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Efficiency analysis of Tose'e Ta'avon Bank branches of Iran in 5 years considering undesirable outputs-A DEA based approach

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Abstract

In order to survive and compete with other financial institutions, banks, and financial institutions are required always to evaluate the efficiency of their branches. In this paper, we evaluate and analyze the efficiency of bank branches in the five last years (from 2018 to 2022). To calculate and present the branch efficiency score, we have considered an undesirable component called Nonperforming Loans (NPL) as an undesirable output in evaluating the efficiency of Tose'e Ta'avon Bank branches. Due to the high inflation in Iran, the increase in the NPL of loans causes a decrease in the banks' deposits and profitability, and ultimately, it causes a considerable decrease in inefficiency. In addition, in extreme cases, it may even cause the bank to go bankrupt. Therefore, to calculate the efficiency of the Tose'e Ta'avon Bank branches using the data envelopment analysis method, we have considered operating costs and non-operating costs as two inputs, total deposits, total loans, and also two categories of revenue (Revenue from Jointly Funded Assets and Fee-based incomes as four desirable outputs and based on Islamic banking methods with Nonperforming loans as an undesirable output. In this paper, to deal with undesirable output issues, we use a direct approach that is more suitable to deal with NPLs since it is more convenient and evident to incorporate undesirable outputs directly into the DEA model. We used the dynamic cross-efficiency technique of DEA with undesirable outputs (DEA-UO) to obtain the efficiency of the branches over five years.

Keywords: Efficiency analysis, Tose'e Ta'avon Bank, DEA based approach.

Introduction

To survive in today's competitive environment, organizations must continuously evaluate and monitor their performance and that of their members. A complete evaluation of the performance and the efficiency of the organization can open the way and provide a roadmap for future developments; on the other hand, without having a proper evaluation, organizations with everyday risk, lack of progress, and even backwardness eventually fall (Park et al., 2015; Zakaria, 2023). Financial institutions, like other organizations, need a continuous evaluation of the performance and efficiency of their units. One of these economic and financial institutions is the bank. Pressures and competition caused by the world, with the significant and increasing growth of non-bank financial and credit institutions in the past years, have forced the banks to put continuous performance evaluation of their branches on the agenda for survival and competition. Each bank should be aware of its effectiveness yearly by doing research and evaluating its performance and should deal with it and think of different solutions for the existing challenges and shortcomings.

Due to the importance of Evaluating and monitoring the performance of organizations and individuals, many types of research have been done in this field in recent years. The researchers have looked at the evaluations from each angle and have presented different models and methods for this purpose. One of these performance measurement tools is data envelopment analysis. In 1978, Charnes et al. (Charnes et al. 1978) presented a nonparametric method for calculating the efficiency of homogeneous units with similar inputs and outputs, which they named data envelopment analysis. This quantitative and standard method became one of the powerful management tools that are widely used in efficiency measurement studies and performance analysis. With the progress and evolution of this method, data envelopment analysis has become one of the active research fields in performance measurement nowadays and has been significantly welcomed by researchers worldwide (Milenković et al., 2022). Data envelopment analysis measures the relative efficiency of units that have similar inputs and outputs compared to each other. Such units are called decision-making units. Therefore, the efficiency score of DMU will be relative. Evaluating and comparing the performance and efficiency of similar units is an important part of managing a complex organization. In this theory, a company or organization or a DMU is considered a production system that consumes deposits of banks (inputs) to create products (outputs).

One of the important issues in the banking industry is the existence of undesirable variables such as bank nonperforming loans (NPL), which is considered an undesirable output in the data envelopment analysis literature. This is different from the usual process of data envelopment analysis, which aims to reduce inputs and increase output to improve the efficiency scores of DMUs. In the real world, some organizations also have undesirable outputs that a manager does not want to increase, such as pollutants such as CO_2 in industry or taxes in an economic enterprise. This means that sometimes the disadvantages of increasing all outputs are greater than reducing the production and consumption of input deposits of the bank, and in such situations, managers are more likely to seek the reduction of undesirable outputs. In facing undesirable outputs, some researchers prefer not to consider the undesirable output at all in the calculation of efficiency. In this case, the obtained efficiency score will have little validity. However, at the same time, many researchers have included this problem in data envelopment analysis models in calculating the efficiency of units that have an undesirable output. There are usually two approaches for the treatment of undesirable outputs that are classified (Scheel, 2001) as direct and indirect approaches. In indirect approaches, the values of the undesirable outputs are transformed by a monotone decreasing function f so that after the transformation, the undesirable outputs become desirable. However, direct approaches avoid data transformation and incorporate the undesirable outputs directly into the DEA model. For the first time, the modeling of data envelopment analysis with undesirable outputs was done by(Färe et al., 1989). Several researchers have developed different models of data envelopment analysis with undesirable outputs some of them are (Seiford & Zhu, 2002), (Färe & Grosskopf, 2004), (Korhonen & Luptacik, 2004), (Jahanshahloo et al., 2005), (Amirteimoori et al., 2006), (P. et al., 2007), (Mandal, 2010),(Mahlberg & Sahoo, 2011), (P. et al., 2012), (Leleu, 2013), (Khoshroo et al., 2018). (Tone, 2004) we have presented a method called the slacks-based measure (SBM) approach, which deals with the undesirable outputs through the slacks of undesirable outputs (Bozorgi et al., 2023).

In this article, we intend to measure the efficiency of Tose'e Ta'avon Bank branches using the DEA method with desirable and undesirable outputs over five years (from 2018 to 2022). The considered model for solving this problem is the input-oriented DEA model based on undesirable outputs and time dependency (Amin & Boamah, 2023). The time-dependent mode of the model means that the efficiency score of a particular branch of the bank in a given year is evaluated in comparison to all of the other branches of the bank during all of the years under review. In this regard, knowing the standards and indicators of efficiency and performance, as well as the collection of data and information, is required for a comprehensive evaluation. While introducing efficient branches, we will present a comprehensive rating and measurement for the efficiency of bank branches (Shabani &Akbarpour, 2024).

What differentiates this article from all of those before it is the fact that this article investigates the efficiency of a bank's branches over several years, with the existence of undesirable output, to consider the NPL index while using time-dependent data envelopment analysis, besides the inputs and outputs that we have considered to evaluate the efficiency of the bank branches, and Last but not least, the final analysis of the article is using indicators of statistical science for its purpose (Amirteimoori et al, 2023).

We measured the efficiency of bank branches in terms of cost efficiency, revenue efficiency, profit efficiency, and profitability while considering undesirable outputs. Additionally, our paper mathematically extends the efficiency measurement models by incorporating both weak and managerial disposability concepts (Bisogno & Donatella, 2021).

They measured the efficiency of stages of bank branches and obtained the efficiency trend of stages during the time, then to estimate their efficiency in the future; therefore, they can be aware of stages inefficiency before occurrence and prevent them (Bozorgi et al., 2023).

Our paper consists of four sections. The first section provides a brief overview of the research problem. Section 2 reviews the articles that have been published so far concerning our research. Section 3 shows the methodology and the model that was used in our research. Section 4 shows the data of the bank branches in the results of the DEA analysis. Section 5 presents the general results of the paper and includes suggestions for future works.

Literature Review

In the field of evaluating the efficiency of banks, many researchers are using a variety of DEA methods that have already been done. If we divide the articles that are used to evaluate the efficiency of banks using the data envelopment analysis method into two categories, The first category is the articles in which the inputs and outputs of each unit are all desirable for evaluating the efficiency of the banks, and the second category is the articles that in evaluating the efficiency of the banks, in addition to desirable inputs and outputs, there are also undesirable outputs considered (Yang, 2021). For the first category articles, we can refer to (Paradi & Schaffnit, 2004), who evaluated the performance of the branches of a large Canadian bank business by using the DEA method. They used two input-oriented and output-oriented models for cost management and profit analysis of the bank branches, respectively. (Portela & Thanassoulis, 2007) they have used the profit efficiency and technical efficiency model of data envelopment analysis to evaluate branches of a Poland bank in terms of their performance in three different areas, including their efficiency in strengthening the use of new trading channels, their efficiency in increasing sales and customer base, and their productivity in their paid interest. (Ariff & Luc, 2008) we have evaluated the performance of Chinese banks with the technical DEA method and second-stage regression. (Liu, Lin, & Fang, 2009)] Moreover, (Staub, e Souza, & Tabak, 2010) used the technical DEA method to measure the efficiency of a bank in Taiwan and to evaluate the economic, technical, and resource allocation efficiency of Brazilian banks in comparison with other banks in Europe and America in 2000 and 2007 respectively. Fukuyama and Matousek (2017) used a two-stage DEA model to evaluate the efficiency of banks in Japan over 13 years. (Kamarudin et al., 2019) used the CCR model of DEA to evaluate the efficiency of the Islamic banking sector in Malaysia from 2006 to 2015, and they also used panel regression to study the determinants of efficiency in banks. (Tavana et al. 2018) in research presented a game-based framework based on a two-stage fuzzy data envelopment analysis by using a bargaining game model.

If we divide the second category of articles into two groups, the first group is the articles that use the classical DEA method. As examples, we can refer to (Subramanyam & Reddy, 2008), which used data envelopment analysis models to identify and asses risk in Indian commercial banks. (Puri & Yadav, 2014) presented a fuzzy DEA model with undesirable fuzzy outputs and a cross-efficiency technique that is applied to increase the discrimination power of the proposed models and to rank the efficient DMUs. Moreover, they presented an application to the banking sector in India. (L. Zhou & Zhu, 2017) investigated the efficiency of 12 Chinese commercial banks from 2005 to 2013 under the consideration of undesirable outputs using the super-SBM DEA model. Furthermore, the second group of the articles uses the network DEA method. As examples, we are referring to (An et al., 2015), who presented a new two-stage data envelopment analysis approach with undesirable output for measuring the slacks-based efficiency of Chinese commercial banks during the years 2008–2012. Also, (Wijesiri et al., 2019) measured the social and financial performance of a sample of 26 Indian public sector banks during 2011-2014 using an innovative multi-activity data envelopment analysis (MDEA) model with common inputs and undesirable outputs. (Shi, Emrouznejad, & Yu, 2021) proposed a new slacks-based measure network data envelopment analysis (SBM-NDEA) model with undesirable outputs to evaluate the performance of production processes that have complex structures containing both series and parallel processes and evaluated Chinese commercial banks during 2012–2016 (Chen, 2024). (Omrani, et al., 2022) proposed a mixed integer network DEA (MI-NDEA) with common inputs and undesirable outputs to evaluate the efficiency of decision-making units and evaluate the "overall" performance of a set of bank branches.

Research theory and design

In the banking industry, what is more suitable is using the direct approach of the DEA method with undesirable outputs. In subsection 1.3, we discuss the theory that we want to use to obtain the efficiency of the units as well as the ranking of the efficient units in the presence of undesirable outputs presented by (Puri & Yadav, 2014). They used the cross-efficiency technique of DEA with undesirable outputs (DEA-UO). In subsection 2.3, we explain how to match the components of the problem while using the theoretical model.

1. Research Theory

Suppose there are n DMUs in which each DMU_j $(j = 1, \dots, n)$ at time t (t=1,…, T) consumes m non-negative inputs $x_{ij}(t)$ $(i = 1, \dots, m)$ and products s non-negative outputs that s outputs divide into s_1 desirable (good) outputs $y_{rj}^{g}(t)(r=1,\dots,s_1)$ and s_2 undesirable (bad) outputs $y_{kj}^{b}(t)(k=1,\dots,s_2)$, that is $s=s_1+s_2$. We want to calculate the efficiency score of each DMU at time period T. Then the CCR efficiency of each DMU at the time t_o in the time period T can be measured by the following Time-dependent multiplier model (1):

$$\max\ E_o(t_o)=\sum_{r=1}^{s_1}u_{ro}^{g}y_{ro}^{g}(t_o)-\sum_{k=1}^{s_2}u_{ko}^{b}y_{ko}^{b}(t_o)$$

s.t

$$\sum_{i=1}^{m}v_{io}x_{io}(t_o)=1 \tag{1}$$

$$\sum_{r=1}^{s_1}u_{ro}^{g}y_{rj}^{g}(t)-\sum_{k=1}^{s_2}u_{ko}^{b}y_{kj}^{b}(t)-\sum_{i=1}^{m}v_{io}x_{ij}(t)\le 0\quad (j=1,\dots,n)(t=1,\dots,T)$$

$$\sum_{r=1}^{s_1}u_{ro}^{g}y_{rj}^{g}(t)-\sum_{k=1}^{s_2}u_{ko}^{b}y_{kj}^{b}(t)\ge 0\ \ (j=1,\dots,n)(t=1,\dots,T)$$

$$u_{ro}^{g},u_{ko}^{b},v_{io}\ge\varepsilon\ \ (r=1,\dots,s_1)(k=1,\dots,s_2)\ (i=1,\dots,m)$$

$$\varepsilon\ge 0$$

Where

$E_o(t_o)$: Efficiency score of DMU_o in the year t_o

u_{ro}^{g}: The weights of the rth desirable output of DMU_o

u_{ko}^{b} : The weights of the kth undesirable output of DMU_o

v_{io}: The weights of the ith input of DMU_o

ε : The non-Archimedean infinitesimal.

In this case, to obtain the efficiency score of each unit, the unit in question is not only compared with all units at the same time but also compared with the efficiency of other units in the entire period.

Definition 1. DMU_o is said to be efficient if $E_o^{*}(t_o)=1$; otherwise, it is said to be inefficient.

Remark: For o=1,…,n and $t_o=2018,\dots,2022,\ 0\le E_o(t_o)\le 1$.

2. Research design

In this section, we describe how to use the method DEA to obtain the efficiency score of the branches. Since Tose'e Ta'avon Bank has 396 branches in Iran, therefore, we consider the number of DMUs to be 396. Considering that in Iran, plans and strategies are considered for five years, therefore, we want to examine the bank's performance during five years, i.e., from 2018 to 2022. So that we can plan more precisely for the next 5-year period according to the performance of the bank branches.

On the contrary, most of the articles consider administrative and personnel costs as bank inputs; in this research, instead of using administrative and personnel costs, two categories of costs have been considered as inputs that contain:

1. Operating costs are related to branch operation costs in equipping deposits and some other items that we consider of each branch (DMU) at time t as the first input ($x_1(\text{t})$) .

2. Non-operating costs, most of which are related to administrative and personnel costs (cost of location and cost of administrative requirements), we consider each branch (DMU) at time t as the second input ($x_2(t)$).

Also, in this research, five categories of cases have been considered as outputs. Because deposits (first output (y_1^g) and loans (second output (y_2^g)) have more impact on the basic strategic programs of Tose'e Ta'avon Bank, then we used two categories of revenue (Revenue from Jointly Funded Assets (third output (y_3^g)) and Fee-based income (fourth output (y_4^g))) based on Islamic banking with Nonperforming loans as undesirable output ($y_{kj}^b(t)$).

Considering that Iran's economic system is bank-centric. In Iran's banking system, over 80% of revenue is generated at the point of payment by institutions. Therefore, the NPL ratio is more important than the NPA because it is related to the sum of loans directly. So, we consider non-current loans (including deferred, doubtful, and overdue) as the undesirable output that at time t is ($y_1^b(t)$) of each branch. Considering that we want to get the efficiency of bank branches during the last 5-year planning, then our model will be time-dependent. That is, the efficiency of each branch in a specific year is obtained in comparison with other branches during a 5-year period. Therefore, the CCR model will be as follows:

$$\max\ E_o(t_o) = \sum_{r=1}^{4} u_{ro}^g y_{ro}^g\,(t_o) - u_{ko}^b y_{ko}^b(t_o)$$

s.t

$$\sum_{i=1}^{2} v_{io} x_{io}(t_o) = 1 \tag{2}$$

$$\sum_{r=1}^{4} u_{ro}^{g} y_{rj}^{g}(t) - u_{ko}^{b} y_{kj}^{b}(t) - \sum_{i=1}^{2} v_{io} x_{ij}(t) \leq 0 \quad (j = 1, \dots, n)(t = 2018, 2019 \dots, 2022)$$

$$\sum_{r=1}^{4} u_{ro}^{g} y_{rj}^{g}(t) - u_{ko}^{b} y_{kj}^{b}(t) \geq 0 \ \ (j = 1, \dots, n)(t = 2018, 2019 \dots, 2022)$$

$$u_{ro}^{g}, u_{ko}^{b}, v_{io} \geq \varepsilon \ \ (r = 1, \dots, s_1)(k = 1, \dots, s_2)\ (i = 1, \dots, m)$$

Results

The Tose'e Ta'avon Bank is one of the government banks of Iran that was established on August 15, 2009, with an initial capital of 500 billion Tomans. Job creation, focusing on providing loans to cooperatives, and strengthening this sector were some of the main approaches of this bank. Tose'e Ta'avon Bank, with having a structure unlike other banks, focuses its services on cooperatives. Regularity emphasizes the need to strengthen and support youth in the form of cooperative activities, and it is hoped that the Tose'e Ta'avon Bank will remove the obstacles to providing loans to cooperatives. Currently, this bank continues to operate with various branches, and it has thousands of employees. Iran has 31 provinces. In this article, we also perform some of the analyses on a provincial basis.

Since one of the important issues in the banking industry is the existence of undesirable variables such as non-current bank loans, which have a great impact on the inefficiency of banks due to inflation in Iran, for evaluating the efficiency of branches of Tose'e Ta'avon Bank, we have examined the efficiency of the banks in the presence of undesirable outputs (NPLs). A summary of descriptive statistics and inputs and outputs data from 2018 to 2022, along with the average, maximum, and minimum indicators for each year, is shown in Table (1). Based on the data and related information, graphs of number (1) have been drawn. What we have found out is the degree of conformity of the average performance of the mentioned years with the number of deposits and total resources and other indicators.$P_{31.}$

Table 1. Summary of descriptive statistics and inputs

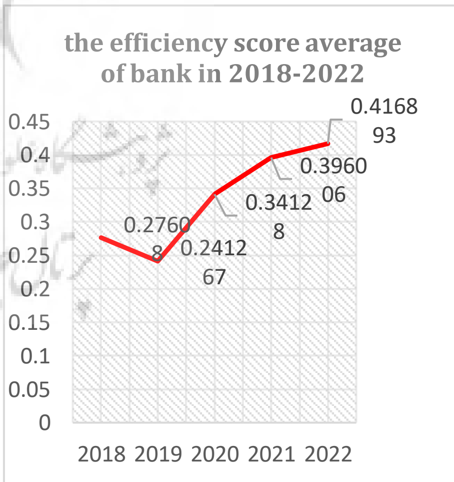
Year	2018	2019

Variable	Mean	Minimum	Maximum	Mean	Minimum	Maximum
deposits	281,999	32,351	2,349,738	254,022	37,014	5,136,609
loans	192,969	25,570	3,067,463	275,114	39,747	5,392,342
Fee-based income	4,173	197	144,120	5,705	229	323,863
Revenue from Jointly Funded	24,380	3,830	464,470	29,295	110	534,323
Non-operating costs	9,528	3,302	44,518	9,988	3,733	65,581
Operating costs	19,749	1,360	2,968,371	18,917	1,660	1,427,668
Nonperforming loans	12,402	24	136,352	15,191	5	231,483

Year	2020			2021			2022		
Variable	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
deposits	347,241	48,227	4,341,390	587,172	94,006	5,806,992	766,357	145,593	11,465,451
loans	437,684	68,572	7,170,896	658,527	85,195	10,419,914	880,373	89,163	10,119,783
Fee-based income	9,871	498	1,032,725	12,313	750	869,033	18,449	1,506	852,698
Revenue from Jointly Funded	39,015	870	710,458	69,080	7,127	2,231,736	87,760	7,731	1,531,507
Non-operating costs	14,960	4,855	165,375	24,288	8,477	323,336	23,502	8,793	195,283
Operating costs	19,009	893	1,856,851	29,128	1,159	4,440,147	46,899	1,612	6,798,207
Nonperforming loans	17,335	117	391,137	22,981	155	917,943	26,165	1	573,150

Year	2018			2019			2020			2021			2022		
Variable	Mea	Mini	Maxi	Mea	Mini	Maxi	Mea	Mini	Maxi	Mea	Mini	Maxim	Mea	Mini	Maxim

	n	mum	mum	n	mum	mum	n	mum	mum	n	mum	um	n	mum	um
deposits	281,999	32,351	2,349,738	254,022	37,014	5,136,609	347,241	48,227	4,341,390	587,172	94,006	5,806,992	766,357	145,593	11,465,451
loans	192,969	25,570	3,067,463	275,114	39,747	5,392,342	437,684	68,572	7,170,896	658,527	85,195	10,419,914	880,373	89,163	10,119,783
Fee-based income	4,173	197	144,120	5,705	229	323,863	9,871	498	1,032,725	12,313	750	869,033	18,449	1,506	852,698
Revenue from Jointly Funded	24,380	3,830	464,470	29,295	110	534,323	39,015	870	710,458	69,080	7,127	2,231,736	87,760	7,731	1,531,507
Non-operating costs	9,528	3,302	44,518	9,988	3,733	65,581	14,960	4,855	165,375	24,288	8,477	323,336	23,502	8,793	195,283
Operating costs	19,749	1,360	2,968,371	18,917	1,660	1,427,668	19,009	893	1,856,851	29,128	1,159	4,440,147	46,899	1,612	6,798,207
Nonperforming loans	12,402	24	136,352	15,191	5	231,483	17,335	117	391,137	22,981	155	917,943	26,165	1	573,150



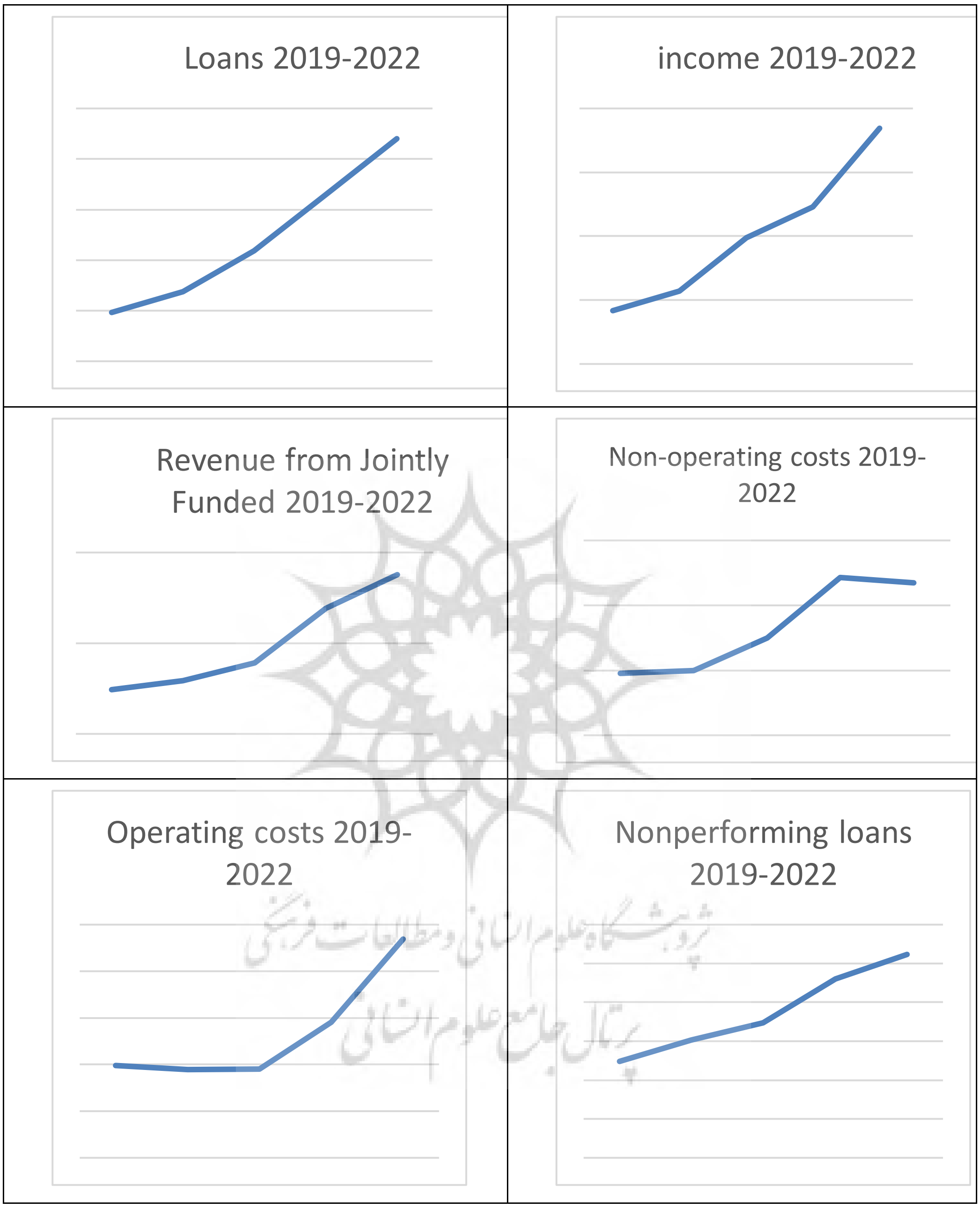


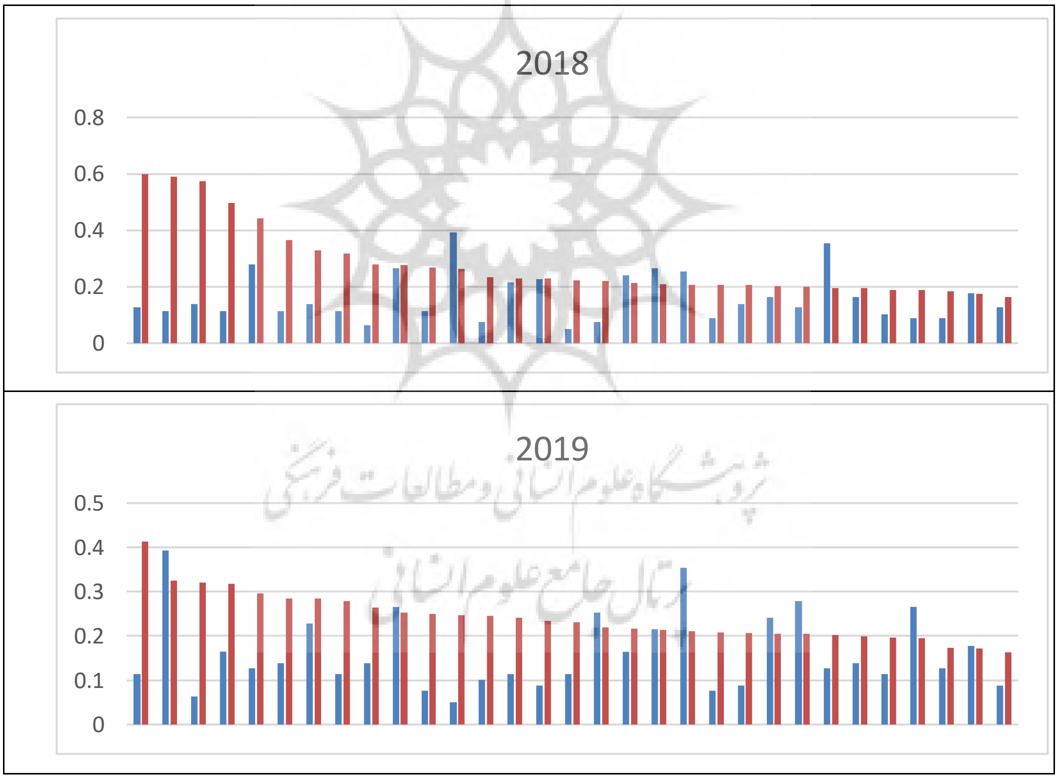
Fig. 1. Relationship between the number of branches

Figure 1 shows the quantitative relationship between the number of branches and the efficiency status of the provinces. Provinces with fewer branches are generally more efficient. This incident has been repeated in different years, and it indicates better management in provinces with fewer branches. According to Table 2, the correlation between the number of branches and efficiency in the provinces is always negative.

Correlations

Table 2. The correlation between the number of branches and efficiency in the 31 provinces

	Num Branches
Efficiency 2018	-0.090
Efficiency 2019	-0.021
Efficiency 2020	-0.201
Efficiency 2021	-0.321
Efficiency 2022	-0.285



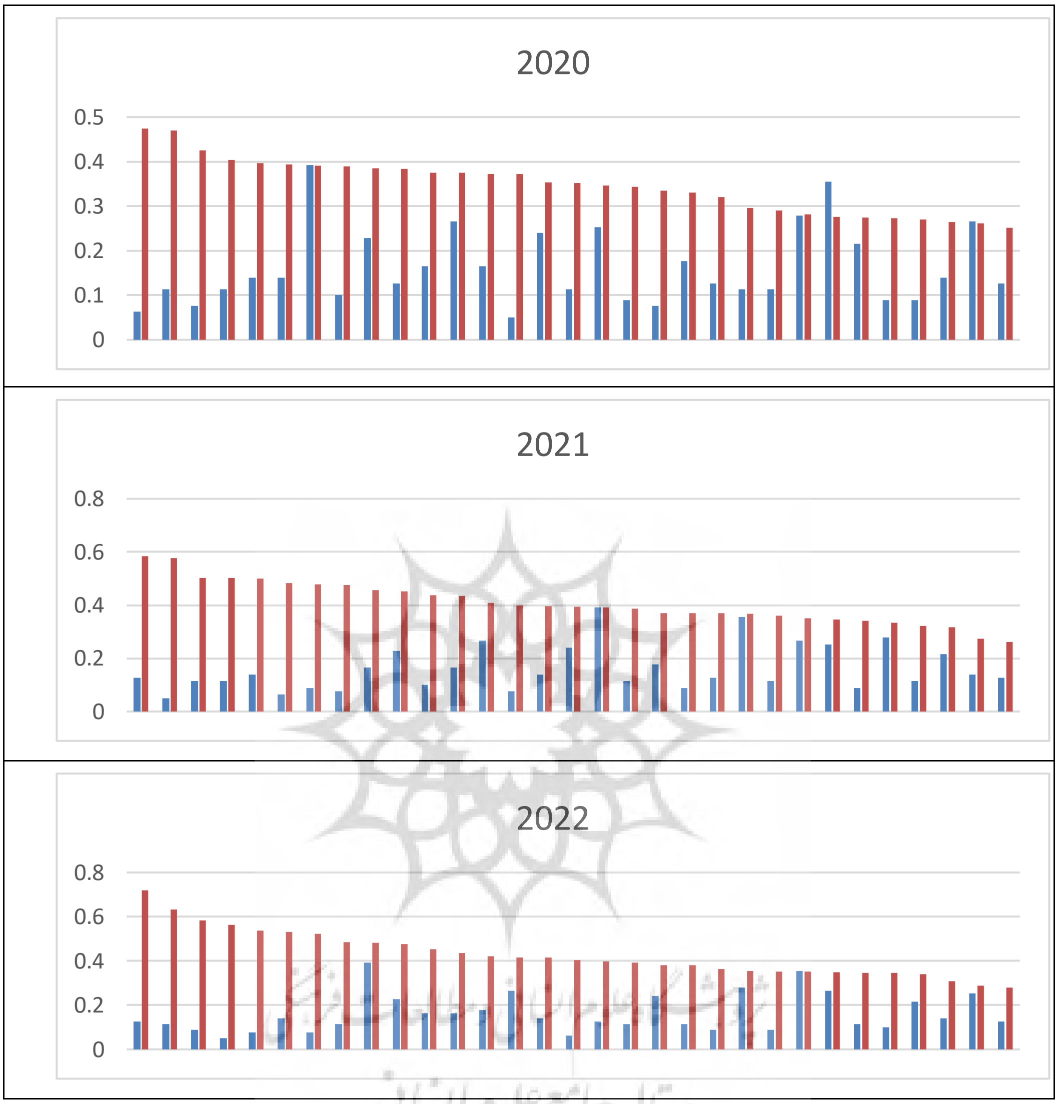


Fig. 2. Efficiency comparison with the number of branches in the provinces

As can be seen in Figure 3, the status of the frequency of branch efficiency in different periods shows that as time goes on, the frequency of the number of branches in the less efficient periods decreases, and the frequency of the number of efficient branches increases in the more efficient periods. The distribution of the corresponding frequency is similar to the distribution of Chi-square.

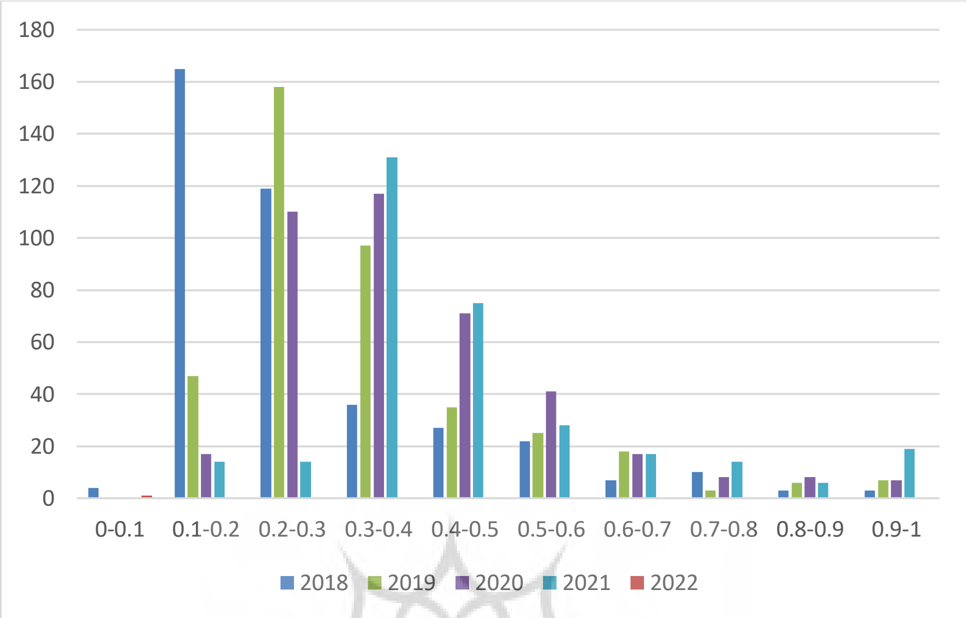


Fig. 3. Number of branches compared to efficiency score in a five-year period

Correlation table in different years, along with descriptive statistics and related indicators

The table of general performance indicators, including the average, the coefficient of variation, the minimum, the median, and the maximum, shows the general status of the data obtained from the annual efficiency calculations and shows a general overview of all of the data. From 2018 to 2022, the average trend will increase, and this will happen while the coefficient of change will almost decrease. This means that the efficiency of the branches is becoming more uniform and better, and the situation is improving. In 2022, the province is observed with a maximum of 70%, and in different years from 2018 to 2022, the overall efficiency of the province is improving.

Table 3. Descriptive statistics indicators of the efficiency of aggregated branches in the provinces

Variable	Mean	CoefVar	Minimum	Median	Maximum
Efficiency 2018	0.2799	45.44	0.1641	0.2225	0.5999
Efficiency 2019	0.24094	22.49	0.16357	0.23056	0.41267
Efficiency 2020	0.3460	17.56	0.2512	0.3522	0.4740
Efficiency 2021	0.4081	19.40	0.2617	0.3948	0.5831
Efficiency 2022	0.4292	24.18	0.2790	0.4048	0.7193

The changes in the average efficiency of the branches are aggregated in each province, and its trend is shown in Table 4,5 and Fig 4. The arrangement of efficient provinces in 2018 was very different compared to 2019, but in 2020 compared to 2020, the changes were largely the same as the previous year. Over time, the effective stations maintained their efficiency in the following years.

Table 4. Provincial Correlations

	Mean 2018	Mean 2019	Mean 2020	Mean 2021
Mean 2018	0.226			
Mean 2019	0.078	0.817		
Mean 2020	0.216	0.611	0.728	
Mean 2021	0.318	0.435	0.492	0.854

Table 4 Correlation coefficients of the average efficiency of aggregated branches in each province in the years 2018 to 2021.

Table 4. Provincial Pairwise Pearson Correlations

Sample 1	Sample 2	N	Correlation	95% CI for ρ	P-Value
Mean 2018	Mean 2018	31	0.226	(-0.139, 0.538)	0.221
Mean 2019	Mean 2019	31	0.817	(0.651, 0.908)	0.000
Mean 2020	Mean 2020	31	0.728	(0.503, 0.860)	0.000
Mean 2021	Mean 2021	31	0.854	(0.716, 0.927)	0.000

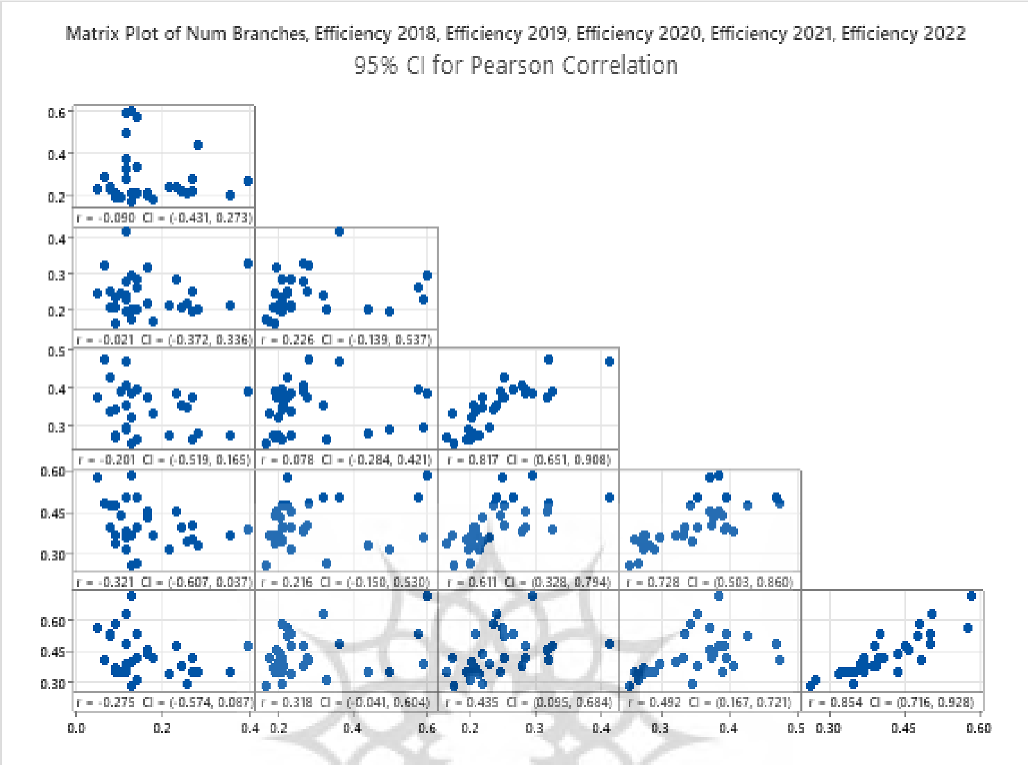


Fig. 4. Correlation chart of the average efficiency of the bank in each province in the five years 2018 to 2022

The changes in the average efficiency of the branches of the bank and its trend are shown in the table 6,7 and Fig 5. The order of the efficient branches, regardless of belonging to the efficient province, was very different in 2018 compared to 2019, whereas in 2018 compared to 2022, the changes were largely the same as the previous year. Moreover, with time, efficient branches have maintained their efficient process in the following years.

Table 5. Branch Correlations

	Efficiency 2018	Efficiency 2019	Efficiency 2020	Efficiency 2021
Efficiency 2019	0.404			
Efficiency 2020	0.227	0.562		
Efficiency 2021	0.245	0.377	0.552	
Efficiency 2022	0.316	0.419	0.418	0.623

Table 6. Correlation coefficients of the average efficiency of branches in the years 2018 to 2022

Sample 1	Sample 2	N	Correlation	95% CI for ρ	P-Value
Efficiency 2019	Efficiency 2018	395	0.404	(0.318, 0.483)	0.000
Efficiency 2020	Efficiency 2019	395	0.562	(0.490, 0.626)	0.000
Efficiency 2021	Efficiency 2020	395	0.552	(0.479, 0.617)	0.000
Efficiency 2022	Efficiency 2021	395	0.623	(0.559, 0.680)	0.000

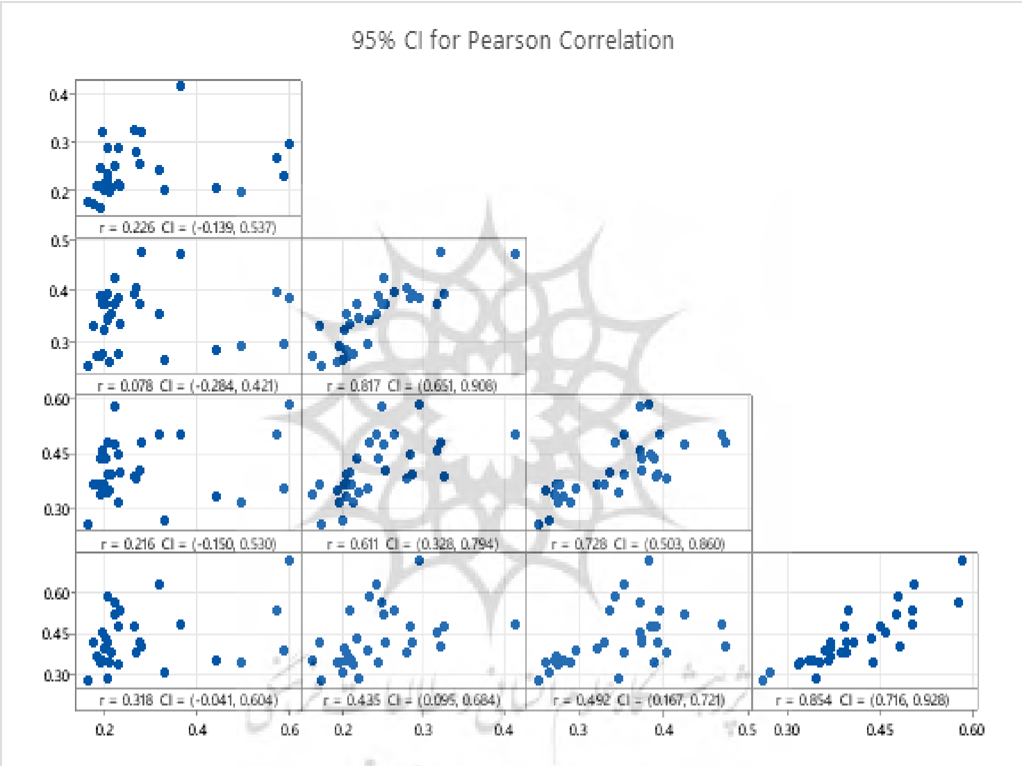


Fig. 5. Correlation of the average efficiency of branches in 2018 to 2022

Fig 6 shows the average bank efficiency of 31 provinces of Iran during the years 2018 to 2022. The efficiency of 20 provinces has been increasing during these five years. The average efficiency of Hamedan, Hormozgan, Khorasan jonoobi, Markazi, Mazandaran, and Yazd provinces has been decreasing from 2018 to 2019, but it has been increasing from 2018 to 2022.

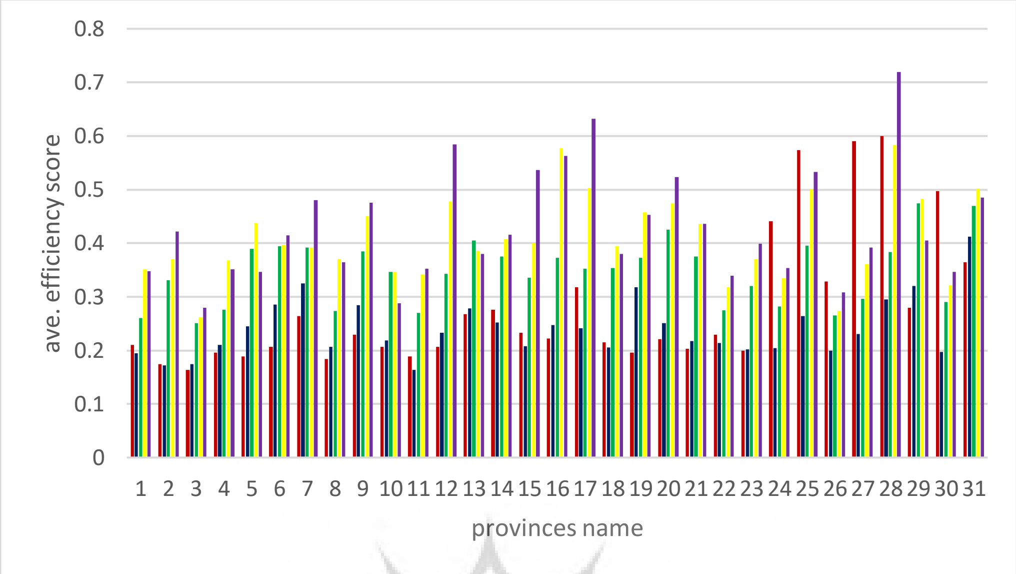


Fig. 6. The average efficiency of the provincial banks during the years 2018 to 2022

Fig 7 shows the total average efficiency of each province during the 5-year period. As can be seen, Yazd province has had the highest efficiency during the 5-year period.

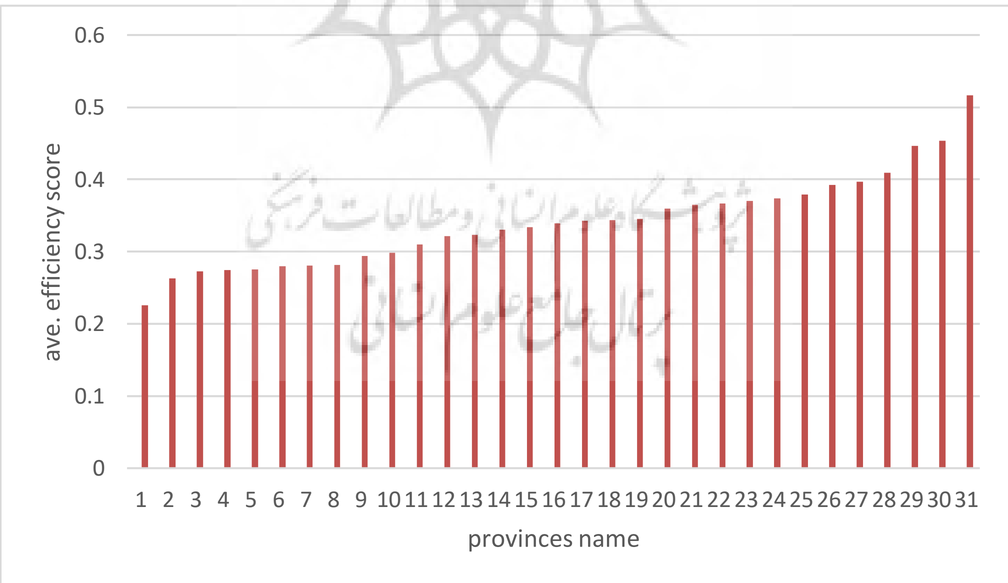
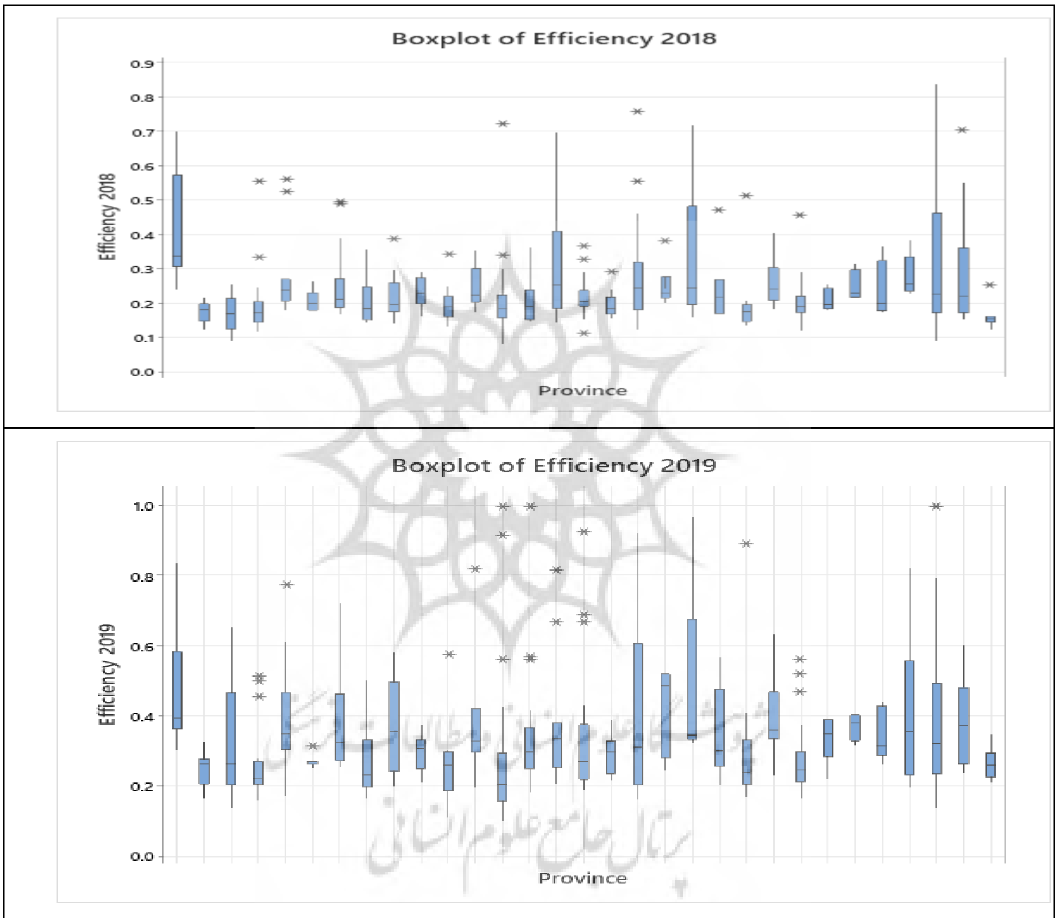


Fig 7. The total average efficiency score of the provinces during the five years

The trend of the provincial box diagram shows the changes and also the efficiency gap of the branches in the provinces. For example, in Ardabil province, there were more dispersions and changes in efficiency than in Yazd province. Also, branches with high efficiency are shown as data outliers, which are usually the branches of the center of each province. With the passage of evaluation in the years from 2018 to 2022, the calculation process shows the stability of efficiency in recent years, which is also evident from the graph.



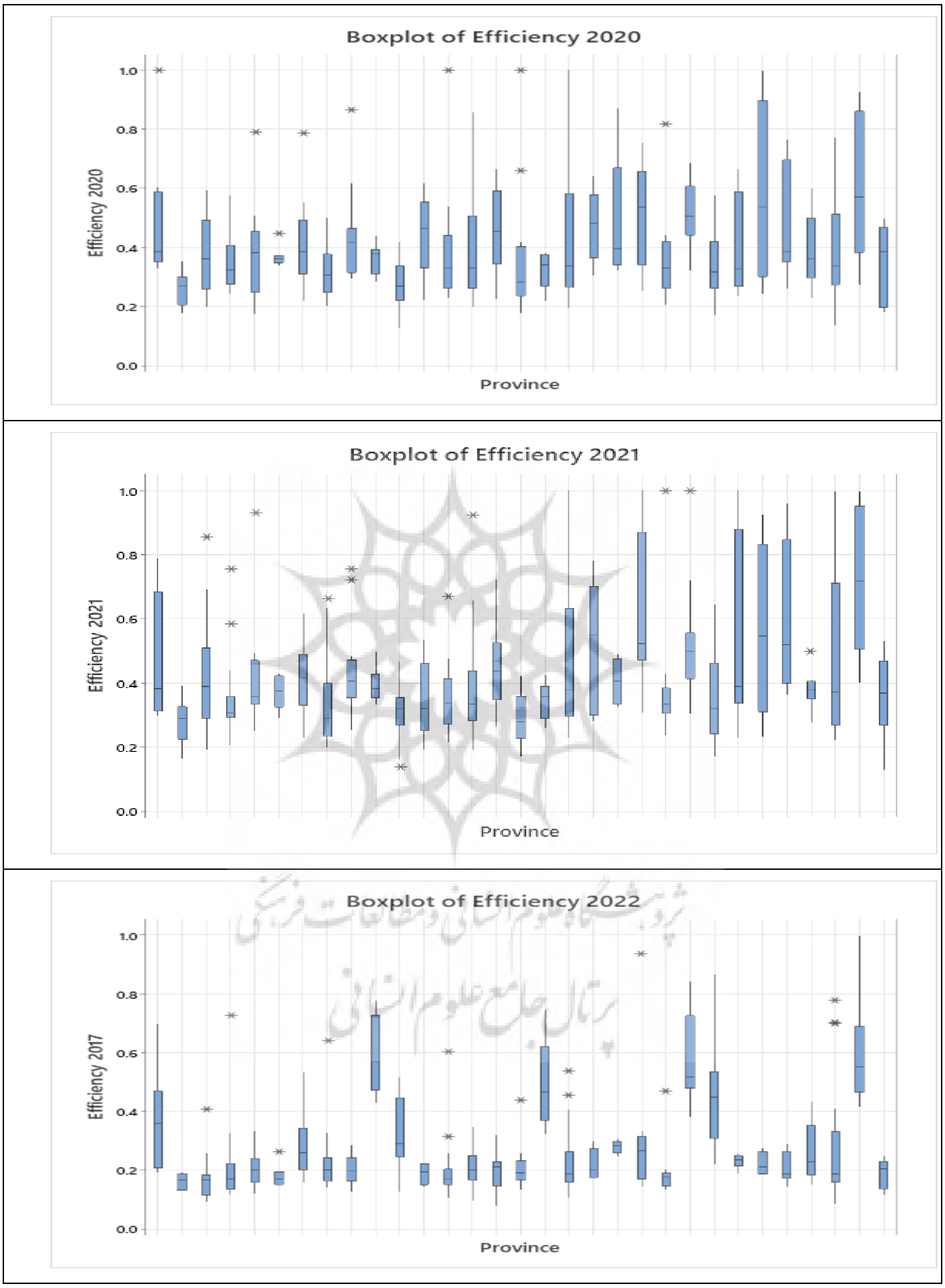


Fig. 8. Box plots of protocol efficiency

Discussion and Conclusion

In this article, we discussed the branch and provincial efficiency of an important bank in Iran. To obtain the efficiency of the branches, we used data envelopment analysis. All the components that we used to obtain efficiency have yet to be discussed altogether in one paper. Among the outputs of each branch, we considered an undesirable output called NPL. Therefore, to obtain the efficiency of the DEA method, we used the suggested multiple input-oriented models with undesirable outputs. However, since we wanted to obtain efficiency over five years, we made the model dependent on time to obtain more accurate results. As a result, we analyzed the answers obtained from the proposed methods with the help of statistical indicators. The information obtained from these indicators helps the managers and planners of the bank to plan more accurately for increasing efficiency and finally getting more profit for the next periods. All the components that we have considered in this article to obtain the efficiency of a bank's branches have yet to be considered in one place in any article. In this article, we tried to address the factors affecting the efficiency of a bank branch, which were of great importance in the opinion of bank managers.

Declaration of Conflicting Interests

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