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A Systematic Framework for Meet the Challenges of Artificial Intelligence Banking

Mahdi Bastan
Graduate School of Management and Economics, Sharif University of Technology
Tehran, Iran
mahdi.bastan@sharif.edu

Negin Hasani and Behnaz Salimi
School of Industrial Engineering, College of Engineering
University of Tehran, Tehran, Iran
negin.hasani@ut.ac.ir, behnaz.salimi@ut.ac.ir

Ali Ghazizadeh
School of Industrial Engineering
Iran University of Science and Technology, Tehran, Iran
Ghazizadeh_Ali@ind.iust.ac.ir

Mahdi Hamid
School of Industrial Engineering, College of Engineering
University of Tehran, Tehran, Iran
m.hamid31400@ut.ac.ir

Abstract

Banking based on artificial intelligence (AI Banking) is a new phenomenon that stresses the integration of advanced AI technologies and techniques in the banking industry. The applications of AI in this industry encompass a wide array of solutions and innovations that are meant to upgrade different aspects of banking operations, customer experience, and financial services. Given the significance of incorporating AI in the banking system, the present study scrutinizes the features of AI banking and explores different challenges facing its implementation. Accordingly, the challenges and their evaluation criteria are ranked using the best-worst method (BWM), and the efficiency of the proposed solutions to address these challenges is assessed using the data envelopment analysis (DEA) method. Following this, a bi-objective mathematical model is proposed with the aim of minimizing the cost of implementing the solutions and maximizing their effectiveness, leading to the selection of the most suitable solution for address each challenge. Subsequently, the proposed model is solved using the augmented ε − constraint method, and the pareto solutions derived from it are ranked using the DEA to identify the most efficient ones. Consequently, the most effective solutions for overcoming the challenges are identified and recommended. The findings indicated that the primary challenge in AI banking, namely the reducing the quality and availability of data, can be effectively addressed through the developing and implementing data governance policies.

Keywords
Intelligent Banking, Artificial Intelligence, Mathematical model, Data Envelopment Analysis, best-worst method

1. Introduction

Artificial intelligence (AI) has become an integral part of contemporary society and has largely affected various dimensions of daily life (Naderi et al., 2021). All industries, including banking, have been transformed to various degrees due to the use of AI technologies. AI is being used in digital and Intelligent banking to create seamless and user-friendly experiences and offer features such as mobile banking applications, digital wallets, contactless payments (Lottu et al., 2023).

Built on the basis of digital banking, smart banking represents the next evolutionary step in the area of banking services (Bastan et al., 2016). While digital banking mainly provides online access to traditional banking services, smart banking pursues this concept and deploys advanced technologies such as AI, machine learning, and the Internet of Things (IoT). This convergence of technologies allows banks to offer highly personalized and proactive services to customers (Kaur et al., 2020).

Many studies have investigated different aspects of this subject. In India, Lande et al. (2018) took advantage of IoT to explore banking frauds and their early detection in smart banking. Arora and Kaur (2020) presented a conceptual structure for smart banking using cloud-based IoT. Ramphull and Nagowah (2022) investigated IoT and its applications in different fields, especially in smart banking. Qatawneh and Makhlouf (2023) focused on banking services that are provided via smart mobile phones. Mohapatra (2021) dealt with some key challenges facing the sustainable implementation of AI in the banking industry. Blanche et al. Belanche et al. (2019) investigated different factors affecting the adoption of AI technology in the banking sector. Sheth et al. (2022) examined the significance of AI banking, focusing on the required skills for operational capacity, users' awareness of AI-mediated banking, and the provision of AI-mediated personalized banking services. Also, Biswas et al. (2020) studied the challenges and prospect of incorporating AI in the banking industry.

This study aims to explore the multifaceted aspects of implementing AI in the banking industry, in addition to its practical applications, associated benefits, potential risks, and challenges facing this transformative process. The remainder of this study is organized as follows: Sections 2 and 3 discuss the research methodology, respectively. In Section 3, the challenges in the implementation of AI in the banking system and suggested solutions are presented. Finally, Sections 4 and 5 present the results of the analysis, and provides suggestions for future research, respectively.

2. Methodology

In this section, a framework is presented in order to investigate AI banking. The steps depicted in the figure are as follows:
Step 1: Identifying different challenges facing the implementation of AI Banking and suggesting solutions based on experts' opinions and reviewing the literature;
Step 2: Using best-worst method (BWM) to assign a weight and rank to the identified challenges and their evaluation criteria;
Step 3: Calculating the efficiency of solutions using data envelopment analysis (DEA) method;
Step 4: Solving the bi-objective mathematical model using augmented $\varepsilon -$ constraint method;
Step 5: Ranking the pareto solutions using DEA; and
Step 6: Suggesting the most appropriate solution to address the identified challenges.

2.1 Mathematical model

In this research, a optimization mathematical model was employed to select the most appropriate solution for tackling AI banking challenges, taking into account both cost and efficiency factors. The indices, parameters, and decision variables of this mathematical model are detailed in Table 1.

Table 1. Table of notations

Indexes	
i	Solution
I	Set of all solutions
j	challenge

J	Set of all challenges
Parameters	
u_{ij}	Efficiency of solution i for addressing challenge j
C_{ij}	Cost of implementing solution i for addressing challenge j
β	The maximum budget for implementing solutions for addressing challenges
Decision variables	
x_{ij}	1 if solution i for addressing challenge j is selected; 0 otherwise

In the following, the proposed mathematical model is explained.

$$Min \sum_{i\in I}\sum_{j\in J} x_{ij}.C_{ij} \quad (1)$$

$$Max \sum_{i\in I}\sum_{j\in J} x_{ij}.u_{ij} \quad (2)$$

s.to

$$\sum_{i\in j} x_{ij} = 1 \qquad \forall\, j \in J \quad (3)$$

$$\sum_{i\in I}\sum_{j\in J} x_{ij}.C_{ij} \le \beta \quad (4)$$

$$x_{ij} \in \{0,1\} \qquad \forall\, i \in I, j \in J \quad (5)$$

The initial objective function (1) demonstrates the minimizing of overall expenses incurred by implementing solutions to address the challenges. The subsequent objective function (2) illustrates the maximizing of the efficiency of the chosen solutions. Constraint (3) ensures that only a single solution is chosen for each challenge. Constraint (4) ensures that the cost of implementing the chosen solutions remains within the designated budget. Lastly, constraint (5) defines the range in which the decision variable can change.

It is worth mentioning that the augmented $\varepsilon -$ constraint method was employed in this study to solve the proposed mathematical model (For further details on this method, please see (Taherifar et al., 2023)). As the utilization of this method leads to a series of Pareto solutions, it is essential to identify the most effective one to aid decision-making. Hence, the method of DEA (Azizi et al., 2023) was utilized to address this challenge.

3. Challenges of Implementing AI Banking

As stated, besides its invaluable features and capabilities, smart banking poses some implementation problems. In this regard, in order to carefully examine this approach in the banking system, we used library resources and conducted interviews with banking experts (Bastan et al., 2023). it should be noted that, staying competitive in the banking industry necessitates recognizing the challenges that exist in making banks smarter and resolving them as much as possible (Akbarpour et al., 2014; Bastan et al., 2016). Hence, once the challenges have been identified, it is crucial to pinpoint efficient solutions to tackle them. The results are presented in Table 2.

Table 2. Challenges and their solutions for implementing AI banking

Challenges	Solutions
Lack of privacy and data security	• Ensuring the high security of technological services received from providers and receiving services from reliable and low-risk authorities • Implementing stronger and more advanced encryption protocols, multi-factor authentication (MFA) such as passwords, tokens, biometric tools, etc., as well as conducting regular and periodic security audits • Investing in cybersecurity training for employees and cyber service providers • Using blockchain technology to securely and immutably saving encrypted records.
Non-compliance in regulatory	• Forming a professional team consisting of elite legal advisors who are proficient in the knowledge of the banking system and the latest regulatory changes • Implementing automated compliance processes using regulatory technology (Reg Tech) tools and platforms and monitoring regulatory changes to monitor compliance with changing regulations • Outsourcing the monitoring process by entering into a cooperation agreement with third-party auditing companies or compliance experts in order to conduct audits and evaluate compliance systems.
Non-compliance in ethical points	• Full supervision of conducting ethical audits and the process of using artificial intelligence approach • Establishing ethical guidelines for the use of artificial intelligence and promoting the culture of its use in the organization • Reviewing customer feedback periodically and continuously and ensuring compliance with ethical principles
Lack of customer trust	• Providing clear explanations to customers and gaining their satisfaction and trust by illustrating how to benefit from artificial intelligence • Assisting customers in choosing the level of artificial intelligence participation in their decisions in various ways, such as providing educational resources and providing explanations about the benefits and safety of banking based on artificial intelligence.
Lack of infrastructure and integration with existing systems	• Strengthening and developing existing systems with service oriented architecture (SOA) and adapting them to integrate with new services and technologies • Gradual transfer of banks to systems based on artificial intelligence and ensuring its compatibility with old systems • Designing primary APIs that are documented, standardized and can be integrated with existing systems in addition to updating traditional systems • Continuous training of employees to use this technology as best and as effectively as possible in order to avoid any inconsistency and possible disruption. • Training employees by attracting, consulting and hiring experienced experts in the field of data science, machine learning and artificial intelligence
Reducing the quality and availability of data	• Create key performance indicators (KPI) and perform calculations to monitor and measure data quality • Applying data quality monitoring tools to continuously evaluate and report data quality • Implement master data management (MDM) practices to ensure consistency and accuracy of critical data • Developing and implementing data governance policies representing the roles, responsibilities and processes related to data quality and access, fostering a culture of data literacy in the organization
Cost of implementation	• Dividing the transformation program into different phases to control the financial burden and realize the benefits earlier • Outsourcing some activities required to implement artificial intelligence in the banking industry • Aligning staff levels, skill sets and roles with the needs of the organization • Using storage and cloud computing in order to reduce initial costs related to hardware • Accepting agile development methods and investing in automation tools
Dependency on a third party	• Investing to create an internal development team focused on maintaining critical banking functions to reduce reliance on third parties • Partnering with different providers to increase flexibility and reduce the impact of potential problems with a partner • Continuous monitoring of performance of third party providers

	• Implementation of win-win strategies with a third party
Scalability and performance improvement	• Utilizing parallel processing techniques to handle large datasets and complex computations more efficiently • Using predictive analytics to anticipate increased workloads and scale resources accordingly to maintain optimal performance • Emploing robust monitoring tools to identify performance issues promptly and enable proactive resolution • Implementing load balancing mechanisms to evenly distribute workloads across servers and preventing bottlenecks
Not staying up to date with technology	• Cultivating a culture of continuous training • Outsourcing some processes with the capacity of innovation ecosystem and fintechs • Implementing agile development methods and devops practices to increase agility and responsiveness • Implementing agile development methods and devops practices to increase agility and responsiveness

4. Results

4.1. Ranking the challenges and their evaluation criteria facing AI banking

In this section, using the BWM method, we estimate and next rank the weight of each challenge to implementing AI banking, and also criteria of evaluation challenges to facing AI banking. BWM is an approach for multi-criteria decision-making (MCDM) problems that employs two vectors of pairwise comparisons among indicators (Otay et al., 2024). The results obtained by BWM are provided in Tables 3 and 4.

Table 3. The relative importance of the challenges of AI banking implementation

	Challenges											
	Not staying up to date with technology	**Dependency on a third party**	**Scalability and performance improvement**	Cost of implementation	Reducing the quality and availability of data	Lack of infrastructure and integration with existing systems	Lack of customer trust	Non-compliance in ethical points	Non-compliance in regulatory	Lack of privacy and data security		degree of inconsistency
	0.065	0.056	0.148	0.181	0.205	0.067	0.31	0.022	0.04	0.185		**0.005**
Rank	6	7	4	3	1	5	9	10	8	2		

Table 4. The results of ranking of the evaluation criteria of AI banking implementation challenges

Challenges	Evaluation criteria	Weight	Rank
Lack of privacy and data security	Incident detection (response) duration	0.0474	4
	The duration of incident resolution	0.268	1
	Number of cyber incidents	0.135	2
	Compliance rate	0.091	3
	Encryption execution rate	0.033	5
Non-compliance in regulatory	Adherence to AI banking policy and procedures	0.12	2
	Incident detection (response) duration	0.088	3
	Compliance with third party vendors	0.032	5
	Compliance rate with regulatory	0.262	1

	Compliance with cyber security laws	0.0498	4
Non-compliance in ethical points	Responsible use of data	0.093	3
	Diversity in AI banking development teams	0.026	5
	Stakeholder engagement in ethical use	0.071	4
	Ethical impact assessment	0.437	1
	Time to respond to ethical events	0.373	2
Lack of customer trust	Customer retention rate	0.548	1
	Time to resolve customer complaints	0.117	3
	Ensuring the privacy of customer data	0.214	2
	Response to incidents and communications	0.079	4
	Customer involvement in ethical discussions	0.041	5
Lack of infrastructure and integration with existing systems	System downtime during integration	0.081	4
	Requests for supporting after integration	0.111	3
	Compliance with integration regulations	0.038	5
	Integration cost	0.522	1
	Reduction in manual processes	0.247	2
Reducing the quality and availability of data	Data accuracy rate	0.431	1
	Data consistency in systems	0.19	2
	Data repetition rate	0.038	5
	Speed of access to critical data	0.157	4
	Data backup and recovery function	0.184	3
Cost of implementation	The ratio of implementation cost to budget	0.397	1
	Return on investment (ROI)	0.371	2
	Training cost per employee	0.011	5
	The cost of integrating the old system	0.097	4
	Cost of scalability measures	0.124	3
Scalability and performance improvement	System response time	0.139	3
	Concurrent user capacity	0.527	1
	Use of resources	0.118	4
	Network latency	0.041	5
	Effectiveness load balancing	0.175	2
Dependency on a third party	Dependency ratio	0.404	1
	Risk of third party lockout	0.339	2
	Security audit findings from third parties	0.028	5
	Strategic alignment with third parties	0.120	3
	Third party management cost	0.100	4
Not staying up to date with technology	Technology update rate	0.504	1
	Time to implement new technology	0.039	4
	Percentage of it budget allocated to innovation	0.120	5
	Number of implemented technological innovations	0.083	3
	Adoption rate of emerging technologies	0.255	2

4.2. Determining efficiency scores of proposed solutions for addressing challenges

Once the weight of the challenges and their corresponding criteria were determined in the previous step, the experts were asked to give their desired score (from 1 to 10) to each solution for each challenge based on each criterion. This normalized decision matrix is presented in Table 5.

Table 5. Decision matrix of evaluation of the solutions to address AI banking challenge

Challenges	**Solutions**	**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**
Lack of privacy and data security	**Solution1**	0.285	0.206	0.119	0.065	0.032
	Solution2	0.463	0.175	0.131	0.041	0.015
	Solution3	0.045	0.154	0.073	0.044	0.020
	Solution 4	0.334	0.267	0.070	0.080	0.018
Non-compliance in regulatory		**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**
	Solution1	0.099	0.081	0.030	0.211	0.032
	Solution2	0.165	0.069	0.027	0.173	0.028
	Solution3	0.058	0.045	0.025	0.214	0.046
Non-compliance in ethical points		**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**
	Solution1	0.069	0.013	0.055	0.434	0.308
	Solution2	0.072	0.020	0.039	0.226	0.158
	Solution3	0.090	0.017	0.045	0.345	0.259
Lack of customer trust		**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**
	Solution1	0.296	0.077	0.164	0.068	0.017
	Solution2	0.276	0.094	0.159	0.059	0.030
Lack of infrastructure and integration with existing systems		**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**
	Solution1	0.072	0.103	0.024	0.422	0.220
	Solution2	0.034	0.072	0.036	0.373	0.198
	Solution3	0.027	0.046	0.028	0.372	0.130
	Solution 4	0.059	0.045	0.023	0.361	0.147
	Solution5	0.062	0.080	0.02	0.387	0.242
Reducing the quality and availability of data		**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**
	Solution1	0.274	0.099	0.033	0.105	0.139
	Solution2	0.193	0.098	0.022	0.097	0.124
	Solution3	0.189	0.157	0.027	0.087	0.129
	Solution 4	0.412	0.121	0.032	0.138	0.152
Cost of implementation		**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**
	Solution1	0.360	0.200	0.009	0.042	0.095
	Solution2	0.221	0.255	0.004	0.047	0.078
	Solution3	0.277	0.260	0.008	0.057	0.087
	Solution 4	0.204	0.270	0.005	0.069	0.105
	Solution5	0.227	0.224	0.009	0.049	0.094
Scalability and performance improvement		**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**
	Solution1	0.093	0.277	0.095	0.021	0.127
	Solution2	0.092	0.230	0.071	0.028	0.172
	Solution3	0.075	0.338	0.084	0.031	0.098
	Solution 4	0.078	0.369	0.076	0.040	0.115
Dependency on a third party		**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**
	Solution1	0.363	0.235	0.017	0.101	0.059
	Solution2	0.231	0.277	0.023	0.029	0.072
	Solution3	0.273	0.234	0.024	0.083	0.053
	Solution 4	0.206	0.135	0.026	0.124	0.040
Not staying up to date with technology		**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**
	Solution1	0.313	0.004	0.030	0.066	0.219
	Solution2	0.323	0.155	0.067	0.054	0.159
	Solution3	0.435	0.029	0.044	0.042	0.218
	Solution 4	0.273	0.025	0.078	0.059	0.193

After the values of the decision matrix were specified, the efficiency score of each solution was determined using the DEA model (Table 6). DEA identifies the most effective solution and possesses a greater differentiation power than other competing models (Habibifar et al., 2019). In this model, the objective function minimizes the maximum deviation from the total efficiency score.

Table 6. Results of calculation of efficiency scores of proposed solutions for each challenge

	Challenges	**Solution**	**Efficiency score**
	Lack of privacy and data security	solution 1	0.812
		solution 2	0.865
		solution 3	0.785
		solution 4	0.625
	Non-compliance in regulatory	solution 1	0.900
		solution 2	0.875
		solution 3	0.986
	Non-compliance in ethical points	solution 1	0.896
		solution 2	0.862
		solution 3	0.796
	Lack of customer trust	solution 1	0.732
		solution 2	0.801
	Lack of infrastructure and integration with existing systems	solution 1	0.986
		solution 2	0.896
		solution 3	0.863
		solution 4	0.725
		solution 5	0.912
	Reducing the quality and availability of data	solution 1	0.863
		solution 2	0.756
		solution 3	0.695
		solution 4	0.983
	Cost of Implementation	solution 1	0.869
		solution 2	0.786
		solution 3	0.861
		solution 4	0.856
		solution 5	0.779
	Scalability and performance improvement	solution 1	0.896
		solution 2	0.800
		solution 3	0.963
		solution 4	0.986
	Dependency on a third party	solution 1	0.983
		solution 2	0.935
		solution 3	0.945
		solution 4	0.899
	Not staying up to date with technology	solution 1	0.895
		solution 2	0.865
		solution 3	0.998
		solution 4	0.915

4.3. Selection model

This section focuses on selecting the optimal solution from the available options through the application of a mathematical model for dual-objective optimization. The decision is based on the dual objectives of cost minimization and effectiveness maximization.

Upon solving the model using augmented $\varepsilon -$ constraint method, Pareto solutions were obtained, as mentioned earlier. The results are detailed in Figure 1. Totally, 10 pareto solutions were derived through the model solving, and the most efficient ones were selected by DEA. Pareto solution 7 emerged as the most effective, as per Table 7, offering a suitable approach to tackling banking challenges. The results of the selected solutions for each challenge, based on the mathematical model presented, can be viewed in Table 8.

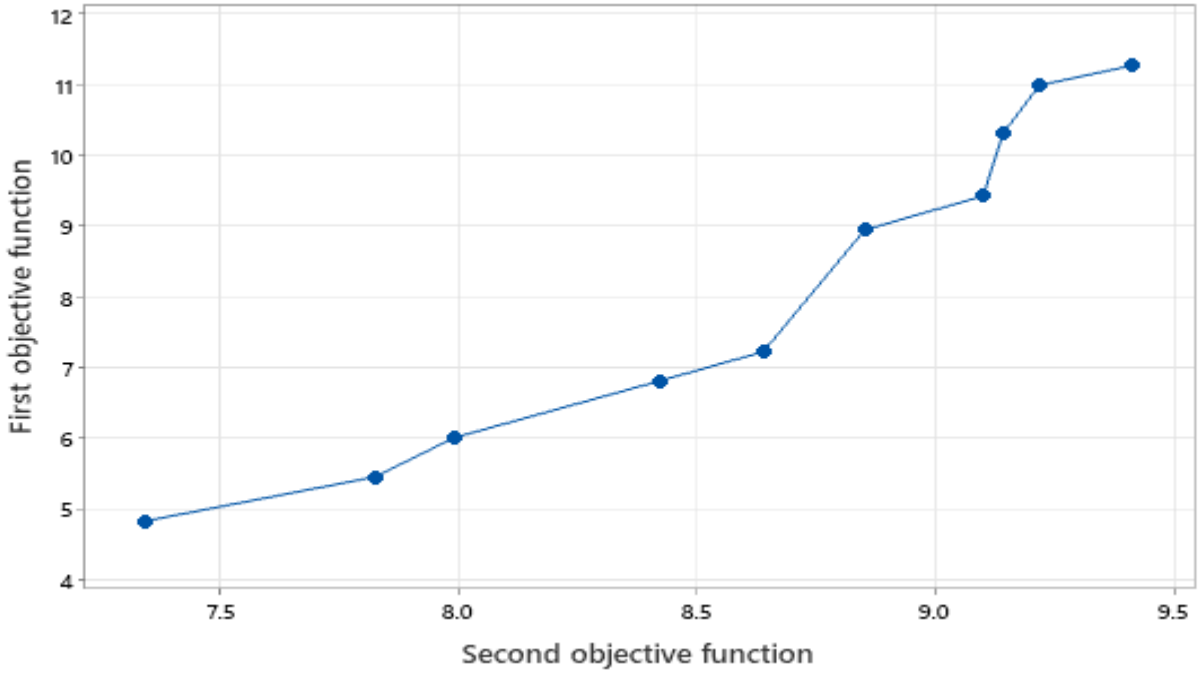

Figure1. Pareto solutions

Table 7. Results of ranking pareto solutions using DEA

Pareto solution No.	First objective function (Billion tomans)	Second objective function	Rank
Pareto solution **1**	4.826	7.341	8
Pareto solution **2**	5.451	7.824	9
Pareto solution **3**	6.005	7.99	10
Pareto solution **4**	6.805	8.42	6
Pareto solution **5**	7.218	8.638	7
Pareto solution **6**	8.94	8.851	5
Pareto solution **7**	9.417	9.099	1
Pareto solution **8**	10.308	9.141	3
Pareto solution **9**	10.981	9.217	4
Pareto solution **10**	11.256	9.409	2

Table 8. Result of selecting the most appropriate solution for addressing AI banking challenges based on pareto solution 7

Challenges			**Most appropriate solution**
Lack of privacy and data security			Solution 2
Non-compliance in Regulatory			Solution 1
Non-compliance in ethical points			Solution 3
Lack of customer trust			Solution 1
Lack of infrastructure and integration with existing systems			Solution 5
Reducing the quality and availability of data			Solution 4
Cost of implementation			Solution 3
Scalability and performance improvement			Solution 3
Dependency on a third party			Solution 2
Not staying up to date with technology			Solution 1

5. Conclusion

Smart banking has fostered a competitive environment in the banking system. It is an advanced and innovative approach that deploys new technologies, especially artificial intelligence and machine learning, to optimize and transform various aspects of the banking industry. Therefore, many banks are interested in incorporating AI in their system. It should be noted, however, that achieving this goal necessitates recognizing and resolving the challenges ahead.

In the current study, an effort was made to identify the AI banking challenges, their evaluation criteria, and the available solutions to address them. To achieve this goal, library resources were reviewed and discussions were held with several banking experts to pinpoint the challenges, solutions, and effective criteria. Subsequently, an endeavor was undertaken to rank the AI banking challenges and evaluation criteria through the utilization of BWM. Additionally, DEA was employed to assess the efficacy of each solution in tackling the identified AI banking challenges.

Furthermore, a bi-objective mathematical model was proposed for a more comprehensive analysis to select the most suitable solution for each challenge. This model had the capability to determine the optimal solution for any challenge by minimizing implementation costs and maximizing efficiency. Upon solving the model using the augmented $\varepsilon -$ constraint method and generating 10 Pareto solutions, the most effective one was chosen utilizing the DEA. Consequently, the Pareto solution 7 was identified as the most efficient option, and the most appropriate solution for each AI banking challenge was determined based on the outcomes of this solution.

In order to better and more thoroughly approach AI banking, it is suggested to conduct further research using other assumptions and tools. For instance, it would be interesting to consider practical implications of these calculations and the non-deterministic nature of data. Also, one could use fuzzy DEA as a solution method. On the other hand, by understanding the existing challenges, one may apply an optimization model to select the appropriate solutions for each challenge while considering the budget constraints of each solution. Finally, simulation methods could be used in identifying challenges and solutions in order to approximate real-world conditions.

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Biographies

Mahdi Bastan is a post doctoral fellowship in AI-Banking in Sharif University of Technology, Iran. He works on analysis of dynamism of complex systems, with focus on Banking, Health Economics, Business Strategy and Competition, and also sustainable development and climate change, using System Dynamics, Simulation, and Business Analytics approaches.

Negin Hassani is the M.Sc. in graduate of Industrial Engineering at University of Tehran, Iran. Her main scientific interests include performance evaluation, optimization, and healthcare system and scheduling.

Behnaz Salimi is the M.Sc. in Industrial Engineering at University of Tehran, Iran. Her main scientific interests include performance evaluation, optimization, and healthcare system and scheduling.

Ali Ghazizadeh is a PhD candidate in the field of Industrial Engineering at the Iran University of Science and Technology. Her research interests include healthcare systems, statistics and artificial neural networks.

Mahdi Hamid is a Ph.D in Industrial Engineering from University of Tehran, Iran. His research interests are mathematical modelling, operation research, logistics, simulation, data analysis, and healthcare engineering. He has published more than 40 papers in reputable conferences and academic journals.