Adv. Math. Fin. App., 2023, **8(**1), P. 287-303

Advances in Mathematical Finance & Applications
www.amfa.iau-arak.ac.ir
Print ISSN: 2538-5569
Online ISSN: 2645-4610
Doi: 10.22034/AMFA.2021.1933481.1610

Applied-Research Paper

An Integrated Hybrid Fuzzy Multiple-Criteria Decision-Making Model for Non-Performing Loans Collections in The Banking System (Case Study: Shahr Bank)

Majid Rashidi[a], Kiamars Fathi Hafshjani[b,*], Mahmoud Modiri[b], Seyedeh Mahboubeh Jafari[c]

[a]*Department of Industrial Management, Kish International Branch, Islamic Azad University, Kish Island, Iran*
[b]*Department of Industrial Management, South Tehran Branch, Islamic Azad University, Tehran, Iran*
[c]*Department of Accounting, South Tehran Branch, Islamic Azad University, Tehran, Iran*

ARTICLE INFO

Article history:
Received 2021-06-17
Accepted 2021-12-12

Keywords:
Bank
Non-performing loans
Fuzzy multiple-criteria decision-making

ABSTRACT

The increase in non-performing loans considerably reduces profit in the banking systems. To solve these problems, factors influencing the collection of non-performing loans have to be examined in a hopeful attempt to reduce them to an acceptable level. The present study is conducted to analyze and study factors influencing the collection of non-performing loans in Shahr Bank. This research is an applied study regarding its goal. It was conducted in two sections, namely the qualitative and quantitative sections. In the qualitative sections, the factors influencing the collection of receivables were identified using the theoretical literature and interviews with senior managers of Shahr Bank through the encoding process. In the quantitative section, data was collected by surveying the opinions of 12 experts, including senior managers of Shahr Bank in 2020 using a questionnaire. Thereafter, the factors were selected using the fuzzy Delphi technique and the relationships between them were determined using the fuzzy DEMATEL method. Finally, the factors were weighted and prioritized using the fuzzy ANP method. The research findings showed that non-performing loans can be collected through six types of factors including organizational, regulatory, customer, banking, environmental, and operational factors. The environmental factor is the most influential factor, while the operational factor is the most influential and important factor. In addition, behavioral, contextual, and structural sub-factors have the highest level of importance in the collection of non-performing loans in the order mentioned. These findings can help bank managers make decisions to improve the collection of receivables.

1 Introduction

The banking industry plays an important role in resource allocation, economic growth and development in each country [1,2]. The stability of the banking system is among the chief preconditions for the economic growth of every society because banks play a substantial role in the allocation of capital to individuals or organizations that are devoid of capital in the economic life of society [3]. Banks provide certain financial services to individuals and companies. They facilitate access to funds. In fact, banks play an important role in the financial stimulation, system stability, productivity, growth,

* Corresponding author. Tel.: +98912-535-8604
E-mail address: *fathi@azad.ac.ir*

and prosperity of the entire economy [4]. Banks grant loans to various plans for the elimination of poverty but due to the lack of repayment in such cases, the assets transform into non-performing loans (NPLs) (including overdue, non-performing, and bad loans). This reduces the return on assets of banks [5]. NPLs are formed for economic reasons such as external and internal bank factors, whereby the loans sometimes fail to fulfill their obligations to pay the loans [6]. Enterprises have been using the NPLs ratio as a performance index for a long time. There is a negative correlation between this ratio and the economic performance of banks [7]. Loans are an important indicator in evaluating the performance of banks [8].

An increase in the amount or ratio of non-performing loans has led to financial crises in developing and developed states. Evidence suggests that financial and banking crises in the Southeastern Asian countries have been caused by the increase in non-performing loans [9]. In general, the stiff competition among banks has increased bad loans and non-performing assets (non-current assets (NPA)), thereby imposing heavy pressure on banks and increasing their credit risk. According to the Central Bank's classifications, the non-performing loans of banks include overdue (overdue for two to six months), non-performing (overdue for six to eighteen months), and bad (overdue for over eighteen months) loans [10]. Mismanagement of assets and bank loans can also result in economic instability and even a state political crisis in countries. It may lead to unexpected losses and bankruptcy of banks [4]. Studies have revealed that the low quality of regulatory activities can considerably influence the growth of NPLs [11]. Besides, other studies have indicated that the loss inflicted by bad loans on banks is one of the main causes of the decreased efficiency [12] because costs exceed profits, thereby increasing the risk and undermining the stability of banks [13].

NPLs hinder interest returns, reduce investment openings, and create a liquidity crisis in the financial system, which leads to bankruptcy and weakness of the economic system. Therefore, identifying the factors influencing NPLs is essential for reducing the rate of NPLs for attaining financial stability and economic goals [14]. According to the World Bank statistics [15], the ratio of non-performing loans in June 2018 in Iran was 11.4%, and in 2017 it was 10%, and the lowest and highest rates in 2012 were 18.1%. However, according to documents and evidence, the average NPL ratio in the branches of Shahr Bank is 12%. In some branches, it has even reached 18 to 20%. According to the non-performing loan statistics, there has been an ascending trend in non-performing assets in the banking sector of Iran in recent years, which has increased the credit risk of banks. Although the banks' attempts to collect non-performing loans through legal means have been highly effective and a large fraction of these loans have turned into performing loans, the collection of loans is not satisfactory and the credit risk of banks is still high. Given the inflation rate of the economy and the decreased value of the Iranian currency, the high NPL ratio in the Iranian banks has reduced the profitability of banks. Hence, Shahr Bank is facing the challenge of improving the collection of its non-performing loans. The research questions are as follows.

1- What factors influence the collection of non-performing loans?

2- What is the relationship between the factors influencing the collection of non-performing loans in banks?

3- What is the weight and importance of the factors influencing the collection of non-performing loans?

In this study, the factors influencing the collection of non-performing loans were identified using the research theoretical literature and interviews with experts. Afterward, the relationships between the factors and the influencing and influenced areas were determined using the fuzzy DEMATEL

(Decision-Making Trial and Evaluation Laboratory) method. Finally, the weight and importance of factors were determined based on the fuzzy DEMATEL method using the fuzzy Analytical Network Process (ANP) technique. In this paper, the new hybrid multiple-criteria decision-making (MCDM) technique, which increases the accuracy of results, is used. The new hybrid technique, which uses fuzzy DEMATEL and Analytical Network Processes, is called the fuzzy ANP based on DEMATEL (F.DANP).

2 Backgrounds and Literature

Banks play an important role in universal economic development because their ability to stimulate savings and strengthen capital flows in the economy is vital to any economy. The financial intermediary function of banks in every economy motivates investments and increases productivity [16]. In the economic banking system, banks play a substantial role in the stability of the banking system and are known as the main source of financing because the capital markets of these countries are still emerging [14]. Lending seems to be fundamentally important for the banking industry because loans granted by banks are their main sources of income. In fact, it has been revealed that loans account for 50 to 75% of the bank's revenues, increasing the lending rate [16]. With the growth of loan credit, banking NPL problems appear in financial systems with structural flaws. When a high level of NPL affects a large number of banks, the normal performance of the financial system is undermined, and banks fail to allocate credit to the economy and are hit by a financial crisis [17] because a high level of NPLs directly affects the financial performance of all banks [14]. Almost throughout the entire economic crisis, research on the causes of financial, banking, and economic instability has garnered the attention of a considerable number of researchers, policymakers, and managers. One of the main characteristics of the banking system and an economic shock is the credit risk in the form of NPL [18]. Minsky's pioneering theory of financial crisis (1974), which is also known as the theory of financial instability, attempts to provide an understanding and explanation of the characteristics of a financial crisis. This theory suggests that at times of prosperity, when the liquidity flow of companies exceeds the liquidity required to pay the debts, an exploitative joy emerges and the debts quickly exceed the revenues, leading to a financial crisis [19]. An increase in NPLs is a common characteristic of financial crises and periods of financial stress. NPLs generally increases with an increase in credit [17].

There are various definitions of NPLs. The NPL refers to receivables with more than 3 unpaid installments [17]. This definition has been approved by regulatory policymakers such as the Basel II Committee or ECB Asset Quality Assessment committee [18]. Non-performing loans are harmful incidents that occur when the debtor is no longer able to pay their debt. With an increase in non-performing loans, the credit risk of banks increases [20] because bad debts harm the bank profit [21] and non-performing loans are considered the bank's economic activities [22]. Research findings indicated that non-performing loans lead to the bankruptcy of banks and negatively affect economic growth [23]. This is because when the NPL rate is high, the tendency to increase loans decreases and it is not possible to finance an economy [21]. According to a study by the International Monetary Fund (2015), countries whose banks have high levels of NPLs experience slow economic growth. In addition, companies that are more dependent on the financial activities of banks probably suffer from the decrease in bank loans more than other companies [22]. There is an extensive body of literature that examines the reasons and consequences of the NPL problem. In general, NPL can be attributed to bank characteristics and macroeconomics [24]. In macroeconomics, researchers refer to the effect of

macroeconomic variables, such as inflation, interest rates, and gross domestic product (GDP) on NPL [25]. NPL is strongly related to macroeconomic conditions [26]. During periods of recession and poor economic growth, companies and households probably face difficulties repaying their loans, which negatively influences the banks' balance sheets [17]. Besides, unemployment has a positive relationship with NPLs [25]. Of the macroeconomic factors, the trade cycle, inflation rate, interest rate, and exchange rate are among the important factors determining NPLs in the portfolios of banks [24]. In other cases, a high NPL rate could result from protracted low growth and structural imbalances in the banking sector [17]. At the macro level, unsatisfactory economic conditions, weakness of banking regulations and control, inadequate corporate governance, and weak incentives to control the market are the most important determinants of NPLs [26]. At the bank level, NPL accumulation can be explained by factors such as the bank's ownership structure, management quality, previous growth in the loan portfolio, and the bank's capital status [27]. Factors such as the capital ratio, risk management quality [25], return on equity, debt, net profit margin, the ratio of operating expenses to the operating income as a measure of inefficiency, and assets or market share are special banking factors that can affect NPLs [28]. Meanwhile, the financial aspects of local banks such as credit growth, capital, loan loss provision, profitability, net profit margin, efficiency, and size are among the important determinants of NPLs [24]. The national regulatory framework may affect the timely enforcement of loan agreement terms. Examples include the correct definition of non-performing loans that have to be defined in the internal accounting regulations or the low reported level of NPLs. Independent states or banks may overestimate or underestimate the reported level of NPLs, which may influence the ability of banks to grant loans and can increase financing costs [29]. Bank regulators are interested in playing a vital role in the banking industry, which can affect the regulatory function of managers and shareholders [30].

Many studies have highlighted the role of the legal and regulatory institutions of banks in the credit behavior of banks. These studies have stressed the role of corruption and its influence on NPLs but the risk of banks' loan regulations can be reduced by proper measures to supervise banks and establish powerful legal authorities. Besides, legal institutes can help banks in this regard [31]. Therefore, Campbell [32] argues that the first step in NPL management entails prevention and control. Having adequate legal permits is substantially important for bank supervisors to fulfill their obligations and be efficient. If a bank wants to achieve the desired result in the collection of NPLs, a number of factors have to coexist and be coordinated. For instance, the legal and regulatory infrastructure must set rules and regulations to facilitate the resolution of NPLs. In addition to the legal and regulatory infrastructure, regulatory authorities have to give stronger incentives to the banks to accelerate the collection of NPLs. Aside from the aforementioned factors, bank shareholders must meet the bank's planning objectives [22]. Adewusi et al. [33] have emphasized the credit evaluation and scoring models for granting loans. Scoring customers' credit is a process whereby banks identify loan applicants with the potential to default. Credit evaluation can be carried out through the subjective-judgmental evaluation of the credit personnel or through various statistical techniques (classification) that are known as credit scoring models. The research theoretical background is discussed in the following.

Kurdmanjiri et al. [34] identified the factors influencing the non-performing loans of banks using neural networks and the support vector machine algorithm. Their study results indicated that non-performing loans can be reduced by focusing on the financial, economic, auditory, and functional variables at the time of payment of loans. Ibrahimzadeh [35] studied the factors influencing the collection of overdue and non-performing loans of banks for the branches of Mehr Eghtesad Bank in the

west of Mazandaran Province. Data analysis with descriptive and inferential statistics showed that employing experienced employees and properly training them are the factors that were effective in collecting overdue and non-performing loans. Mahayi [36] studied the application of the Analytic Hierarchy Process (AHP) to the identification and ranking of factors influencing non-performing loans in Bank Melli of Mazandaran Province. The final results showed that the failure to employ specialized and efficient personnel, the lack of an evaluation system and personnel motivation and job security instruments, the low financial capacity of the recipients of loans, the lack of mastery of managers of most economic units over the management knowledge and relevant specialties, the instability of monetary policies and frequent variations of rules, and the lack of mastery of the market and competitors' conditions had the highest priorities in the order mentioned. Muhammadzadeh et al. [37] identified and prioritized the barriers to the collection of non-performing loans using a combination of the DEMATEL and Vlsekriterijumska Optimizacija I KOmpromisno Resenje (VIKOR) models. In this study, the barriers to the acquisition of a valid guarantee had the first priority while the inadequate information of the Central Bank had the second priority.

Khan et al. [14] studied the "determinants of non-performing loans in the banking sector in a developing country". The results of their studies showed that the operating efficiency and profitability indices were negatively linked to NPLs but were statistically significant. However, capital adequacy and income diversity had a negative relationship with NPLs but were statistically insignificant. Radivojević et al. [3] proposed an economic model for determinants of non-performing loans. Their findings indicated that the growth of economic activities was effective for the quality of bank assets but the inflation rate and microeconomic variables were not effective. Manz [18] studied the factors influencing the collection of non-performing loans using the structured review method. The results of this study showed that three main dimensions namely economy, bank characteristics, and loan characteristics influence the collection of non-performing loans. Ben Saada [38] studied the effect of quality control on the non-performing loans of the mentioned banks in Tunisia. The results indicated that the presence of foreign managers on the board of directors of the Bank of Tunisia along with knowledge, independence, technology transfer, and more control than institutional managers or state representatives influences the decrease in non-performing loans.

Table 1: Factors Influencing The Collection Of Non-Performing Loans Based On The Theoretical Literature

Factor	Reference
Personnel	[36] [35]
Motivational	[40]
Regulatory activities	[11]
Inflation	[26], [24]
Interest rate	[26], [24]
Economic growth and recession	[3][17][27]
Unemployment	[25]
Currency rate	[24]
Structural equilibrium	[17]
Banking regulations and control	[27][29][32][22]
Inadequate corporate governance	[27]
Poor motivations for supervision	[27]
Management quality	[25]
Financial indices	[28] [24]
Legal	[36] [31] [22]
Management	[22] [38]
Validation	[33] [37]

Kumar et al. [28] studied the "determinants of NPLs in a Fiji bank sector". They reported that macroeconomic/structural factors such as economic growth, inflation, currency fluctuations, unemployment, political instability, and foreign events such as the global financial crisis, return on equity, capital adequacy requirement, and market share based on assets are negatively linked to NPLs and are statistically significant with normal levels. Partovi and Matousek [39] carried out a study titled "banking productivity and performing loans: evidence from Turkey". The results showed that mismanagement in the banking sector affects performing loans. Mirpourian et al. [40] carried out a study titled "determinants of loan repayment performance among loanees of microfinance institutions: evidence from India" and concluded that motivational issues influence the likelihood of full or partial repayment of loans. Some of the factors influencing the collection of non-performing loans are listed in Table 1, which are included in the research theoretical literature. As suggested by the research background, multiple-criteria decision-making methods such as the hybrid ANP based on fuzzy DEMATEL have not been used in the collection of bank loans, while understanding the relationships between the factors of collection of bank non-performable loans and its improvement is highly important for managers' decision-making. Therefore, the innovation of our research is using a novel hybrid method for attaining better results, which has been overlooked in previous research.

DEMATEL is a comprehensive method for determining the causal relationship between complicated factors using diagrams [41] that make it possible to understand the mutual relationships between factors. The ANP method also obtains the weight of factors based on the mutual independence of the factors [42]. The ANP method prioritizes elements considering their independence and dependence. However, ANP has certain disadvantages. Since ANP needs pairwise comparison of the factors and the conformity of all pairwise comparison matrices has to be assessed, it leads to the deviation of the decision results and the increasing complexity and number of factors. By combining ANP with DEMATEL, the problem complexity can be reduced and the influence of factors on other factors can be identified. The DEMATEL method does not call for pairwise comparison of the elements, which considerably reduces the complexity of the decision-making operations [43]. The new hybrid DANP method (ANP based on DEMATEL) uses the weights and the influence of the DEMATEL method to convert to the prioritized ANP vectors [44]. Besides, for the expert's subjective judgments, which have ambiguities in a real situation, the fuzzy sets theory is used to control the ambiguity and inaccuracy of decision-making [41]. The new fuzzy hybrid DANP method has been used in financial and banking areas such as the selection of the competitive strategy in the European banking sector [42], financial modeling and improvement planning [45], financial evaluation [46], portfolio selection [47], and bank performance assessment [48], and the results of this method have been satisfactory.

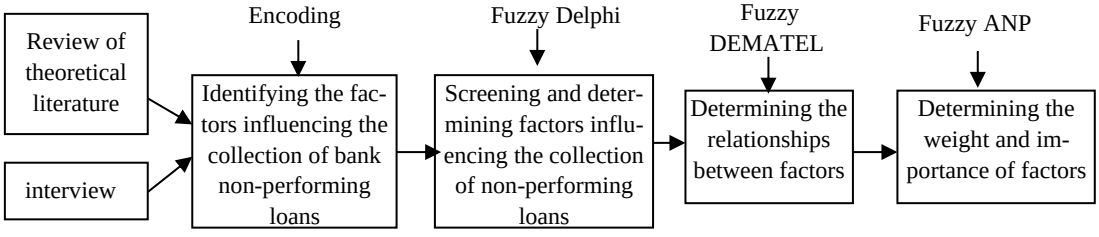

Fig. 1: Model flowchart

3 Research Method

The present study is applied descriptive-exploratory research because it develops the applied knowledge of the collection of non-performing loans of banks. The information collection method is the desk method and the data collection method is the field method with the interview and questionnaire tools. The research expert population included the senior managers and experts at Shahr Bank. A total of 12 experts with characteristics such as extensive experience, experience in collecting loans, and availability were selected. The expert samples were selected using the purposive sampling technique and the snowball sampling method. Figure 1 presents the process of the present study.

3.1 Fuzzy Decision-Making Trial and Evaluation Laboratory

DEMATEL is a suitable method for complicated structures as it studies the model of relationships between the determining parameters and presents a visual structural model as a cause and effect graph. The steps of this method are as follows [49]:

Step 1: create the matrix of direct fuzzy relationships by determining the effect of criterion i on j according to Table 2.

Table 2: Language Scales For Pairwise Comparisons [49].

Language words for pairwise comparisons		Fuzzy numbers
Extremely high influence	$\tilde{4}$	(0.75, 1, 1)
High influence	$\tilde{3}$	(0.5, 0.75, 1)
Low influence	$\tilde{2}$	(0.25, 0.5, 0.75)
Extremely low influence	$\tilde{1}$	(0, 0.25, 0.5)
No influence	0	(0, 0, 0.25)

Step 2: Normalization of the direct relationships matrix through (1) and (2).

$$\tilde{X} = K.\tilde{A} \tag{1}$$

$$k = min\left[\frac{1}{max_{1\le i\le n}\sum_{j=1}^{n}\tilde{A}_{ij}}, \frac{1}{max_{1\le i\le n}\sum_{i=1}^{n}\tilde{A}_{ij}}\right] \quad i,j = 1,2 \dots n \tag{2}$$

Step 3: Calculate the general relations matrix through (3).

$$\tilde{T} = \tilde{X}(I-\tilde{X})^{-1} \tag{3}$$

Step 4: Identifying vectors $\widetilde{D}$ and $\widetilde{R}$ through (4), (5) and (6).

$$\tilde{T} = [\tilde{t}_{ij}]n \times n, \qquad i,j = 1,2 \dots n \tag{4}$$

$$\widetilde{D} = \left[\sum_{j=1}^{n}\tilde{t}_{ij}\right] = [\tilde{t}_i]\, n \times 1 \tag{5}$$

$$\tilde{R} = \left[\sum_{i=1}^{n}\tilde{t}_{ij}\right] = [\tilde{t}_j]1 \times n \tag{6}$$

Step 5: calculating $(\widetilde{D}+\widetilde{R})$ and $(\widetilde{D}-\widetilde{R})$ and plotting the Influential Network Relationship Map (INRM) on the coordinate axis.

The following steps have to be taken based on the assumptions in this technique to identify the relationships between factors.

1. If a factor $(\widetilde{D}-\widetilde{R})<0$, then that factor is influenced.
2. If a factor $(\widetilde{D}-\widetilde{R})>0$, then that factor is influencing.

3.2 The fuzzy ANP based on DEMATEL

At this stage, the unbalanced supermatrix is obtained through the fuzzy DEMATEL general relations matrix by combining DEMATEL and ANP methods. The steps of this method are as follows [46]:

Step 1: First, matrix T is normalized based on (7):

$$T_C^{nor_{11}}=\begin{bmatrix} t_{C_{11}}^{11}/d_1^{11} & \cdots & t_{C_{1j}}^{11}/d_1^{11} & \cdots & t_{C_{1m_1}}^{11}/d_1^{11} \\ \vdots & & \vdots & & \vdots \\ t_{C_{i1}}^{11}/d_i^{11} & \cdots & t_{C_{ij}}^{11}/d_i^{11} & \cdots & t_{C_{im_1}}^{11}/d_i^{11} \\ \vdots & & \vdots & & \vdots \\ t_{C_{m_11}}^{11}/d_{m_1}^{11} & \cdots & t_{C_{m_1j}}^{11}/d_{m_1}^{11} & \cdots & t_{C_{m_1m_1}}^{11}/d_{m_1}^{11} \end{bmatrix} \tag{7}$$

$$d_i^{11}=\sum_{j=1}^{m_1} t_{c_{ij}}^{11},\ i=1,2,\ldots,m_1$$

Finally, the normalized general influence matrix is formed on (8).

$$\mathbf{T}_C^{nor}=\begin{bmatrix} T_C^{nor_{11}} & \cdots & T_C^{nor_{1j}} & \cdots & T_C^{nor_{1n}} \\ \vdots & & \vdots & & \vdots \\ T_C^{nor_{i1}} & \cdots & T_C^{nor_{ij}} & \cdots & T_C^{nor_{in}} \\ \vdots & & \vdots & & \vdots \\ T_C^{nor_{n1}} & \cdots & T_C^{nor_{nj}} & \cdots & T_C^{nor_{nn}} \end{bmatrix} \tag{8}$$

By calculating the transpose of the normalized overall influence matrix, the unbalanced supermatrix is obtained. The resulting matrix is linearly normalized based on (9) and (10), and then each element of this matrix is multiplied by all the entries of the corresponding block of that element in the unbalanced supermatrix.

$$\boldsymbol{W}=(\boldsymbol{T}_C^{nor})' \tag{9}$$

$$\boldsymbol{T}_D^{nor}=\begin{bmatrix} t_D^{11}/t_D^1 & \cdots & t_D^{1j}/t_D^1 & \cdots & t_D^{1m}/t_D^1 \\ \vdots & & \vdots & & \vdots \\ t_D^{i1}/t_D^i & \cdots & t_D^{ij}/t_D^i & \cdots & t_D^{im}/t_D^i \\ \vdots & & \vdots & & \vdots \\ t_D^{m1}/t_D^m & \cdots & t_D^{mj}/t_D^m & \cdots & t_D^{mm}/t_D^m \end{bmatrix}=\begin{bmatrix} t_D^{nor_{11}} & \cdots & t_D^{nor_{1j}} & \cdots & t_D^{nor_{1m}} \\ \vdots & & \vdots & & \vdots \\ t_D^{nor_{i1}} & \cdots & t_D^{nor_{ij}} & \cdots & t_D^{nor_{im}} \\ \vdots & & \vdots & & \vdots \\ t_D^{nor_{m1}} & \cdots & t_D^{nor_{mj}} & \cdots & t_D^{nor_{mm}} \end{bmatrix}$$

$$t_D^i = \sum_{j=1}^{m} t_D^{ij}$$

$$\boldsymbol{W}^w = \boldsymbol{T}_D^{nor}\boldsymbol{W} = \begin{bmatrix} t_D^{nor_{11}} \times \boldsymbol{W}^{11} & \cdots & t_D^{nor_{i1}} \times \boldsymbol{W}^{i1} & \cdots & t_D^{nor_{n1}} \times \boldsymbol{W}^{n1} \\ \vdots & & \vdots & & \vdots \\ t_D^{nor_{1j}} \times \boldsymbol{W}^{1j} & \cdots & t_D^{nor_{ij}} \times \boldsymbol{W}^{ij} & \cdots & t_D^{nor_{nj}} \times \boldsymbol{W}^{nj} \\ \vdots & & \vdots & & \vdots \\ t_D^{nor_{in}} \times \boldsymbol{W}^{1n} & \cdots & t_D^{nor_{in}} \times \boldsymbol{W}^{in} & \cdots & t_D^{nor_{nn}} \times \boldsymbol{W}^{nn} \end{bmatrix} \quad (10)$$

The resulting unbalanced supermatrix is raised to power until all elements converge based (11) and the weight of each element is calculated.

$$\lim_{h\to\infty} (\mathbf{W}^w)^h \quad (11)$$

4 Findings

To identify the factors influencing the collection of non-performing loans in Shahr Bank, first, experts were interviewed based on their theoretical background, and then the factors and sub-factors were identified and classified into various categories by encoding the interviews. Afterward, the fuzzy Delphi method was used to select and screen the factors and sub-factors. Experts expressed their opinions on the removal, integration, correction, and addition of factors in three rounds. Finally, 6 primary factors and 16 sub-factors influencing the collection of non-performing loans were selected as listed in Table 3.

Table 3: Factors And Sub-Factors Influencing The Collection Of Bank's Non-Performing Loans

Factors	sub-factors	code
Organizational factors C1	human rsources	C_{11}
	Managerial	C_{12}
	Legal	C_{13}
Regulatory factors C2	Technical	C_{21}
	Process	C_{22}
	Guarantee	C_{23}
Customer factors C3	Validation	C_{31}
	Needs assessment	C_{32}
Banking factors C4	Collaboration	C_{41}
	Database	C_{42}
Environmental factors C5	Market	C_{51}
	Political	C_{52}
	Economic	C_{53}
Operational factors C6	Structural	C_{61}
	Behavioural	C_{62}
	contextual	C_{63}

Afterward, the pairwise comparison questionnaire was designed and experts expressed their opinions about the influence of each factor on other factors according to Table 1. The expert opinions were converted into fuzzy numbers and were then summed. The matrix of the direct fuzzy relation-

ships was formed as presented in tables 4 and 5.

Table 4: Matrix Of Fuzzy Direct Relationships Of Factors.

	C1			C2			C3			C4			C5			C6		
	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U
C1	0	0	0	0.5	0.75	0.94	0.19	0.44	0.69	0	0.19	0.44	0.06	0.25	0.5	0.63	0.88	0.94
C2	0.13	0.25	0.5	0	0	0	0.06	0.31	0.56	0.06	0.19	0.44	0	0.13	0.38	0.5	0.75	0.88
C3	0.13	0.38	0.63	0.44	0.69	0.88	0	0	0	0.06	0.31	0.56	0.06	0.25	0.5	0.63	0.88	1
C4	0.13	0.38	0.63	0.44	0.69	0.94	0.31	0.56	0.81	0	0	0	0.5	0.75	0.94	0.06	0.31	0.56
C5	0.38	0.63	0.88	0.63	0.88	1	0.5	0.75	0.94	0.31	0.56	0.81	0	0	0	0.69	0.94	1
C6	0.06	0.19	0.44	0.13	0.31	0.56	0.13	0.25	0.5	0	0.13	0.38	0	0.06	0.31	0	0	0

Table 5: Matrix Of Fuzzy Direct Relationships Of Sub-Factors.

	C_{11}			C_{12}			$C_{...}$	C_{62}			C_{63}		
	L	M	U	L	M	U		L	M	U	L	M	U
C_{11}	0	0	0	0.29	0.54	0.7917	...	0.54	0.79	0.96	0.54	0.79	0.92
C_{12}	0.54	0.79	0.96	0	0	0	...	0.54	0.79	0.96	0.71	0.96	1
C_{13}	0.54	0.79	0.96	0.29	0.54	0.7917	...	0.71	0.96	1	0.71	0.96	1
C_{21}	0.08	0.29	0.54	0.29	0.54	0.7917		0.29	0.54	0.79	0.29	0.54	0.75
C_{22}	0.29	0.54	0.79	0.54	0.79	0.9583		0.08	0.29	0.54	0.08	0.29	0.5
C_{23}	0.54	0.79	0.96	0.54	0.79	0.9583	...	0.29	0.54	0.79	0.29	0.54	0.75
C_{31}	0.08	0.29	0.54	0.08	0.29	0.5417	...	0.54	0.79	0.96	0.71	0.96	1
C_{32}	0.08	0.29	0.54	0.08	0.29	0.5417	...	0.71	0.96	1	0.54	0.79	0.92
C_{41}	0.08	0.29	0.54	0.29	0.54	0.7917		0.71	0.96	1	0.54	0.79	0.92
C_{42}	0.08	0.29	0.54	0.54	0.79	0.9583		0.54	0.79	0.96	0.54	0.79	0.92
C_{51}	0.29	0.54	0.79	0.54	0.79	0.9583	...	0.54	0.79	0.96	0.71	0.96	1
C_{52}	0.29	0.54	0.79	0.54	0.79	0.9583	...	0.71	0.96	1	0.54	0.79	0.92
C_{53}	0.54	0.79	0.96	0.54	0.79	0.9583	...	0.71	0.96	1	0.71	0.96	1
C_{61}	0.29	0.54	0.79	0.08	0.29	0.5417	...	0.54	0.79	0.96	0.29	0.54	0.75
C_{62}	0.29	0.54	0.79	0.08	0.29	0.5417		0	0	0	0.29	0.54	0.75
C_{63}	0.08	0.29	0.54	0.08	0.29	0.5417		0.54	0.79	0.96	0	0	0

The fuzzy normalized matrix was obtained based on (1) and (2). Afterward, the general relationships matrix was calculated based on relation 3. In this matrix, the rate of influence ($\widetilde{D}$) of each factor was obtained based on the sum of the columns of the general relationships matrix (5) and the rate of influencing them ($\widetilde{R}$) was obtained from the sum of the rows of the general relationships matrix (6). Afterward, by summing ($\widetilde{D} + \widetilde{R}$) and subtracting ($\widetilde{D} - \widetilde{R}$), the degrees of interaction and intensity of the net influencing/influenced of each factor and sub-factors were obtained. These values are listed in Table 6.

Table 6: Values $\widetilde{\mathbf{D}}$, $\widetilde{\mathbf{R}}$, $\widetilde{\mathbf{D}} + \widetilde{\mathbf{R}}$, $\widetilde{\mathbf{D}} - \widetilde{\mathbf{R}}$.

Factors / sub-factors	$\widetilde{\mathbf{D}}$	$\widetilde{\mathbf{R}}$	$\widetilde{\mathbf{D}} + \widetilde{\mathbf{R}}$	$\widetilde{\mathbf{D}} - \widetilde{\mathbf{R}}$	Result
Organizational factors	1.272	1.075	2.347	0.197	Cause
human rsources	0.3759	0.3797	0.7556	-0.0038	effect
Managerial	0.422	0.3616	0.7836	0.0604	Cause
Legal	0.396	0.4526	0.8486	-0.0566	effect
Regulatory factors	0.952	1.638	2.59	-0.69	effect

Table 6: Values $\widetilde{D}$, $\widetilde{R}$, $\widetilde{D}+\widetilde{R}$, $\widetilde{D}-\widetilde{R}$.

Factors / sub-factors	$\widetilde{D}$	$\widetilde{R}$	$\widetilde{D}+\widetilde{R}$	$\widetilde{D}-\widetilde{R}$	Result
Technical	0.3954	0.3978	0.7932	-0.0024	effect
Process	0.3757	0.3949	0.7706	-0.0192	effect
Guarantee	0.4219	0.4003	0.8222	0.0216	Cause
Customer factors	1.286	1.258	2.544	0.028	Cause
Validation	0.2652	0.2501	0.5152	0.0151	Cause
Needs assessment	0.2389	0.254	0.4929	-0.0151	effect
Banking factors	1.495	0.886	2.381	0.61	Cause
Collaboration	0.2464	0.2215	0.4679	0.0249	Cause
Database	0.2451	0.27	0.5151	-0.0249	effect
Environmental factors	1.808	0.887	2.695	0.921	Cause
Market	0.4366	0.4488	0.8854	-0.0122	effect
Political	0.4337	0.4151	0.8488	0.0186	Cause
Economic	0.4465	0.453	0.8995	-0.0065	effect
Operational factors	0.725	1.794	2.519	-1.07	effect
Structural	0.3601	0.3172	0.6773	0.0429	Cause
Behavioural	0.3194	0.3686	0.688	-0.0492	effect
contextual	0.331	0.3248	0.6558	0.0062	Cause

Therefore, among the primary factors, "environmental factors" with a net influencing/influenced rate of 0.921 are the most influencing factors, while "operational factors" with a net influencing/influenced rate of 1.07 are the most influenced factors. In general, positive $\widetilde{R}$-$\widetilde{D}$, causal factors, and negative $\widetilde{R}$-$\widetilde{D}$ are considered influenced passive factors. Thereafter, the Network Relationships Map (NRM) was plotted based on data in Table 6, as shown in Figure 2.

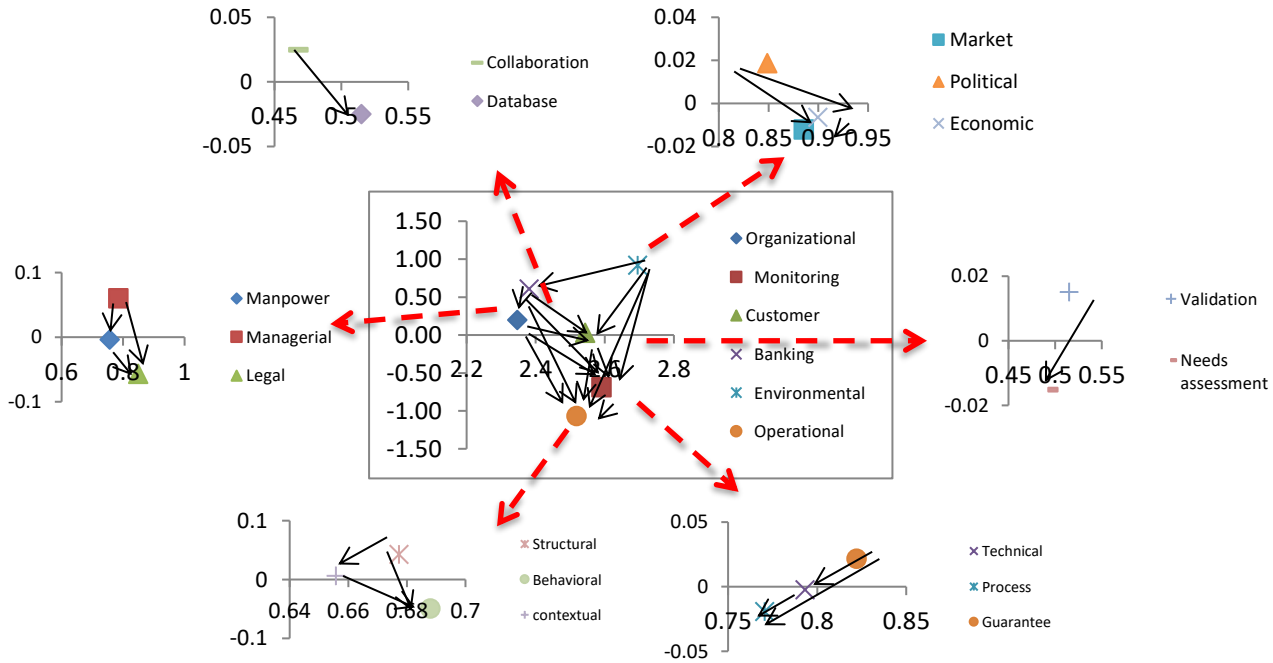

Fig. 2: The Cause and Effect Diagram And Network Relationships Map Of Factors And Sub-Factors Influencing The Collection Of Bank Non-Performing Loans.

Fig. 2 shows the relationships between the factors and sub-factors. Among the primary factors, environmental factors, banking factors, organizational factors and customer factors are causal factors that are linked to each other and influence the passive factors including regulatory factors and operational factors. The ANP method is used to determine the weight and importance of factors influencing the collection of loans. To solve the fuzzy analytical network process model, the fuzzy DEMATEL method is used. Therefore, first, the DEMATEL general relationships matrix was normalized based on (7). Thereafter, the fuzzy balanced supermatrix and matrix were obtained using (8) and (9). Following normalization, the balanced supermatrix converged by (10) to the power of 9 and the limited supermatrix was formed. Finally, after the acquisition of the limited supermatrix and defuzzification of this matrix, the weights of the factors and sub-factors were determined and the findings are listed in Table 7.

Table 7: The Weight And Importance Of Factors And Sub-Factors Influencing The Collection Of Bank Non-Performing Loans.

Weight and importance of the main factors	sub-factors	code	Local weight and importance of sub-factors		Global weight and importance of sub-factors	
Organizational (C1) 0.065 (6)	human resources	C11	0.2987	(3)	0.0195	(16)
	Managerial	C12	0.3083	(2)	0.0201	(15)
	Legal	C13	0.393	(1)	0.0257	(14)
Regulatory (C1) 0.275 (2)	Technical	C21	0.3268	(3)	0.0898	(6)
	Process	C22	0.3401	(1)	0.0934	(4)
	Guarantee	C23	0.3331	(2)	0.0915	(5)
Customer (C1) 0.161 (3)	Validation	C31	0.5161	(1)	0.0833	(7)
	Needs assessment	C32	0.4839	(2)	0.0781	(8)
Banking (C1) 0.077 (5)	Collaboration	C41	0.4408	(2)	0.0338	(10)
	Database	C42	0.5592	(1)	0.0429	(9)
Environment (C1) 0.091 (4)	Market	C51	0.3421	(2)	0.031	(12)
	Political	C52	0.3057	(3)	0.0277	(13)
	Economic	C53	0.3522	(1)	0.032	(11)
Operational (C1) 0.331 (1)	Structural	C61	0.3205	(3)	0.1061	(3)
	Behavioural	C62	0.3547	(1)	0.1174	(1)
	contextual	C63	0.3248	(2)	0.1075	(2)

According to the results in Table 7, among the primary factors, the “operational” factor with a weight of 0.331 has the highest level of importance on the strategic level. Thereafter, the “regulatory” the factor with a weight of 0.275 has the second importance and finally, the “organizational” factor with the lowest weight of 0.065 has the lowest importance. Among the sub-factors of collection of non-performing loans, the “behavioral” factor has the highest weight, which is 0.117, and the first importance. The “contextual” and “structural” factors with a weight of 0.108 and 0.106 have the second and third importance levels, respectively. Moreover, among the sub-factors of collection of bank non-performing loans, the “human resources” factor with a weight of 0.095 and the “management” factor with a weight of 0.201 have the lowest levels of importance.

5 Conclusion and Suggestions

In this study, to determine the factors influencing the collection of loans, the factors were extracted using the research theoretical background and interviews with experts, and the key points of the interviews were extracted through open coding, axial coding, and selective coding. Afterward, by obtain-

ing expert opinions, they were screened and confirmed. The ANP based on the DEMATEL technique was used to determine the relationships and assign weights to the factors. DEMATEL findings showed that environmental factors, banking factors, organizational factors, customer factors, regulatory factors, and operational factors influence the collection of loans in the order mentioned. The "environmental" factors have the greatest influence on the collection of loans. To improve the system of collecting non-performing loans in banks, managers must prioritize the improvement in "environmental" factors for decision-making. Environmental factors including political, economic and market factors are among the factors that can increase the collection of loans if they are improved. The "operational" factors are the most influential factors in collecting non-performing loans in the banking system. This finding indicates that "operational" factors are the major challenge and problem in the loan collection system and they have to be improved as soon as possible. It seems that the development of the structure and practical actions to monitor the collection of loans, the behaviors and methods of collection of loans for monitoring the loan collection employees, and methods of collection of loans influence the actions taken to collect loans. The weighting findings also indicated that "operational" factors have the first priority.

This result is the same as the DEMATEL result. As revealed by the DEMATEL result, this factor is the most influential factor and an issue in the collection of a bank's non-performing loans, which has to be prioritized for improvements. The "behavioral" sub-factors gained the highest importance for the collection of non-performing loans for Shahr Bank. This finding indicates that encouraging and motivating the non-performing loan collection personnel enables the employees to pursue the collection of non-performing loans more effectively. Moreover, the bank must take motivating measures for amnesties to collect the loans. Another suggestion is that monitoring and identifying the employees' behaviors for the collection of loans by their managers can increase supervision for employees' practical actions in the collection of loans. Besides, the "contextual" sub-factor gained the second priority in the collection of non-performing loans. The banks or loan collection companies are advised to cooperate and coordinate to pursue the non-performing loans. Besides, legal employees have to be employed in the loans collection department and planning has to be scheduled for them to improve their skills. The present study is in line with the findings from the study by Ebrahimzadeh [35]. Both studies stress the use of experienced personnel in the credit sector and the provision of proper training in the collection of overdue and non-performing loans.

The findings from Mahayi's research [36] are similar to our research because both studies stress the role of expertise and efficiency, tools for motivation and job security of personnel, stability of monetary policies, frequent changes of roles, and mastery of market conditions. Radivojević et al. [3] reported that the growth of economic activities was effective for the quality of bank assets but the inflation rate and microeconomic variables were not effective, which is almost similar to our research findings. Based on the findings from Ben Saada's [38] study, the presence of managers with knowledge, independence and control is effective in reducing non-performing loans, and a similar result was obtained in our study. Partovi and Matousek [39] showed in their study that mismanagement in the banking sector influences bank productivity and performing loans, and studies stress the role of management in the collection of loans and have similar findings. There were also limitations to the present study. Changes in the characteristics and conditions of experts may change the research findings. This study was conducted in 2020 in Shahr Bank as a private study. Therefore, the findings from this study have to be generalized with caution to other organizations and banks as well as to future decisions. Future researchers are also advised to conduct the present study in other banks and

compare the findings to gain an integrated understanding of the factors influencing the collection of loans.

6 Acknowledgment

The authors express their gratitude to the senior managers of Shahr Bank for their assistance in conducting this study.

References

[1] Khorramin, M., Talebnia, G., Ranjbar, M., Amiri, A., *Ranking the Efficiency and Soundness of Business Banks Using a Combined Method of Data Envelopment Analysis and Fuzzy VIKOR*, Advances in Mathematical Finance and Applications, 2021, **6**(3), P. 425-439. Doi: 10.22034/amfa.2020.1874697.1267.

[2] Balouei, E., Anvary Rostamy, A., Sadeghi Sharif, S., Saeedi, A., *The Impacts of Financial Structure on Financial Performance of Banks listed in Tehran Stock Exchange: An Empirical Application*, Advances in Mathematical Finance and Applications, 2018, **3**(3), P. 11-26. Doi: 10.22034/amfa.2018.544946.

[3] Radivojević, N., Cvijanović, D., Sekulic, D., Pavlovic, D., Jovic, S., Maksimović, G., *Econometric model of non-performing loans determinants*, Physica A: Statistical Mechanics and Its Applications, 2019, **520**, P. 481-488. Doi: 10.1016/j.physa.2019.01.015.

[4] Tarchouna, A., Jarraya, B., and Bouri, A., *Shadow prices of non-performing loans and the global financial crisis: Empirical evidence from US commercial banks*, Journal of Risk Finance, 2019, **20**(5), P. 411-434. Doi: 10.1108/JRF-03-2018-0030.

[5] Arora, N., Arora, N. G., Kanwar, K., *Non-performing assets and technical efficiency of Indian banks:a meta-frontier analysis*, Benchmarking: An International Journal, 2018, **25**(7), P. 2105-2125. Doi: 10.1108/BIJ-03-2017-0040.

[6] Jayaraman, T.K., Lee, C.-Y., Ng, C.-F., *The Causal Factors behind Rising Non-performing Assets of India's Commercial Banks: A Panel Study*, Advances in Pacific Basin Business, Economics and Finance (Advances in Pacific Basin Business, Economics and Finance, 2019, **7**, P.201-212. Doi:10.1108/S2514-465020190000007008.

[7] Lafuente, E., Vaillant, Y., Vendrell-Herrero, F., *Conformance and performance roles of bank boards: The connection between non-performing loans and non-performing directorships*, European Management Journal, 2019, **33**(1), P. 2–15. Doi: 10.1016/j.emj.2019.04.005.

[8] Esfandiar, M., Saremi, M., Jahangiri Nia, H., *Assessment of the efficiency of banks accepted in Tehran Stock Exchange using the data envelopment analysis technique*, Advances in Mathematical Finance and Applications, 2018, **3**(2), P: 1-11. Doi: 10.22034/amfa.2018.540815

[9] Mehrabian, A., Seifipour, R., *Pathology of current receivables in the Iranian banking system*, Financial Economics, 2016, **10**(136), P. 73-86. (In Persian)

[10] Sharifi, S., Haldar, A., Rao, S. V. D. N., *The relationship between credit risk management and non-performing assets of commercial banks in India*, Managerial Finance, 2019, **45**(3), P. 399-412. Doi: 10.1108/MF-06-2018-0259.

[11] Piatti, D., Cincinelli, P., *Does the threshold matter? The impact of the monitoring activity on non-performing loans*, Managerial Finance, 2019, **45**(2), P. 190-221. Doi: 10.1108/MF-02-2018-0077.

[12] Podpiera, J., Weill, L., *Bad luck or bad management? Emerging banking market experience*, Journal of Financial Stability, 2008, **4**(2), P. 135-148. Doi: 10.1016/j.jfs.2008.01.005

[13] AlKhouri, R., Arouri, H., *The effect of diversification on risk and return in banking sector: Evidence from the Gulf Cooperation Council countries*, International Journal of Managerial Finance, 2019, **15**(1), P. 100-128. Doi: 10.1108/IJMF-01-2018-0024.

[14] Khan, M.A., Siddique, A. and Sarwar, Z., *Determinants of non-performing loans in the banking sector in developing state*, Asian Journal of Accounting Research, 2020, **5**(1), P. 135-145. Doi: 10.1108/AJAR-10-2019-0080

[15] CEIC, 2019, https://www.ceicdata.com/en/indicator/iran/non-performing-loans-ratio. Updated on 28 Nov 2019.

[16] Oynaka, N. N., *Factors Affecting Non-Performing Loans in Commercial Banking Sector: A Comparative Study of Public and Private Banks a Case Study of Commercial Bank of Ethiopia and Dashen Bank District in Southern Region of Ethiopia*, Research Journal of Finance and Accounting, 2019, **10**(3), P.50-61. Doi: 10.7176/rjfa/10-3-07.

[17] Baudino, P., Yun, H., *Resolution of non-performing loans – policy options.* Bank for International Settlements. on policy implementation, FSI Insights, 2017, P. 5–35.

[18] Manz, F, *Determinants of non-performing loans: What do we know? A systematic review and avenues for future research*. Management Review Quarterly, 2019, **69**(1), P.389-401. Doi: 10.1007/s11301-019-00156-7.

[19] Barongo, W. M., *Factors Contributing to Nonperforming Loans in Non-Banking Institutions in Tanzania: A Case of National Security Fund*, M.A. thesis, The Open University of Tanzania, Tanzania, 2013.

[20] Barazzetti, A., Iorio, A. D., *Fintech: The Recovery Activity for Non-Performing Loans.* Information and Communication Technologies (ICT) in Economic Modelling, 2019, P. 117–128. Doi: 10.1007/978-3-030-22605-3-7.

[21] Argaw, S.A., *Factors Affecting Non-Performing Loans: In Case of Commercial Bank of Ethiopia*. M.A. thesis, Mekelle University, Ethiopia, 2016.

[22] Anastasiou, D., *Management and Resolution Methods of Non-Performing Loans: A Review of the Literature*. SSRN Electronic Journal, 2016, P. 1-28. Doi: 10.2139/ssrn.2825819.

[23] Yang, C. C., *Reduction of non-performing loans in the banking industry: an application of data envelopment analysis*. J Bus Econ Manag, 2017, **18**(5), P. 411-434 Doi: 10.3846/16111699.2017.1358209

[24] Arrina Rachman, R., Berenika Kadarusman, Y., Anggriono, K., Setiadi, R., *Bank-specific Factors Affecting Non-Performing Loans in Developing Countries: Case Study of Indonesia*. Journal of Asian Finance, Economics and Business, 2018, **5**(2), P. 833-851. Doi: 10.13106/jafeb.

[25] Arham, N., Salisi, M. S., Mohammed, R. U., Tuyon, J., *Impact of macroeconomic cyclical indicators and country governance on bank non-performing loans in Emerging Asia*, Eurasian Economic Review, 2020, **10**, P.

707–726. Doi: 10.1007/s40822-020-00156-z.

[26] Berti, K., Engelen, C., Vasicek, B., *A macroeconomic perspective on non-performing loans (NPLs)*, Quarterly Report on the Euro Area (QREA), 2017, **16**(1), P. 7–21.

[27] Amin, A. S., Imam, M. O., Malik, M., *Regulations, Governance, and Resolution of Non-Performing Loan: Evidence from an Emerging Economy*, Emerging Markets Finance and Trade, 2019, **55**(10), P. 2275-2297. Doi: 10.1080/1540496X.2018.1523788.

[28] Kumar, R. R., Stauvermann, P. J., Patel, A., Prasad, S. S., *Determinants of non-performing loans in banking sector in small developing island states: a study of Fiji*, Accounting Research Journal, 2018, **31**(2), P.192-213. Doi: 10.1108/ARJ-06-2015-0077.

[29] Olivares-Caminal, R., Miglionico, A., *Non-performing Loans: Challenges and Options for Banks and Corporations. In: Monokroussos P., Gortsos C. (eds) Non-Performing Loans and Resolving Private Sector Insolvency*, Palgrave Macmillan Studies in Banking and Financial Institutions, Palgrave Macmillan, Cham, 2017, P. 17-45. Doi: 10.1007/978-3-319-50313-4.

[30] Adegboye, A., Ojeka, S., Adegboye, K., *Corporate governance structure, Bank externalities and sensitivity of non-performing loans in Nigeria*, Cogent Economics and Finance, 2020, **8**(1), P.1816611. Doi: 10.1080/23322039.2020.1816611.

[31] Mohamad, A., Jenkins, H., *Corruption and banks' non-performing loans: empirical evidence from MENA countries*, Macroeconomics and Finance in Emerging Market Economies, 2021, **14**(3), P.1–14. Doi: 10.1080/17520843.2020.1842478.

[32] Campbell, A., *Bank insolvency and the problem of non-performing loans*. Journal of Banking Regulation, 2007, **9**(1), P. 25–45. Doi: 10.1057/palgrave.jbr.2350057.

[33] Adewusi, A. O., Oyedokun, T. B., Bello, M. O., *Application of artificial neural network to loan recovery prediction*, International Journal of Housing Markets and Analysis, 2016, **9**(2), P. 222–238. Doi: 10.1108/IJHMA-01-2015-0003.

[34] kordmanjiri, S., dadashi, I., Khoshnood, Z., gholamnia roshan, H., *Identifying Factors Affecting Non-curent Debts of Banks Using Neural Networks and Support Vector Machine Algorithm*. Economic Modeling, 2020, **14**(49), P. 127-151. (In Persian). Doi: 10.30495/ECO.2020.672520.

[35] Ebrahimzadeh, M., *Investigating the effective factors in collecting past due and overdue receivables of banks (Case study: Mehr Eghtesad Bank branches in the west of Mazandaran province)*, Quarterly Journal of New Banking Studies, 2009, **2**(2), P. 289-312. (In Persian).

[36] Mahaei, A., *Application of AHP in identifying and ranking the factors affecting overdue receivables in National Bank of Mazandaran province*. M.A. thesis, Amol Non-Profit Higher Education Institute, Amol, Iran, 2017 (In Persian).

[37] Mohammadzadeh, A., Ataei, M., Salimi, H., *Identifying and Prioritizing the Obstacles Leading to Bank Overdue, Using DEMATEL and VIKOR*, Journal of Development and Evolution Mnagement, 2014, **16**, P. 15-26. (In Persian).

[38] Ben Saada, M., *The impact of control quality on the non-performing loans of Tunisian listed banks*, Managerial Auditing Journal, 2018, **33**(1), P. 2–15. Doi: org/10.1108/MAJ-01-2017-1506.

[39] Partovi, E., Matousek, R., *Bank Efficiency and Non-Performing Loans: Evidence from Turkey*, Research in International Business and Finance, 2019, **48**, P. 287-309. Doi: 10.1016/j.ribaf.2018.12.011.

[40] Mirpourian, S., Caragliu, A., Di Maio, G., Landoni, P., & Rusinà, E., *Determinants of loan repayment performance among borrowers of microfinance institutions: Evidence from India*, World Development Perspectives, 2016, **1**, P. 49–52. Doi: 10.1016/j.wdp.2016.06.002.

[41] Sufiyan, M., Haleem, A., Khan, SH., Khan, M. I., *Evaluating food supply chain performance using hybrid fuzzy MCDM technique*, Sustainable Production and Consumption, 2019, **20**, P. 40–57.
Doi: 10.1016/j.spc.2019.03.004.

[42] Dinçer, H., Yüksel, S., Martínez, L., *Interval type 2-based hybrid fuzzy evaluation of financial services in E7 economies with DEMATEL-ANP and MOORA methods*, Applied Soft Computing, 2019, **79**, P. 186-202.
Doi: 10.1016/j.asoc.2019.03.018.

[43] Chen, Z., Ming, X., Zhang, X., Yin, D., Sun, Z., Chen, Z., Sun, Z., *A rough-fuzzy DEMATEL-ANP method for evaluating sustainable value requirement of product service system*, Journal of Cleaner Production, 2019, **228**, P. 485-508. Doi: 10.1016/j.jclepro.2019.04.145.

[44] Lin, S.-H., Zhao, X., Wu, J., Liang, F., Li, J.-H., Lai, R.-J., Tzeng, G.-H., *An evaluation framework for developing green infrastructure by using a new hybrid multiple attribute decision-making model for promoting environmental* sustainability, Socio-Economic Planning Sciences, 2020, **75**, P.100909.
Doi: 10.1016/j.seps.2020.100909.

[45] Shen, K.-Y., Hu, S.-K., Tzeng, G.-H., *Financial modeling and improvement planning for the life insurance industry by using a rough knowledge based hybrid MCDM model*, Information Sciences, 2017, **375**, P. 296–313.
Doi: 10.1016/j.ins.2016.09.055.

[46] Shen, K.-Y., Tzeng, G.-H., *A new approach and insightful financial diagnoses for the IT industry based on a hybrid MADM model*, Knowledge-Based Systems, 2015, **85**, P. 112–130.
Doi: 10.1016/j.knosys.2015.04.024.

[47] Shen, K.-Y., Yan, M.-R., Tzeng, G.-H., *Combining VIKOR-DANP model for glamor stock selection and stock performance improvement*, Knowledge-Based Systems, 2014, **58**, P. 86–97.
Doi: 10.1016/j.knosys.2013.07.023.

[48] Wu, H.-Y., Tzeng, G.-H., Chen, Y.-H., *A fuzzy MCDM approach for evaluating banking performance based on Balanced Scorecard*, Expert Systems with Applications, 2009, **36**(6), P. 10135–10147.
Doi: 10.1016/j.eswa.2009.01.005.

[49] Hu, S., Lu, M.-T., Tzeng, G.-H., *Improving Mobile Commerce Adoption Using a New Hybrid Fuzzy MADM Model*, International Journal of Fuzzy Systems, 2015, **17**(3), P. 399–413. Doi: 10.1007/s40815-015-0054-z.