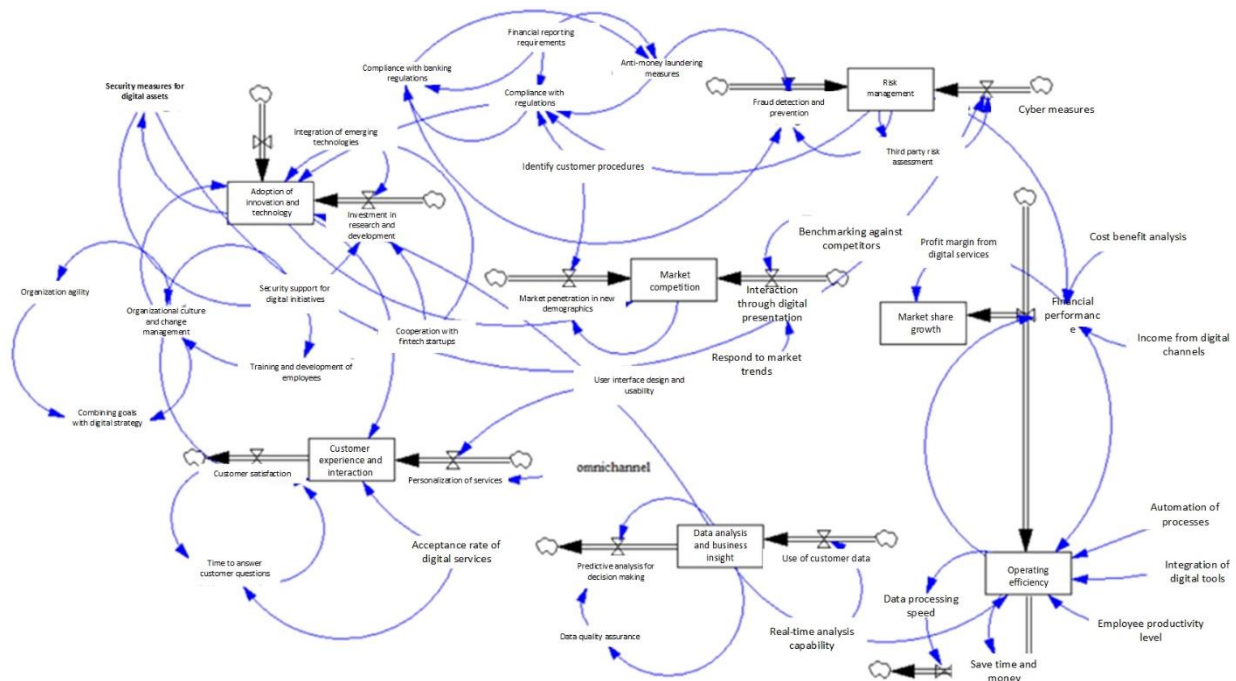


Figure 4: Flow diagram

A state flow diagram is an analytical tool used to analyze dynamic systems. This diagram shows how the system changes from one state to another and how these changes occur. The above diagram shows the connections between the various elements of the banking system for the establishment of digital transformation, such as communication with customers, the technologies used, and the data collected and used in the system. This diagram can help provide solutions and strategies to improve the performance and effectiveness of the banking system in the face of digital transformations. In the case of the banking system and the establishment of digital transformation, the state flow diagram can help understand the system's different processes and identify its strengths and weaknesses. After reviewing this chart, it is possible to provide a more detailed analysis and review of each state variable. For example, for the variable "Analyzing data and gaining insights," we can refer to the methods banks use to collect and analyze data to gain insight into the behavior of their customers. For the variable "adoption of innovation and technology," we can refer to banks' strategies to transfer to digital systems and provide innovative services.

Useful points that can be raised in this analysis include the following:

1. The importance of flexibility and adaptability in facing technological changes and customer needs.
2. Using advanced data analysis and artificial intelligence to improve banking processes and provide better services to customers.
3. Managing security risks and protecting information exposed to digital threats.
4. Improve customer experience through digital solutions such as online banking, mobile payments, and smart systems.
5. Competing with other institutions and providing a competitive advantage through innovation and continuous improvement of banking services.
6. The importance of productivity and operational efficiency in banking business and the use of technology to improve processes and reduce costs.

Examining the results of the efficiency scores obtained from the fuzzy network data coverage analysis shows that the efficiency scores are variable. Banks with higher efficiency scores are considered more effective in their digital transformation efforts, indicating that they use their resources well to achieve desired results. In the following the efficiency scores of the studied banks are listed in Table 3:

Table 3: Performance scores of the studied banks

Bank	Performance scores
Bank 1	0/790
Bank 2	0/792
Bank 3	0/712
Bank 4	0/984
Bank 5	0/954
Bank 6	0/917
Bank 7	0/904
Bank 8	0/820
Bank 9	0/785

The results of sensitivity analysis are also different in different banks. Some banks show high sensitivity to changes in input and output variables, which shows that small changes in data can significantly affect their efficiency score. Others show less sensitivity, which shows they are stronger against changes in input and output data. According to the obtained results, it can be stated that banks with higher efficiency scores and less sensitivity to changes perform well in their digital transformation efforts and probably maintain their effectiveness even in the face of data fluctuations. Conversely, banks with lower efficiency scores and higher sensitivity may need to closely monitor their digital transformation processes and adapt their strategies to improve effectiveness and flexibility.

5- Discussion and Conclusion

According to the topic of the research, which is "designing an evaluation model for the effectiveness of the digital transformation of the banking system," and the qualitative analysis that was carried out, it can be said that the identification and analysis of the practical components in the digital transformation of the banking system are essential for the design of the evaluation model for the effectiveness of these developments. These components, which include customer experience and engagement, operational efficiency, innovation and technology adoption, risk management, financial performance, data analytics and insights, regulatory compliance, organizational culture and change management, and market competition, provide critical tools to assess and predict the effects of digital transformation in the banking system. Customer experience and interaction are important components that indicate the need to pay attention to customers' opinions and preferences in the digital transformation process. Improving the customer experience, increasing customer satisfaction and loyalty, and attracting new customers can create a positive view of digital transformation. The operational efficiency component is focused on improving the efficiency and effectiveness of banking system operations. Using digital technologies makes it possible to optimize banking operations and continuously improve in this area. The component of accepting

innovation and technology indicates the readiness of the banking system to benefit from new technologies and innovations. Creating a space for the adoption and implementation of advanced technologies can determine the long-term success strategies of the banking system. Also, risk management is another component that indicates the need to identify, evaluate, and manage risks related to the implementation of digital transformation projects, which can reduce financial and operational complications caused by unexpected developments. Addressing security, privacy, and data management risks can help prevent unintended consequences and bank financial losses.

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