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Enhancing Cooperation: A Futuristic ANFIS Model for Anticipating Strategic Alliances between Fintech Start-ups and the Banking Sector

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ABSTRACT

This study introduces an innovative approach for evaluating the strategic cooperation between Iran's Fin-tech startups and the banking sector using the Adaptive Neural Fuzzy Inference System (ANFIS). By surveying 14 experts from financial institutions and Fin-tech firms and conducting a comprehensive literature review, six critical factors comprising 31 unique indicators are identified. These factors include motivations, effectiveness, cooperation levels, external organizational influences, barriers, and outcomes of strategic cooperation. Employing ANFIS and MATLAB software, a robust conceptual model is developed and rigorously assessed, resulting in a commendable rating of 7.06. This rating signifies a medium-to-high level of performance in the strategic cooperation landscape. The study emphasizes the significance of surmounting barriers and underscores the pivotal role played by external organizational factors, effectiveness, cooperation levels, outcomes, and motivations in shaping strategic cooperation dynamics between banking institutions and fin-tech startups. It offers valuable insights into this vital nexus within the financial ecosystem, shedding light on its potential impacts and significance for the industry.

1. Introduction

The rapid advancements in financial technology often referred to as fin-tech, have ushered in a transformative era within the global banking industry. Fintech innovations, characterized by the fusion of cutting-edge technology and financial services, have triggered substantial disruptions across traditional banking

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models, revolutionizing the way financial transactions are conducted and managed [21]. As the world becomes increasingly interconnected, fin-tech's influence on financial systems worldwide is undeniable, and Iran is no exception to this global fin-tech wave.

Fintech, as a broad term, encompasses a wide spectrum of applications ranging from mobile banking and digital payments to lending platforms, block chain technology, and Robo-advisory services [20]. These technological advancements have emerged as disruptive forces, challenging conventional banking models and introducing groundbreaking solutions to the world of finance. Iran, as a developing economy with aspirations of staying abreast of global financial trends, has been witnessing the gradual but steady emergence of fin-tech as a promising sector.

In this dynamic and evolving landscape, the importance of strategic cooperation between the banking system and fin-tech startups in Iran cannot be overstated. Such cooperation holds the key to harnessing their complementary strengths, sharing vital resources, and collectively achieving common goals [15]. Unlike developed economies where fin-tech has already made significant inroads into the financial sector, Iran stands at a crucial juncture, poised to capitalize on the opportunities that fin-tech presents.

Cooperation between established banks and nimble fin-tech startups offers numerous advantages that contribute to the growth and innovation of the financial ecosystem. Firstly, these collaborations enable both parties to leverage each other's strengths, thereby enhancing their competitiveness [7]. Banks, with their established infrastructure and substantial customer bases, can provide fin-tech startups in Iran with access to an extensive network, invaluable regulatory expertise, and essential financial resources [9]. Conversely, fin-tech startups bring agility, technological innovations, and disruptive ideas that can enhance the banks' offerings, streamline their processes, and extend their reach to previously untapped customer segments [14].

Secondly, fostering strategic cooperation in Iran between banks and fin-tech startups allows these entities to collectively address the evolving needs and preferences of customers, facilitating the development of tailored and innovative financial products and services [12]. Recognizing that customer-centricity is the hallmark of modern financial services, these collaborations can offer agile, user-friendly, and customized solutions that resonate with the Iranian populace.

In light of these developments, our research sets out to explore the dimensions and components that influence strategic cooperation between Iran's banking system and fin-tech startups. While extensive research has been conducted on fin-tech and its impact on the global financial sector, there exists a significant research gap when it comes to understanding the intricacies of strategic cooperation between banks and fin-tech startups in Iran [27].

This research aims to address this gap comprehensively by employing advanced fuzzy inference techniques, particularly the Adaptive Neural Fuzzy Inference System (ANFIS). ANFIS combines the capabilities of neural networks and fuzzy logic to model complex, uncertain relationships within datasets [1]. By utilizing this innovative approach, we seek to navigate the intricate landscape of strategic cooperation between banks and fin-tech startups in Iran, predict future scenarios, and evaluate their viability with enhanced accuracy.

Iran, as a developing economy, has witnessed the emergence of fin-tech as a new and promising sector. However, strategic cooperation between the banking system and fin-tech startups in Iran remains relatively unexplored. In the Iranian context, understanding the complexities and implications of such cooperation is of utmost importance, given the unique challenges and opportunities this emerging sector faces.

Despite the growing presence of fin-tech startups and their potential to drive innovation and transform the financial landscape in Iran, there is a notable absence of a well-designed model that accurately identifies the factors influencing strategic cooperation between the banking system and fin-tech startups. The Iran banking and fin-tech landscape is marked by its distinct regulatory framework, cultural nuances, and economic conditions, which necessitate tailored research and models that cater specifically to this environment.

Therefore, this research endeavors to bridge this research gap, addressing the critical need for a comprehensive and integrated understanding of strategic cooperation between banks and fin-tech startups in Iran. Our study seeks to formulate a comprehensive model that encompasses the key dimensions and

components shaping collaboration between these two entities within Iran's unique financial ecosystem. By conducting a thorough analysis of both domestic and foreign research, we aim to uncover the challenges, complexities, and potential benefits of strategic cooperation within Iran's distinct financial landscape.

This research is underpinned by several specific objectives and a well-defined methodology that guide our exploration into the dimensions and components influencing strategic cooperation between the banking system and fin-tech startups in Iran. While we will delve deeper into the specifics of our methodology in the subsequent sections, it's imperative to provide a brief overview of our research approach here. Our primary research question that drives this study is to identify the key dimensions and components that influence strategic cooperation between the banking system and fin-tech startups in Iran. To address this question, our research objectives encompass the following:

- To Identify Influential Factors: We aim to identify and categorize the multifaceted factors that impact strategic cooperation within Iran's banking and fin-tech sectors.
- To Develop a Comprehensive Model: Building on our analysis, we will formulate a comprehensive model that encapsulates the identified dimensions and components of strategic cooperation.
- To Evaluate the Model: We will apply advanced fuzzy inference techniques, particularly the ANFIS model, to evaluate the predictive accuracy and viability of our comprehensive model within the Iranian context.
- To Provide Practical Recommendations: Based on our findings, we will offer practical recommendations tailored to policymakers, regulatory bodies, and industry stakeholders, enabling them to facilitate and guide strategic collaboration initiatives within Iran's unique financial landscape.

The execution of this research holds significant relevance and promises several critical contributions. Firstly, it sheds light on untapped potential and unexplored dynamics of cooperation between banks and fin-tech startups in Iran, empowering both parties to leverage each other's strengths and enhance their competitiveness within Iran's financial ecosystem. Secondly, by developing a comprehensive model, this study provides a valuable framework for policymakers, regulators, and industry stakeholders to facilitate and guide strategic collaboration initiatives within Iran's unique financial environment. As Iran seeks to modernize its financial services sector and keep pace with global fin-tech trends, our research offers timely insights that can inform policy and regulatory decisions.

Furthermore, the findings of this research contribute to a broader discourse on fin-tech innovation and its implications for the Iranian financial ecosystem. By examining the complexities of strategic cooperation and identifying the vital dimensions and components within Iran's distinct context, this research lays the foundation for more efficient and effective cooperation between banks and fin-tech startups. Ultimately, the successful implementation of strategic cooperation models in Iran can drive innovation, improve financial services, and establish a sustainable ecosystem that benefits both customers and the banking industry. As Iran continues its journey towards becoming a prominent player in the global fin-tech arena, our research stands as a beacon of guidance and insight, poised to empower the financial sector and foster innovation.

2. Literature Review and Conceptual Framework

2.1. Fin-tech

Fin-tech, or financial technology, represents a transformative and innovative field within the financial industry, using advanced technologies to offer novel financial services and products. Fin-tech covers various applications, including mobile banking, digital payments, lending platforms, block chain technology, and Robo-advisory, among others [20]. Fintech has emerged as a disruptive force, challenging conventional banking models and introducing groundbreaking solutions for conducting transactions and managing financial activities [26].

Fintech startups and businesses play a pivotal role in driving innovation in the financial sector. Leveraging technology, data analysis, and user-centric design, they address the limitations and gaps within the traditional banking system [24]. The primary objective of fin-tech startups and businesses is to amalgamate financial

expertise with technological advancements, ultimately delivering enhanced customer experiences, improved financial accessibility, and streamlined financial processes. These innovations utilize technology and data to optimize processes and offer tailored solutions to customers [10].

2.2. Startups

Startups are newly established business enterprises operating in a dynamic and rapidly evolving environment. They are characterized by limited resources, high levels of uncertainty, and a strong focus on scalability. Startups often bring disruptive and innovative ideas to the market, challenging industry norms and offering novel solutions to customer needs [16].

In the field of fin-tech, startups play a pivotal role in driving innovation and transforming the financial landscape. Leveraging emerging technologies such as artificial intelligence, machine learning, and big data analytics, fin-tech startups develop advanced financial products and services. Their agility and adaptability enable them to quickly respond to market changes and evolving customer preferences, presenting unique opportunities for collaboration with traditional banking institutions [5].

2.3. Strategic Cooperation

Strategic cooperation between the banking system and fin-tech startups entails a mutually beneficial collaboration aimed at achieving common objectives. The goal of this cooperation is to leverage the complementary strengths of both parties, share resources, and integrate efforts. Traditional banks and fin-tech startups join forces to enhance and develop their services by combining the established infrastructure and expertise of traditional banking with the capabilities and innovations of fin-tech startups. For banks, collaboration with fin-tech startups provides access to new technologies and fresh perspectives, facilitating service enhancement, operational performance improvement, and attracting new customers [16]. Conversely, fin-tech startups can benefit from the customer base and financial resources of banks, accelerating their growth and market expansion [13].

Understanding the dynamics of fin-tech and the significance of strategic cooperation in this realm is crucial for comprehending the context and importance of this issue. By harnessing the synergy and interaction between banks and fin-tech startups, collaborative relationships can be established that foster innovation, drive growth, and shape the future of financial services [15].

2.4. Research background

Klus et al. [18] highlight that technology-based innovation poses challenges to established institutions, such as banks, requiring them to swiftly adapt to the demands of the digital era. Conversely, young fin-tech companies face obstacles like regulatory compliance and earning the trust of potential customers. To bridge these gaps and capitalize on synergies, banks and fin-techs are increasingly engaging in collaborations. The results reveal that banks are particularly interested in harnessing rapid innovation without necessarily being involved in its development, while fin-techs seek the resources and expertise to scale in the highly regulated financial sector.

Shahhosseini et al. [23] conducted research on the formation of cooperation patterns between banks and fin-techs, emphasizing that the cooperation between these entities are driven by the capabilities and mutual benefits they bring to each other. The study examined the factors that influence the patterns of cooperation and identified 43 factors categorized into 11 structures and 4 main categories: party characteristics, communication characteristics, cooperation prerequisites, and macro factors. This research highlights the multifaceted nature of cooperation between banks and fin-techs, emphasizing that this relationship should not be viewed as a simple phenomenon. Instead, it requires a comprehensive and multidimensional perspective for a thorough investigation.

Drasch et al. [9] identified six primary cooperation patterns between banks and fin-tech companies based on factors such as technology type, progress and growth, bank type, strategic goals, communication channels,

business ecosystem, licenses, position in the value chain, collaboration type, innovation type, and innovation ownership. These patterns are ranked in order of the highest to the lowest level of cooperation: investing in financial technology, preparation and integration of channel solutions and superior platform innovation, innovation to improve the processes of providing banking services to customers, access to capital markets for financial technologies to provide services, reciprocal services to banks for innovation in service delivery, cooperation in the early stage of access to technology. These cooperation patterns provide a framework for understanding the diverse ways in which banks and fin-techs can collaborate to drive innovation and enhance the delivery of financial services.

Khazaei et al. [17] proposed a model for the acceptance of new financial technologies, finding that variables such as awareness, perceived security, efficiency, ease of use, and relative advantage positively influence attitudes towards fin-tech products and services. However, cost has a negative impact. Age and experience were identified as positive moderating factors on attitude, but experience did not moderate the relationship between attitude and acceptance, while age had a negative moderating role. Consequently, attitude serves as a mediating variable in these relationships.

Gholami et al. [11] conducted a comprehensive analysis of the factors influencing the implementation of fin-tech in the banking industry, providing solutions to overcome obstacles and foster industry development. The findings underscore the need for legal harmonization, infrastructure development, and the necessary tools to support fin-tech strategies in the banking sector. These measures aim to promote transparency, reduce costs, provide high-speed services, and facilitate the transition towards a smart economy.

Li et al. [21] conducted a study on investment patterns and performance of banks in fin-tech ventures in the United States. Their findings indicate that banks tend to invest a larger proportion in fin-tech startups compared to independent venture capitalists and achieve a higher exit rate. This outperformance is particularly observed in homegrown fin-tech startups and those that align with banks' core business segments. The study suggests that banks' industry expertise plays a role in their selection process and contributes to their investment success. Moreover, the study reveals that banks are more likely to participate on the boards of fin-tech startups, indicating their active involvement in guiding and supporting these ventures beyond financial investment.

Najafi et al. [22] conducted a comprehensive analysis of factors influencing the interaction between banks and modern financial technologies. Through surveys and interviews with banking system managers and fintech service providers, they identified four categories of factors: beneficiary characteristics, environmental factors, organizational factors, and financial factors. The study ranked these factors based on their impact on the relationship between banks and fin-tech. The results highlighted the positive influence of all identified factors, with beneficiary characteristics, environmental factors, financial factors, and organizational factors exerting the greatest influence in that order.

In the study conducted by Tahmasebiaghbelaghi et al. [25], a framework for strategic cooperation between the private banking system and fin-tech was proposed. The research highlights that environmental obstacles and uncertainties within organizations can serve as the catalyst for establishing strategic cooperation between the parties. The framework identifies several essential conditions for effective cooperation, including fin-tech opportunism, digital behavior and customer needs assessment, customer recognition of fin-tech, maintaining a competitive environment, adherence to principles and laws of Islamic finance, and accurate business valuation. Additionally, the study emphasizes the influential role of insiders within the private banking system as the most significant intervening factor. It is suggested that this strategic cooperation between the private banking system and fin-tech will lead to growth and have significant financial, process, operational, and intervention-related consequences.

Bartolacci et al., [4] examined the characteristics, motivations, and processes involved in forming strategic alliances between a small cooperative bank and a fin-tech startup. The study identified various motives for forming strategic alliances for both banks and fin-tech startups. Banks were driven by motives such as outsourcing, innovation, evolving business models, competitive advantage, cost savings, service quality improvement, and learning. Fin-techs, on the other hand, were motivated by factors like accessing customers,

loans, banking licenses, economies of scale, trust, and credit. Success factors identified in the study included strategic and combined alignment, competence and experience, cultural value and territorial proximity, and professionalism.

Kwon et al. [19] investigated the factors influencing international bank acquisitions of fin-tech companies between 2010 and 2018. The study revealed that bank boards with a higher representation of women and longer-tenured CEOs were more likely to pursue fin-tech acquisitions. The financial performance also played a role, as banks with greater capital strength and liquidity showed a higher propensity for acquiring fin-tech. Furthermore, banks with higher IT spending, indicative of in-house digital solution development, were less likely to target fin-tech acquisitions. Younger CEOs and banks with lower IT costs also displayed a higher likelihood of engaging in fin-tech acquisitions. The study emphasized the importance of nationality diversity in the boardroom for cross-border bank and fin-tech transactions.

The research conducted by Asadollah et al. [2] highlights the impact of fin-tech and financial startups on the business model of electronic banking. The study identifies key factors influencing this model, including the structure of financial institutions, customer segmentation, fin-tech developers, and the business environment. Additionally, various dimensions, such as offered services, customer communication structure, infrastructure management, and financial aspects, are crucial in designing this model. The research further examines the consequences of this model, indicating that improvements in the business environment, organizational performance, and the prevalence of virtual banking have the most significant effects. The findings underscore the need for a multidimensional perspective to understand this complex phenomenon and emphasize the importance of considering multiple factors in shaping the cooperation pattern between banks and fin-tech.

Chen et al. [8] conducted research on the impact of cooperation with fin-tech on the organizational dimensions of banks. The study highlights the influential role of the parties' positions within the cooperation relationship and their interaction in contractual matters, specifically in terms of power and commitment. Factors such as infrastructural and technical capacities, perceived fairness in benefit distribution, approach to intellectual property, and future predictions of cooperation play pivotal roles in determining the choice and formation of the cooperation model.

Examining the business model of fin-tech, Bomer and Maxin [6] found that cooperation with banks enables fin-tech to integrate into industrial networks and leverage the robust infrastructure of banks to develop innovative products and services. Fin-techs rely on banks' support to access the larger customer market, leading to increased profits as a secondary goal. The research emphasizes that fin-techs seek cooperation opportunities with traditional financial institutions to enhance their credibility and market their products under a trusted bank's brand. The commitment of banks to foster a relationship that allows fin-tech to continually produce new products and access new markets significantly influences fin-techs' willingness to cooperate. However, the study cautions that the bank's opportunistic behavior, lack of respect for fin-tech goals and plans, or undervaluation of fin-tech knowledge can negatively impact the cooperation.

Based on an extensive review of the literature and empirical research, this study presents a conceptual model illustrating the key indicators influencing the strategic cooperation between the banking system and fin-tech startups. The model, depicted in Figure , provides a comprehensive framework that integrates the findings from previous studies to identify the essential factors driving successful cooperation in this context.

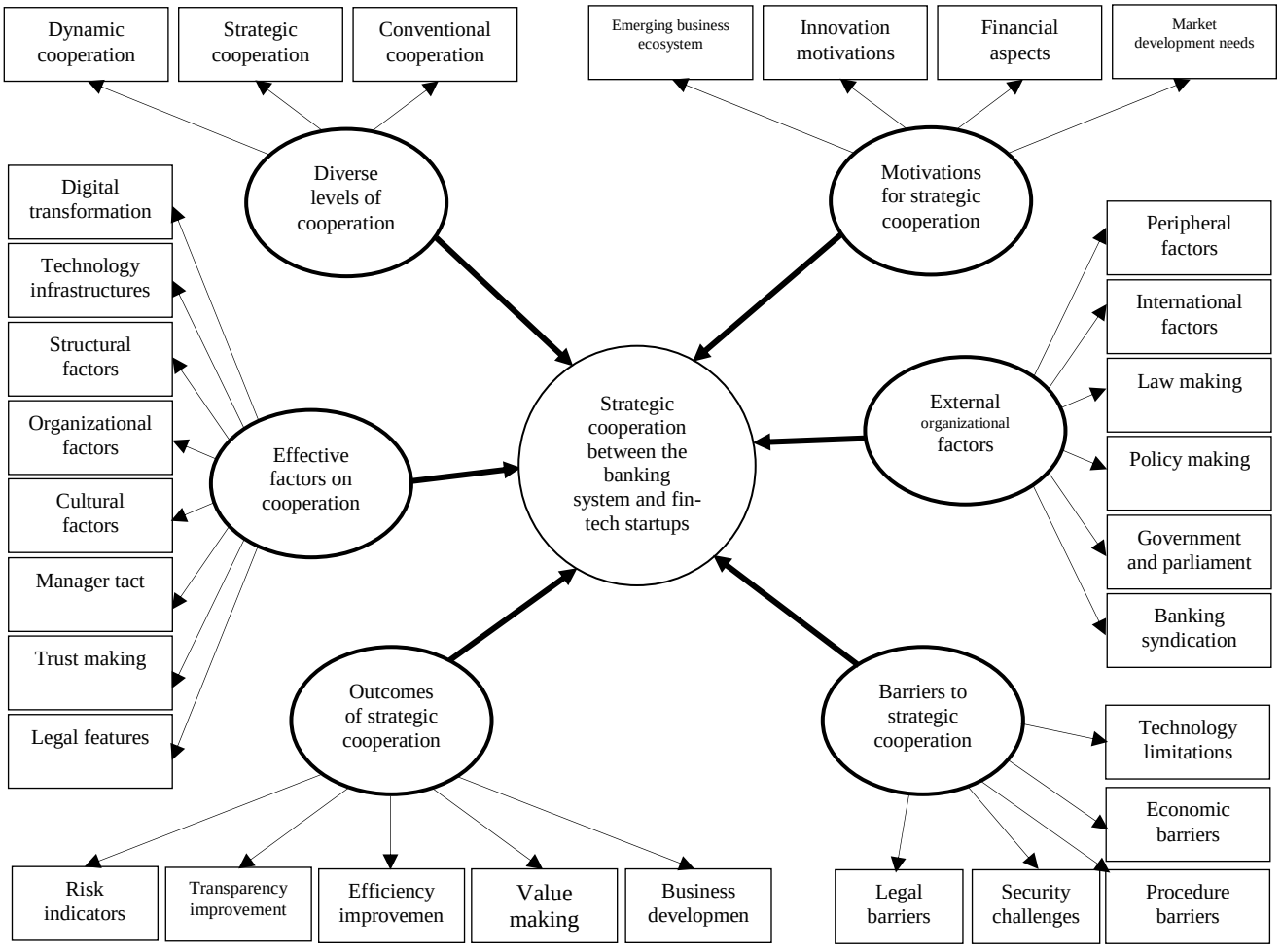

Figure 1. Conceptual model

3. Methodology

The primary objective of this research is to develop a model for strategic cooperation between the banking system and fin-tech startups. The research methodology employed in this study is practical in terms of its purpose and descriptive-survey in terms of data collection. Additionally, due to the exploration of dimensions and influential factors, this research can be classified as exploratory.

Utilization of ANFIS and Fuzzy Approach: To design the inference rules, the Adaptive Neural Fuzzy Inference System (ANFIS) is employed as a robust tool that combines the learning capabilities of neural networks with the performance of fuzzy systems [1]. Fuzzy logic is a key aspect of this approach, which allows for handling and modelling complex, non-linear relationships within datasets.

Introduction to Fuzzy Symbols: Fuzzy logic, represented by symbols such as "μ," which signifies membership functions, plays a pivotal role in ANFIS. Membership functions describe the degree of membership or truth for a particular element in a fuzzy set. They are used to capture the uncertainty and imprecision inherent in real-world data. In the context of this research, these symbols help translate expert opinions and data from the questionnaire into the model's framework.

Data Collection: In the initial stage, a semi-structured questionnaire was prepared based on a literature review to interview 14 experts from the banking system and fin-tech companies. The snowball sampling method was employed to ensure theoretical saturation, with data collection continuing until the fourteenth interview for sufficient confidence. At this stage, the snowball sampling method was employed to ensure theoretical

saturation. The process began with the twelfth interview and continued until the fourteenth interview to achieve sufficient confidence and reach a point of theoretical saturation.

Sample Size Determination: The sample size was determined based on the principle of saturation, where data collection is stopped when no new information is obtained and repetition occurs. Data analysis after the twelfth interview did not yield new concepts and categories. However, two additional interviews were conducted to ensure theoretical saturation, and their data were analysed accordingly. The extracted dimensions and components from the literature review and experts' knowledge were then analysed using ATLAS.ti software.

Questionnaire Design and Validation: A questionnaire was designed based on the identified dimensions and components to formulate, implement, and test the model. Face and content validity methods were employed to ensure its scientific validity, and the reliability of the questionnaires was confirmed through Cronbach's alpha coefficient. The questionnaire demonstrated acceptable validity and reliability. Using Sample Power v3.0.1 software, a sample size of 291 respondents was calculated, with an alpha value of 0.01 and a test power of 0.85.

The questionnaire was distributed to 321 individuals, representing a 10% increase over the estimated sample size, through online and written formats. A total of 320 completed questionnaires were collected from experts, managers, and policymakers in the banking industry and fin-tech businesses/startups, all of whom had over 10 years of experience in management positions and held master's or doctoral degrees. The respondents were purposefully and conveniently selected, and they were requested to rate the level of strategic cooperation between the banking system and fin-tech startups based on their experience and expertise, considering the effects of the identified dimensions, using a scale of 0 to 10.

Data Analysis and ANFIS: The collected questionnaire data were then analysed using the ANFIS implemented in MATLAB software. The data were divided into three categories: training, testing, and validation. The training data were utilized to model the target system, while the testing data were used to validate the designed model.

The ANFIS model, combining fuzzy inference methods with artificial neural networks, is well-suited for solving nonlinear problems. It functions as a black box model that transforms inputs into outputs without requiring extensive knowledge of the internal processes of the system. This feature makes it comparable to regression models but with greater flexibility in weight adjustments. Consequently, ANFIS is also employed as an alternative to multivariate regressions. The ANFIS model exhibits higher accuracy compared to regression models and provides highly accurate forecasts that align with reality, establishing it as a superior forecasting tool [3]. The process of developing a fuzzy system based on data begins by collecting a dataset from the system to be modelled, consisting of one output variable and several input variables. The process involves clustering the output variable and expanding each cluster on the input variable space using the principle of fuzzy expansion.

Following the extraction of image representations for each developed cluster, membership functions can be calculated for each input variable, thereby illustrating the relationship between the input and output variables through the corresponding clusters. Subsequently, the system rules are derived based on the relationships among these clusters, and the fuzzy rule base is formed by combining these rules. Consequently, the number of rules in the system is determined by the number of output variable clusters obtained in the initial step using the clustering technique. The subsequent sections will delve into the design, implementation, and evaluation of the ANFIS, which serves as the focal point of this research.

4. Results

4.1. Fuzzy Inference System Design with Adaptive Neural Approach

The main ANFIS model consisted of six inputs or dimensions, which included the motivation of banks and fin-tech for cooperation, effective factors on cooperation between banks and fin-tech, diverse levels of cooperation, external organizational dimensions and components, barriers and problems of strategic cooperation, and outcomes of strategic cooperation. The output variable of the model was the strategic cooperation between the banking system and fin-tech startups. Table 1 provided an overview of the main

components of the research, including the final output, dimensions, and their related components. Based on this, a mathematical model was developed, which included a main ANFIS for strategic cooperation between the banking system and fin-tech startups, along with six sub-ANFIS models that captured the effects of each component on the corresponding dimensions. The designed model consisted of six inputs (dimensions) and outputs for strategic cooperation, resulting in a total of 15 inference rules.

Table 1. Research dimensions and components

Main component	Dimensions	Symbol	Components	Symbol
Strategic cooperation between the banking system and fin-tech startups (SCOBF)	Strategic Cooperation Motivations	SCM	Market development needs	MD
			Financial aspects	FA
			Innovation motivations	IM
			Emerging business ecosystem	BE
	Effective Factors on Cooperation	EFOC	Digital transformation	DT
			Technology infrastructures	TI
			Structural factors	SF
			Organizational factors	OF
			Cultural factors	CF
			Manager tact	MT
			Trust making	TM
			Legal features	LF
	Levels of Cooperation Between Banks and Fintech	LCBF	Conventional cooperation	CC
			Strategic cooperation	SC
			Dynamic cooperation	DC
	External Organizational Factors	EOF	Peripheral factors	PF
			International factors	IF
			Law making	LM
			Policy making	PM
			Government and parliament	GP
			Banking syndication	BS
	Strategic Cooperation Barriers	SCB	Technology limitations	TL
			Economic barriers	EB
			Procedure barriers	PB
			Security challenges	SC
			Legal barriers	LB
	Strategic Cooperation Outcomes	SCO	Business development	BD
			Value making	VM
			Efficiency improvement	EI
			Transparency improvement	TIM
			Risk indicators	RI

4.2. Definition of Initial Membership Functions for Input and Output Variables in ANFIS Systems

The design of ANFIS requires the selection of appropriate membership functions for input and output variables. In this research, Gaussian functions have been chosen as the preferred category of membership functions, as they have been widely utilized in network-based adaptive fuzzy inference systems.

Gaussian functions possess the desirable property of being differentiable, which is crucial for ANFIS systems to ensure smooth and continuous modelling. The flexibility of Gaussian functions allows them to adapt to various data patterns by adjusting the parameter σ, which represents the standard deviation. By manipulating σ, the Gaussian functions can expand or contract, effectively covering a wide range of input and output values. This utilization of Gaussian membership functions in ANFIS systems contributes to their ability to accurately capture the complex relationships and patterns within the data, enhancing the modelling and inference capabilities of the system.

The initial membership functions for the linguistic variables in the ANFIS of the strategic cooperation

between the banking system and fin-tech startups, as well as its subsystems, are illustrated in Figure 1. These membership functions are based on the Gaussian function, represented by the equation:

$$Gaussian(x,\sigma,c) = e^{-(\frac{x-c}{\sigma})^2} \quad (1)$$

In the above equation, c represents the centre of symmetry, while σ determines the degree of openness or spread of the function. Gaussian functions exhibit a continuous curve, and their parameters can be adjusted to align with the characteristics of linguistic variables.

For the ANFIS model in this research, the input and output variables are defined within a range of 0 to 10. By appropriately tuning the parameters c and σ, the Gaussian membership functions capture the linguistic interpretations and variations of the input and output variables.

The initial membership functions depicted in Figure 1 illustrate the shape and characteristics of the linguistic variables used in the ANFIS system. These functions serve as the foundation for subsequent modelling and inference processes, enabling the ANFIS system to effectively capture the complexities and relationships within the strategic cooperation between the banking system and fin-tech startups.

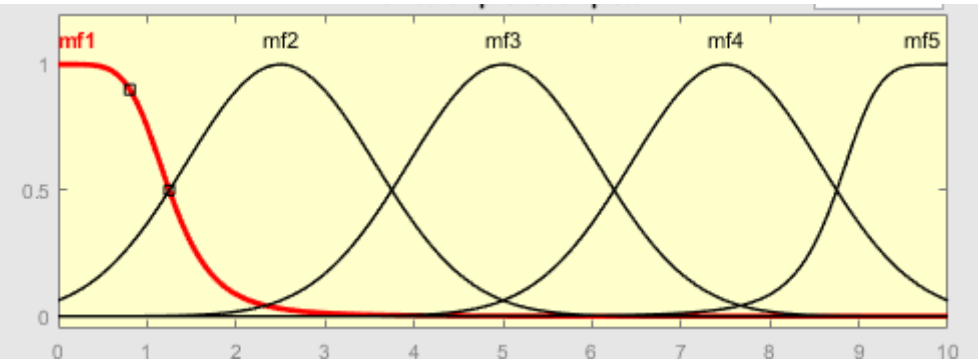

Figure 1. Initial membership function for evaluating the strategic cooperation of the banking system and fin-tech startups

4.3. ANFIS Training and Error Analysis

To determine the parameters of the membership function during the training process, two methods are employed: backpropagation and hybrid methods. In the backpropagation method, the error is calculated, and through backtracking, the error is propagated to the inputs (parameters) for parameter correction using the error gradient descent algorithm, similar to the backpropagation method in neural networks. By combining these two methods, an optimal training approach is achieved, which is utilized in this research.

The range of error changes is directly related to the magnitude of the error and serves as a criterion for stopping the training process. In this study, the ANFIS models are trained over 30 training epochs, which resulted in an acceptable level of error. Table 2 presents the error values obtained for the main ANFIS and sub-ANFIS after the 30 training epochs.

The average error calculated during the training phase of the model is 7.7 x 10^{-8}, indicating the high validity and accuracy of the model. This low level of error demonstrates the effectiveness of the training process in capturing the complexities and relationships within the strategic cooperation of the banking system and fintech startups.

Table 2. Error Analysis of the Designed ANFIS

ANFIS Model	SCM	EFOC	LCBF	EOF	SCB	SCO	SCOBF
Error	2.2×10^{-8}	2.1×10^{-8}	5.5×10^{-10}	8.4×10^{-9}	1.4×10^{-8}	1.9×10^{-8}	7.7×10^{-8}

4.4. Implementation of Mathematical Model

Following the implementation of the Sub-ANFIS models, their outputs are utilized as inputs for the main ANFIS model to evaluate the influential dimensions of the strategic cooperation between the banking system and fin-tech startups. Table 3 presents the input and output values in the main model, while Figure 2 illustrates the rule base of the main ANFIS.

The assessment reveals that the level of strategic cooperation between the banking system and fin-tech startups is determined to be 7.06, indicating a positive and favourable condition. Notably, the dimension of "Barriers to Entering Strategic Cooperation" holds a value of 6.9 based on Table 3, reflecting a relatively high position among the input variables. Conversely, the dimension of "The Motivation of Banks and Fin-techs to Enter into Cooperation" receives the lowest value of 6, indicating comparatively lower significance among the inputs.

Table 3. ANFIS Input and Output Values for Strategic Cooperation

Input Variables	SCM	EFOC	LCBF	EOF	SCB	SCO	SCOBF
Output Variable	6	6.6	6.17	6.68	6.9	6.17	7.60

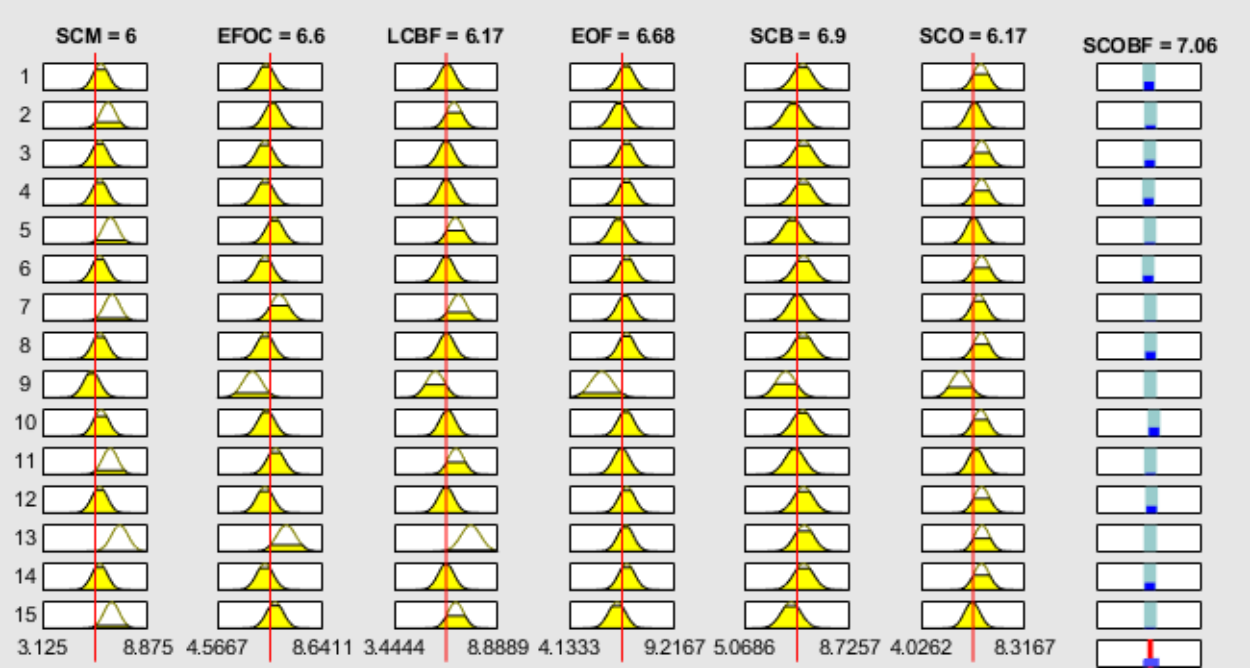

Figure 2. Rule Base of Strategic Cooperation between the Banking System and Fintech Startups

4.5. Mathematical model validation: Testing and checking the data set

Before implementing the system in the actual research, it is essential to validate the accuracy and reliability of the mathematical model. This ensures the model's applicability and trustworthiness. Two validation methods were employed: dataset testing and limit condition testing.

A) Dataset testing: In the validation process, test data is employed to assess the generalization ability of the designed fuzzy inference system. To mitigate the risk of overfitting, the last set of data, which consists of survey data, is utilized. The performance of the designed ANFIS is thoroughly examined, and the results are illustrated in Figure 3 and Figure 4, showcasing the agreement between the training and testing data.

Figure 3 depicts a comparison chart between the ANFIS output and the training data. The "•" symbol represents the ANFIS output, while the "*" symbol represents the training data. The average calculation error is found to be 7.7×10^{-8}, indicating a high level of accuracy. Similarly, Figure 4 displays a comparison chart

between the ANFIS output and the checking data. The "•" symbol represents the output of the system, while the "*" symbol represents the checking data. The close match between the two sets of data demonstrates the absence of overfitting in the designed ANFIS. This signifies that the model possesses strong predictive capabilities and is able to effectively generalize from the training data to new, unseen data. Overall, the performance of the designed ANFIS is assessed through the testing and checking of the data set, affirming the model's ability to generalize and make accurate predictions.

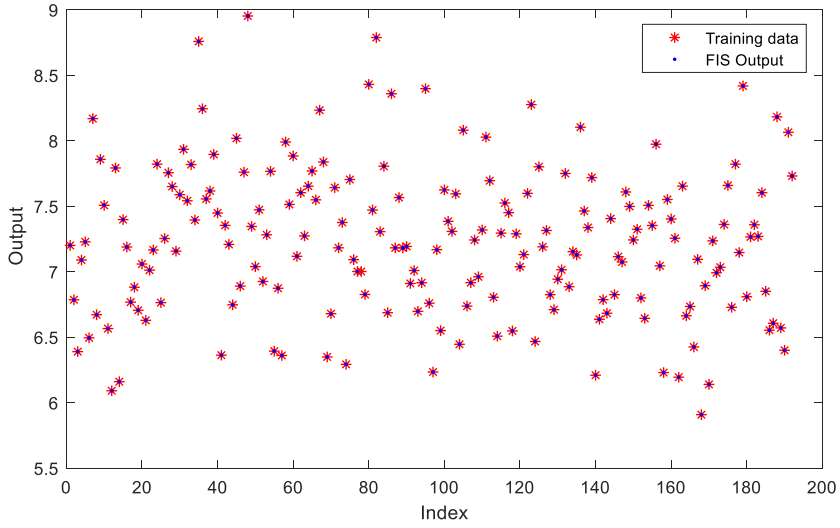

Figure 3. Comparison chart between ANFIS output and training data

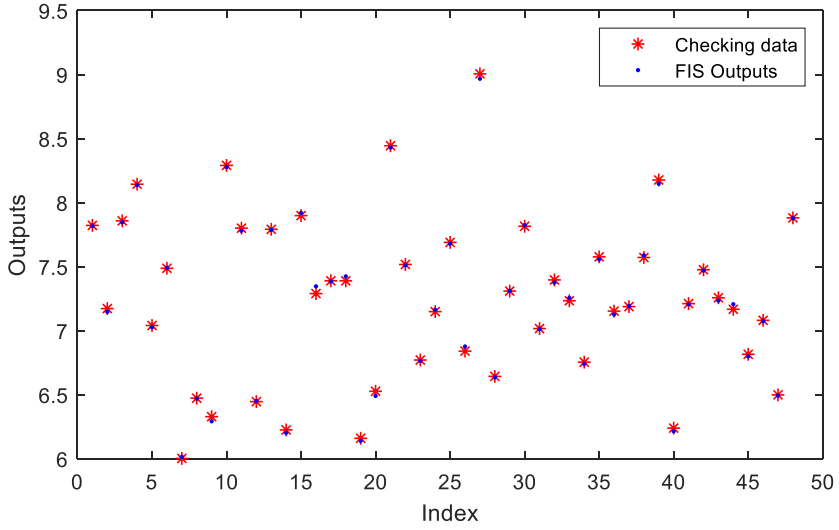

Figure 4. Comparison chart between ANFIS output and checking data

B) Limit condition testing: The model's behaviour was evaluated by subjecting the main ANFIS input variables to extreme limit states, both very high and very low values. This test aims to verify the correctness and reliability of the mathematical model in response to changes in input values. Table 4 demonstrates the model's reasonable behaviour across various input value ranges, ranging from very low (0) to very high (10). The test was also conducted for all six Sub-ANFIS, and they all exhibited reasonable behaviour towards the limit values of the inputs, affirming the validity of the designed model. Overall, the validation process confirms the accuracy and reliability of the mathematical model, ensuring its effectiveness in predicting and generalizing the strategic cooperation between the banking system and fin-tech startups.

Table 4. The effect of simultaneous changes in inputs on output

Inputs						Output
SCO	SCB	EOF	LCBF	EFOC	SCM	SCOBF
0	0	0	0	0	0	0.04
5	5	5	5	5	5	4.57
10	10	10	10	10	10	9.75

4.6. Model sensitivity analysis

To assess the impact of changes in input variables on the output, a sensitivity analysis is conducted. Two inputs with the maximum and minimum effects on the output are selected, and the effect of their changes on the output is examined. The input related to SCB is identified as the dimension with the greatest impact on the output. By increasing its value by one unit, the resulting changes in the output are presented in Table 5. Similarly, by reducing the input related to SCM by one unit while keeping all other dimensions constant, the changes in the output are examined and presented in Table 6.

Table 5. Changes in the output in response to changes in SCB

SCM	EFOC	LCBF	EOF	SCB	SCO	SCOBF
6	6.6	6.17	6.67	7.9	6.17	7.25

Table 6. Changes in the output in response to changes in SCM

SCM	EFOC	LCBF	EOF	SCB	SCO	SCOBF
5	6.6	6.17	6.67	6.9	6.17	6.88

Based on the observed changes, it is evident that the output changes by 0.19 in response to the change in the dimension SCB, while the same change in the dimension SCM results in an 18.0 change in the output. These findings confirm the greater influence of the variable SCB on the output. Moreover, it can be concluded that the model is not highly sensitive to the resulting changes, indicating its robustness.

4.7. The effect of research dimensions on the strategic cooperation of the banking system and fin-tech startups

The results presented in Table 7 demonstrate the varying impact of the research dimensions on the strategic cooperation between the banking system and fin-tech startups.

Table 7. Ranking the Impact of Research Dimensions on Strategic Cooperation

The degree of importance	Input	Impact rate
1	SCB	0.39
2	EOF	0.3
3	EFOC	0.28
4	LCBF	0.25
5	SCO	0.21
6	SCM	0.16

According to the findings in Table 7, the dimension SCB is ranked first with an impact rate of 0.39, indicating its highest importance among the dimensions affecting strategic cooperation. Following that, the dimensions of EOF and EFOC have the next highest impact on the output. Conversely, the dimension SCM is ranked last with a change rate of 0.16 in the output value.

5. Conclusion

The rapid evolution of financial technology (Fin-tech) has revolutionized the banking sector globally, presenting new opportunities and challenges. Iran, like many other countries, is navigating this transformative landscape. This research has delved into the dynamics of strategic cooperation between the banking system and Fin-tech startups in Iran, yielding valuable insights into how these two sectors can collaborate effectively. This research has not only successfully developed a model that encompasses 31 indicators, categorized into six factors, unveiling the intricate dimensions of strategic cooperation but has also highlighted its potential to significantly impact innovation, financial services, and the overall sustainability of the banking industry in Iran.

Our analysis has identified that certain dimensions wield substantial influence over strategic cooperation. These dimensions, including strategic cooperation barriers, external organizational factors, effective factors on cooperation, levels of cooperation between banks and fintech firms, strategic cooperation outcomes, and strategic cooperation motivations, have a far-reaching impact on the financial landscape. Addressing these dimensions, such as overcoming technological limitations, economic barriers, and legal challenges, is paramount to enhance the likelihood of successful cooperation.

Moreover, we emphasize the pivotal role of external dimensions, encompassing environmental factors, international influences, regulatory frameworks, and industry associations, in driving effective decision-making and fostering cooperation within the financial ecosystem. Understanding and prioritizing the factors that facilitate cooperation, such as digital transformation, infrastructure development, organizational and structural considerations, cultural aspects, managerial perspectives, trust-building mechanisms, and legal compliance, are vital for nurturing thriving partnerships.

Furthermore, creating an enabling environment that actively promotes cooperation through market development, financial incentives, and innovation is not just beneficial but necessary for the sustainable growth of the Iranian banking industry. Lastly, identifying and aligning different levels of cooperation, such as common cooperation, strategic cooperation, and flexible and dynamic strategic cooperation, facilitates the establishment of clear expectations and optimization of outcomes.

The evaluation of strategic cooperation between the banking system and fin-tech startups, yielding a commendable score of 7.06, underscores the potential for innovation and positive transformation in financial services. These identified dimensions serve as a robust framework for organizations to formulate effective strategies, fostering even more successful and sustainable collaborations that drive innovation and positively impact financial services in Iran.

In this section, we will not only outline the recommendations based on the research findings but also delve into their practical implications, emphasizing how these proposals can be applied by policymakers, regulators, industry stakeholders, and ultimately, their potential benefits for the Iranian financial ecosystem and customers.

- **Cultivating a Culture of Cooperation:** Policymakers, bank managers, and Fin-tech leaders should foster a collaborative mindset by promoting open communication and knowledge sharing. Platforms for regular interaction and cooperation should be established to facilitate the exchange of opinions and expertise. The success of any collaboration effort hinges on a shared vision and culture of cooperation. For policymakers and regulators, promoting this culture means creating an environment where traditional banks and Fin-tech startups perceive each other as partners rather than competitors. Initiatives like industry forums, innovation hubs, and cross-sector conferences can serve as platforms for fostering such a culture. A cooperative culture can lead to more effective and harmonious partnerships. Banks and Fin-tech startups can pool their resources, expertise, and experience to develop innovative solutions that benefit the Iranian financial ecosystem and customers. By working together, they can address challenges such as financial inclusion, technological advancement, and improved services.
- **Facilitating Strategic Partnerships**: Policymakers and bank managers should actively seek opportunities for strategic partnerships between banks and Fin-tech startups. Clear frameworks and agreements defining common goals should be developed to facilitate effective cooperation on joint projects and innovative ventures. To facilitate such partnerships, policymakers and regulators should

play a role in creating an enabling environment. This includes setting up regulatory sandboxes where Fin-tech startups can experiment with new ideas, providing guidance on data sharing and access, and offering incentives for joint projects. Strategic partnerships can lead to the development of innovative financial products and services that cater to the evolving needs of customers. Banks, with their experience and resources, can collaborate with Fin-tech startups to bring these solutions to market faster, enhancing the overall customer experience.

- **Embracing Digital Transformation**: Policymakers and banking leaders should emphasize the importance of digital transformation within the banking system and encourage Fin-tech startups to provide innovative technological solutions. Investments in advanced technologies such as artificial intelligence, blockchain, and data analysis should be made to enhance operational efficiency, improve customer experience, and offer innovative products/services. Embracing digital transformation requires not only investment in technology but also a strategic shift in organizational culture and processes. Regulators should support these efforts by providing guidelines and frameworks for adopting emerging technologies securely. The adoption of advanced technologies can streamline banking operations, reduce costs, and improve the customer experience. For instance, AI-powered chat-bots can provide instant customer support, while block chain can enhance security and transparency in financial transactions.
- **Regulatory Support and Flexibility:** Policymakers and regulatory institutions play a crucial role in creating a supportive environment for cooperation. It is recommended to develop flexible regulatory frameworks that accommodate emerging technologies and foster experimentation while ensuring consumer protection and financial stability. Regulatory bodies should adopt a proactive approach to regulatory frameworks. This means staying updated with the latest technological advancements and working closely with industry stakeholders to develop regulations that balance innovation and security. Flexible regulations can encourage innovation and experimentation, making it easier for Fin-tech startups to bring new solutions to market. Customers can benefit from a wider range of innovative financial services, and the financial ecosystem becomes more resilient to emerging risks.
- **Talent Acquisition and Development:** Bank managers and Fin-tech leaders should prioritize talent acquisition and development. Encouraging knowledge exchange and cooperation between the banking system and Fin-tech startups is crucial. Investment in training programs to strengthen skills related to digital finance, technology, and entrepreneurship is necessary. Creating talent development programs that bridge the gap between traditional banking and Fin-tech is essential. Collaboration between banks and Fin-tech startups can involve skill-sharing initiatives, internship programs, and joint training sessions. A well-trained workforce equipped with both traditional banking and Fin-tech knowledge can drive innovation and adapt to changing customer preferences. This ultimately leads to the development of more customer-centric products and services.
- **Customer-Centric Solutions:** Policymakers, bank managers, and Fin-tech leaders should collaborate in developing customer-centric products and services. Leveraging the agility and innovation of Fin-tech startups, the banking system should enhance its ability to provide personalized, convenient, and user-friendly solutions. Developing customer-centric solutions requires a deep understanding of customer needs and preferences. Data sharing agreements, within the bounds of privacy regulations, can facilitate the exchange of customer insights between banks and Fin-tech firms. Customer-centric solutions lead to improved customer satisfaction and loyalty. By working together, banks and Fin-tech startups can harness data-driven insights to create tailored financial products and services.
- **Continuous Monitoring and Evaluation:** Policymakers, regulatory bodies, and bank executives should establish mechanisms to monitor and evaluate the progress and impact of strategic cooperation plans. Regular evaluations of partnership effectiveness should inform adaptive strategies for long-term success. Setting up dedicated units or committees for monitoring and evaluation can ensure that strategic cooperation efforts are on track. Key performance indicators (KPIs) should be established to

measure the impact of cooperation initiatives. Continuous monitoring and evaluation allow for the adjustment of strategies in response to changing market dynamics. This ensures that cooperative efforts remain aligned with the evolving needs of the financial ecosystem and its customers.

- **Knowledge Sharing and Industry Collaboration:** Policymakers are advised to encourage banking leaders, Fin-tech managers, and relevant stakeholders to engage in knowledge sharing and industry collaboration. Supporting initiatives, consortia, and associations that facilitate the exchange of best practices and insights will contribute to collective growth and development. Policymakers can play a pivotal role in fostering knowledge sharing and industry collaboration by providing incentives for participation in industry consortia, supporting research and development initiatives, and promoting cross-sector partnerships. Knowledge sharing and industry collaboration can accelerate innovation and create synergies between banks and Fin-tech startups. This, in turn, leads to the development of more robust and customer-friendly financial services.

By addressing these recommendations, policymakers, regulatory bodies, banking executives, and Fin-tech leaders can create an enabling environment for effective strategic cooperation. This fosters innovation, strengthens the financial ecosystem, and ultimately benefits the customers and the financial industry as a whole. The collaboration between banks and fin-tech startups can drive positive outcomes, shaping the future of banking in Iran and contributing to the country's economic growth.

6. Limitations and Future Directions

While our research has made significant contributions, it is important to acknowledge its limitations and suggest potential areas for future study. Our study primarily focuses on the banking system and fin-tech startups in Iran. Caution should be exercised when extending these findings to other regions and industries. Future research could explore comparative analyses across diverse contexts for broader insights. The reliance on questionnaires and interviews, while valuable, may introduce biases associated with self-reported data. Future studies might employ mixed-method approaches to enhance the comprehensiveness of our understanding of strategic cooperation dynamics. To deepen our understanding of strategic cooperation, future research should explore sectors beyond banking and fin-tech. Examining various industries can shed light on unique challenges and opportunities in different contexts. Given the dynamic nature of the banking and fin-tech sectors, conducting longitudinal studies is advisable. Continuous monitoring of industry trends, regulatory changes, and evolving collaboration models will help stay current with emerging challenges and opportunities. Future research should investigate additional dimensions impacting strategic cooperation, such as technological advancements, regulatory environments, cultural factors, and market dynamics, providing a more nuanced understanding of their influence on collaboration outcomes. Encouraging collaboration and knowledge exchange between researchers, industry practitioners, and policymakers can enrich future research efforts. Establishing partnerships and platforms for sharing best practices will deepen our understanding of the dynamics of strategic cooperation.

In conclusion, while this research provides valuable insights into strategic cooperation between the banking system and fin-tech startups, it is important to acknowledge its limitations. By addressing these limitations and considering the recommendations for future research, the field can advance, expand knowledge, and adapt to the evolving dynamics of the industry.

Conflict of interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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