An integrated framework to assess and improve the financial soundness of private banks

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Abstract

According to significant challenges of the banks, there is a greater need to assess the existing banking system and implement corrective actions. In this paper, the financial soundness of 11 Iranian private banks is evaluated by using the CAMELS indicators (Capital adequacy, Asset quality, Management, Earning, Liquidity, and Sensitivity to market risk). The weights of indicators are determined using the Best-Worst Method (BWM). Data Envelopment Analysis (DEA) is consequently used to calculate the efficiency score of the Decision-Making Units (DMUs). Principal Component Analysis (PCA) is used to validate the DEA results. Also, several sensitivity analyses are conducted on private banks. The intuitive results of sensitivity analysis prove accurate as demonstrated by statistical tests. The results of sensitivity analysis and statistical tests demonstrate that Iranian private banks have the best performance in terms of the indicators of Management and Capital adequacy, and the poorest performance in terms of Asset quality. Also, using the Strengths-Weaknesses-Opportunities-Threats (SWOT) matrix, the authors present appropriate strategies for improving the performance of the banking system. To the best of our knowledge, the present study for the first time aims to assess and improve financial soundness of private banks by using a combination of qualitative and quantitative methods.

Keywords: financial soundness, CAMELS, performance evaluation, best worst method, data envelopment analysis, principal component analysis, SWOT

1. Introduction

Banks' performance is highly important due to the central role they have in the economy. Iranian private banks have been the target of enormous criticism because of their poor performance in the last decade. Assessing the performance of these financial institutions enlightens investors about the current situation and is helpful in their future investments. Both financial and non-financial researchers are interested in performance measurement among workers in the industrial sector. Banks are not an exception, and they are one of the sectors receiving considerable attention from analysts and researchers [1]. Several indicators are used to estimate and determine the performance of banks. A popular instance is CAMELS, which combines Capital adequacy, Asset quality, Management, Earning, Liquidity, and Sensitivity to market risk.

The CAMELS rating system is highly valued by senior bank managers and economists worldwide, since it provides a comprehensive assessment of the banking system from financial, operational, and managerial perspectives. The United States introduced the CAMELS indicator

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in 1978, and many banks have used it as the benchmark for making decisions and evaluating their performance. In the United States, most banks use this indicator to evaluate their performance and determine their position among competitors. It is, therefore, regarded as a reliable indicator for assessing banks' performance.

According to official reports, the Iranian economy is dependent on the performance of the private banking sector because around 70% of bank deposits are held by private banks. Based on the financial statements published by the Securities and Exchange Organization of Iran, the debt of private banks to the Central Bank increased from 610 billion rials to 3,240 billion rials from 2013 to 2020. Poor performance of banks, including private ones, contributes to inflation and financial stress in society.

The main objective of this research is to present a comprehensive quantitative and qualitative framework to assess the performance and financial soundness of private banks. The proposed framework allows us to compare all private banks of Iran with each other in terms of performance and financial soundness during different time periods. This framework also makes it possible to compare these banks in terms of their overall performance, to compare their performance in terms of each indicator, and to compare the performance of each indicator among all private banks. The main questions that our study aims to answer are briefly presented as follows:

1. How can we improve the performance of private banks by using CAMELS indicators, mathematical models, and qualitative and quantitative methods?
2. Which indicators of the CAMELS framework are associated with the best and poorest performance of the private banks in Iran?
3. Which banks have the best and poorest performance in terms of each CAMELS indicator?
4. Which banks are the most positively and the most negatively impacted in terms of each indicator?
5. By recognizing the external threats and opportunities as well as the strengths and weaknesses on the basis of sensitivity analysis and statistical tests, what strategies can be proposed in order to improve the performance of private banks in Iran?

Regarding the questions mentioned above, we offer a quantitative and qualitative framework in order to assess the performance and financial soundness of the private banks in Iran. The required data for this research were collected from the Securities and Exchange Organization and analyzed in order to compare the performance of these banks in terms of each CAMELS indicator. We also examined the constancy of the data of the banks in terms of each indicator. In order to determine the weights of the indicators, we used the best-worst method (BWM) and to calculate and rank the score of each bank during different time periods, we ran data envelopment analysis (DEA). The results of sensitivity analysis and statistical tests were used to determine the positive or negative impact of each indicator on the overall performance of the banks. Eventually, we proposed a number of strategies to upgrade the performance of private banks in accordance with the results of sensitivity analysis as well as the identified external threats and opportunities.

The present paper is organized as follows. A brief review of the existing literature on the subject is presented after the introductory section. The third section elaborates the CAMELS indicators. Section four discusses the research methodology. The next section presents the

results of the analysis. Section six provides the managerial insights, and the final section discusses the research gaps and provides suggestions for future research.

2. Literature Review

Analysts and researchers have used the CAMELS indicator to determine bank performance and predict bankruptcy in recent decades. Among the essential financial soundness indicators, the CAMELS indicators are instrumental for internal and external evaluation of financial institutions. Every country has a system of ranking banks to gauge how healthy they are [2]. In most countries, these rankings draw on the CAMELS system, which is highly accurate and reliable for assessing bank performance and predicting future obstacles [3].

Shaddady and Moore [4] used the CAMELS system to demonstrate the sustainability of financial regulations in banks. They selected a sample from 47 European countries while considering the size of the banks and the country's economic status. The authors also suggested that more capital regulation has a direct relationship with the stability of banks, but it seems that imposing more restrictions, supervision, and higher deposit insurance could adversely influence the stability of banks. Furthermore, they added the small and new commercial banks are more sensitive to monitoring shocks. This article considered large amounts of bank data in Europe, but it lacks an appropriate method for validating data. Davis and Albright [5] argued the potential balanced scorecard could have an effect on measuring a bank's financial performance. As a result, the branches that implemented BSC showed a better performance than those that chose not to adopt BSC.

Analyzing the Turkish banking sector, Dincer, Gencer [6] calculated the CAMELS indicators for private, public, and foreign banks from 2002 to 2009 and found that the size of banks and their “Sensitivity to market risk” are inversely related. They examined the performance of three types of Turkish banks introduced over the past three years, and found that banks have sufficient capital to withstand future risks under the current conditions in the Turkish banking sector. Lack of proper statistical analysis and lack of solutions to improve the performance of banks are among the main drawbacks of this article. Slam and R. M [7] reviewed 17 private commercial banks in Bangladesh from 2010 to 2016. They calculated each CAMELS criterion based on a variety of methods, and classified the banks based on each ratio and calculating the average rank for each subsystem. This study, however, did not provide a method to improve the performance of the banks.

Ongore and Kusa [8] demonstrated that many factors, including critical indicators from CAMEL, GDP, and external factors (macroeconomics), have a bearing on the financial performance of commercial banks. The objective of this study was to understand how boards of directors and management of commercial banks in Kenya influence the banks’ financial performance. To this end, the authors evaluated shareholders' equity, return on assets, and net profit margin while identifying the most critical indicators of banks' financial performance. It was found that the effect of macroeconomic growth on financial performance is minimal. Ledhem and Mekidiche [9] addressed the same issue, looking at the link between economic growth and financial performance in five Islamic countries. The authors concluded that earning and inflation rate are the main factors affecting the economy.

Makinen and Solanko [10] examined the effects of CAMEL variables on bank closure. The authors reviewed the monthly data of Russian banks and concluded that higher levels of sluggish capital, profits, and liquidity are inversely related to bankruptcy, while poor quality of assets is directly correlated with bankruptcy. Bashatweh and Ahmed [11] examined the financial performance of 13 Jordanian banks from 2014 to 2018 based on the CAMELS

framework. They concluded that these banks are well positioned for risk capital, even if they have higher operating costs because of their favorable performance in terms of Capital adequacy. DeYoung and Rice [12] provided practical solutions for non-profit banks, business strategies, market conditions, financial performance, and technological changes. Pastor, Lovell [13] used 12 indicators to determine whether saving on customers' costs is worthwhile. They considered four cost indicators, three revenue indicators, two customer indicators, and two traditional sources of financing. Applying FDH and DEA methods, they concluded that although many relevant indicators are available, only four are deemed necessary to evaluate the financial performance of bank branches. In addition to the abovementioned methods, many authors have used artificial intelligence, genetic algorithms, and other similar techniques to improve the performance of banks [14].

Compared to previous studies which have evaluated the performance of banks, the distinguishing features of our study are presented in Table 1.

Reviewing the literature, one notices that most studies have adopted either a quantitative or a qualitative perspective, but it seems that considering both perspectives yield more accurate and reliable results ([15-19]. Compared to the more widely used Analytical Hierarchy process, the BWM has advantages such as requiring fewer pairwise comparisons and possessing a high level of consistency and reliability. This is the first study that applies BWM to evaluate the performance of banks. As shown in Table 1, no previous study has offered both a quantitative-qualitative approach and improvement actions in the context of performance evaluation of banks. In the Supplementary Materials, we elaborate on the contributions of the present study from practical and theoretical perspectives.

3. CAMELS

Many performance indicators are used to evaluate the performance of organizations. Analyzing these indicators in operational and supply chain systems such as warehouse [20], health systems such as hospitals, and financial systems such as banks and blockchain [21], in addition to taking action to improve these indicators, could boost the performance of organizations. One of the indicators frequently used to assess the performance and financial soundness of banks is CAMELS. As shown in Figure 1, the CAMELS system offers six indicators to evaluate banks: 1) Capital adequacy (C), 2) Asset quality (A), 3) Management (M), 4) Earnings (E), 5) Liquidity (L), and 6) Sensitivity to market risk (S). Ratios are used to describe and calculate the performance of each of these indicators. The definition of each indicator is elaborated in the Supplementary Materials.

4. Methodology

Most studies investigating bank performance use one-dimensional indicators such as Z-score, non-functional loans, stock returns, credit ratings, and capital ratios [22]. Using these indices will not obtain accurate results because they do not address the specific characteristics of each bank; besides, some of these factors are measured through different methods, hence the introduction of measurement errors. [23]. However, thanks to the multidimensional nature of indicator in performance and risk surveys, their results are reliable and are used in many banks and organizations. In this section, we present the solutions used in the present study. In Figure 2, the steps of implementing the performance assessment methodology are shown in a flowchart.

4.1. The number of periods and source data

In this study, the financial statements and balance sheets of the by the National Audit Organization-supervised private banks were acquired from the Securities and Exchange Organization.

The data of 11 private banks- total of 165 Decision-Making Units (DMUs)- between September 2013 and March 2020, 15 six-month periods, were collected to assess the actual performance of these banks. For security reasons, the names of these private banks remain anonymous in this study and are therefore coded with certain phrases: 1) Bank B1, 2) Bank B2, 3) Bank B3, 4) Bank B4, 5) Bank B5, 6) Bank B6, 7) Bank B7, 8) Bank B8, 9) Bank B9, 10) Bank B10, and 11) Bank B11.

4.2. Best Worst Method

BWM is a pairwise comparison method that provides more reliable results than similar methods [24-27]. It is used to calculate the optimal weight of each indicator [28]. More explanation about BWM and its employed model is presented in the Supplementary Materials.

4.3. Data Envelopment Analysis

DEA obtains the optimal weights for maximizing the efficiency score of an organization. In the present study, the DEA model introduced by Toloo [29] is used to identify the top DMUs. More details about DEA model are available in the Supplementary Materials.

4.4. Sensitivity Analysis

In this section, we illustrate how changes in each indicator might affect the performance of the DMU; thereby, it is discovered whether the indicator performs as it should or not. Model (S2), which is explained in the Supplementary Materials, is repeated six times for each indicator. As part of the sensitivity analysis, we remove one indicator in each repetition. The resulting mean efficiency score of the DMU is compared with the mean efficiency score of the DMU in the initial state, when the indicator has not been omitted. Intuitive results are obtained concerning whether the banks performed well in terms of each indicator [30]. As described in the Supplementary Materials, the results are also statistically examined for more detailed analysis.

4.5. SWOT Analysis

Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis is one of the most powerful tools for exploring and designing effective strategies to deal with desirable and undesirable situations in an organization [31]. Organizations benefit from this popular method thanks to its capacity to create a competitive environment [32]. The detailed explanation of SWOT Analysis is accessible in the Supplementary Materials.

4.6. Principal Component Analysis

The principal component analysis (PCA) is an important multivariate statistical method for reducing problem dimensions and ranking DMUs. In this method, the indicators of the problem are measured through dividing the k-th output of the j-th DMU by the h-th input of the j-th DMU

(d_{hk}^{j})Finally, the DMUs are ranked based on their respective score. [33]. This procedure is detailed in the Supplementary Materials.

5. Computational results

5.1. BWM results

After comparing the indicators by the experts' opinions (which are elaborated in tables S1 and S2 of Supplementary Materials), by using Model (S1) and the GAMS software, we evaluated the importance of each indicator and the consistency ratio ψ .The results are shown in Table 2 (Consistency ratios less than 0.1 indicate that pairwise comparisons are valid).

5-2. CAMELS results

In this section, we calculate the value of each CAMELS indicator for each decision-making unit (DMU). To this end, the weight obtained through BWM is multiplied by the values of CAMELS indicators. Next, we separately calculate the average value of CAMELS indicators for each bank during different time periods. The results of the overall performance assessment of all the 11 private banks based on each indicator are presented in Figure 3. According to Table 3, after calculating standard deviation and dividing it by the average value, we calculate the coefficient of variation of each bank based on each indicator. Thus, the constancy of the data related to each bank is established in terms of that specific indicator. (The bank with a lower coefficient of variation is more consistent on different time periods in terms of that specific indicator.) According to Figure 3 and Table 3, we discuss the intuitive results in the Supplementary Materials.

To examine the intuitive results more accurately, we conducted the analysis of variance (ANOVA) in SPSS at a significance level of 0.95 under the following assumptions.

$$\begin{cases} H_0 : \mu_1 = \mu_2 = \mu_3 = \ldots = \mu_{11} \\ H_1 : otherwise \end{cases}$$

More details are available in table S3 of the Supplementary Materials. The results are shown in Figure 4.

5.3. DEA results

By solving Model (S2), it is possible to derive the efficiency score for each of the 165 DMUs. Using this efficiency score, we may rank each DMU and each bank as follows.

- **DEA results for each DMU**

The efficiency scores and ranking of each DMU are shown in Table S4 in the Supplementary Materials. As can be seen from Table S4, DMUs 93 and 18 correspond to the best and poorest performance of Banks B7 and B2 in September 2014.

- **DEA results for each bank**

According to Figure 5, which shows the mean efficiency of 15 DMUs per bank, it can be said that the best and poorest performance are related to Banks B1 and B2 had with mean efficiency scores of 0.476 and 0.155, respectively.

5.4. Results of sensitivity analysis

Sensitivity analysis was performed, as described in Section 4, in order to examine the banks' actual functioning in terms of each indicator. The intuitive results of removing each indicator were minutely investigated with the help of an appropriate statistical test. To choose the right statistical test, one should check the three conditions for using parametric tests, and if even one of them is missing, a nonparametric test should be used. In this research, the condition of independence is established since the efficiency scores of the DMUs were collected from the financial statements of different time periods of each bank. Kolmogorov-Smirnov and Levene's tests were used to check data normality and homogeneity, respectively. Generally, either a parametric or a non-parametric test can be performed depending on the results of these two tests. Additionally, we used SPSS 21 to perform all statistical tests at $\alpha = 0.05$ significance level.

5.4.1 Sensitivity analysis for all private banks in general

According to Table S5 of the Supplementary Materials, the three conditions were not met by removing any of six indicators. Therefore, the Wilcoxon nonparametric test was used. Table 4 presents the results of sensitivity analysis of all private banks as a whole. Accordingly, Capital adequacy, Management, Earning, Liquidity, and Sensitivity to market risk reduce the mean efficiency score. These reductions are significant for the mean performance score at the level of $\alpha = 0.05$, and the null hypothesis $(\mu_1 = \mu_2)$ is rejected, so that private banks have been performing well as far as these indicators are concerned. Additionally, removing Asset quality leads to an increase in the mean efficiency score, but this increase is not significant at the level of $\alpha = 0.05$; therefore, the null hypothesis cannot be rejected.

5.4.2. Sensitivity analysis for each private bank individually

Kolmogorov-Smirnov and Levene's tests were performed for each of the six indicators in each private bank, and the calculated results are shown in Table S6 of the Supplementary Materials. Table 5 shows the efficiency scores of the 11 banks before and after removing each of the six CAMELS indicators. These intuitions were subsequently tested by appropriate statistical tests based on the results in Table S6. The null hypothesis in these statistical tests is $H_0 : \mu_1 = \mu_2$. It could also be denoted by $"*"$,since the triple conditions for using paired t-test were not met, Wilcoxon nonparametric tests were used to evaluate the statistical tests. The final results presented in Table 5 are discussed in the Supplementary Materials as well.

5.4.3. Sensitivity analysis for each indicator

This section presents the sensitivity analysis of the obtained results for each single CAMELS indicator. Each time the model was run, one of the CAMELS indicators was removed. Next, in case of each bank, the mean efficiency score prior to this omission was subtracted from the resulting mean efficiency score after the omission. Figures 6 to 11 show these values for all the 11 banks under investigation and results are discussed in the Supplementary Materials.

5.5. Verification and validation

The PCA model was implemented on the banks' data to validate and rank the DEA results. The final scores of each DMU achieved through the PCA method, along with their rankings, are summarized in Table S7 in the Supplementary Materials.

The correlation between PCA rating and DEA rating based on Spearman's coefficient is 0.62. Since this technique rejects correlations less than 0.6, validation of the DEA results was concluded the validity of the DEA results in the present study is confirmed [34].

To confirm the intuitive results, using SPSS software, we calculated Spearman correlation between the efficiency scores of DMUs before and after removing each indicator. Part (a) in Figure 12 presents the results of correlation analysis and mean efficiency scores of all private banks taken as a whole. The lowest correlation (0.646) occurs between the original state when no indicator is removed and the state when the Management indicator is removed. Along the mean efficiency score of 0.195 and the $P\text{-}value = 0$, this finding suggests that omitting the Management indicator from performance evaluation will bring about the most negative impact on the performance of private banks in Iran. On the other hand, after the removal of the Sensitivity to market risk indicator, the correlation value of the two states is equal to 0.993, implying that the removal of this indicator entails a negligible impact on the performance of private banks.

For each of the private banks, the correlation before and after removing a given indicator was calculated separately. In parts (b) to (l) of Figure 12, the mean efficiency scores after removing each indicator and the correlation values are shown schematically for each of the private banks. The greater the impact on the mean performance after removing an indicator, the lower the correlation in that state. For example, as demonstrated in part (h) of Figure 12, the highest impact of removing an indicator from Bank B7 is related to Management. This finding, along with the lowest correlation obtained after omitting this indicator, confirms the correctness of the calculations.

5.6. Improving measures

According to the results of sensitivity analysis, Bank B7 performed poorly in terms of the two indicators of Asset quality and Sensitivity to market risk; therefore, improvement measures are suggested in this regard. To improve the bank's performance in terms of Asset quality, the ratio of non-current facilities to total facilities should be reduced, and the ratio of profitable assets to total assets should be increased. Bank B7 must also make optimal investments in capital markets to strengthen its performance in terms of Sensitivity to market risk. Table 6 lists various measures to improve performance with respect to each of the CAMELS indicators.

The SWOT matrix analysis was utilized to enhance the status of Bank B7 from the standpoint of CAMELS indicators. Based on the results of sensitivity analysis, Bank B7 performs well in terms of Earning and Management, but poorly in terms of Asset quality and Sensitivity to market risk. Considering these findings alongside the external opportunities and threats that exist for the bank, we developed some improvement strategies: 1) Strength-Opportunities (SO), 2) Strength-Threats (ST), 3) Weakness-Opportunities (WO), and 4) Weakness-Threats (WT) in Table 7.

6. Managerial insights

Economy has a great impact on our everyday life on both social and individual levels. On an individual level, our economic status can have an effect on many of our decisions such as our choice of career, leisure time activities, as well as our expenses and savings. On a social level, it has a great impact on the inflation rate, interest rate, and life expectancy rate. One of the basic pillars of success of any modern economy is the development of a banking system with acceptable performance that results in industrial and commercial developments, contributions

in economic activities, agricultural developments, investments in newly-founded companies, monetary policy implementations, and export promotion. Therefore, assessment of the financial soundness of banks is an important subject that needs to be addressed. Taking into consideration the CAMELS indicators, the present research proposes a comprehensive quantitative and qualitative framework to assess the performance and financial soundness of private banks. The first step to improve a bank is to understand its current status and identify its strengths and weaknesses. However, restriction of the budget and resources available to the banks and government policies also have to be taken into account. Having an accurate understanding of the existing conditions helps managers make the necessary decisions about allocating resources to urging matters and issues that have greater impact on the overall performance of the bank. The next step is providing practical and pragmatic strategies based on the results of the first step. The first two steps will be most effective if implemented simultaneously.

After the implementation of the suggested framework in the private banks in Iran, the weaknesses of the banking system in terms of Asset quality were identified. Experts' opinions were considered in order to analyze the findings. Accordingly, it was noted that poor performance in terms of Asset quality in private banks can have a negative impact on Capital adequacy, revenue, and liquidity in the future. As banks' assets mostly consist of concessional loans, quality assessment of bank assets is synonymous to quality assessment of these facilities. More precisely, it consists of examining deficient facilities and reducing their share in the overall portfolio. Unfortunately, due to the current recession and its impact on the economy of Iran, businesses suffer from instability. On the other hand, officials who are not directly involved in the banking system interfere with the responsibilities of the banks in providing facilities. This leads to the emergence of command economy in granting loans, very often to persons and institutions that are unlikely to repay. To better evaluate the quality of facilities, the banks must take into consideration 5 major criteria when granting loans: a) the ability of borrowers based on the amount of their income and the number of loan installments; b) the quality and value of collateral guarantees; c) economic, industrial, and competitive circumstances that the borrowers face; d) the amount of the borrower's contributions to joint ventures with the bank; and e) the borrowers' willingness to repay the loans.

Finally, in order to differentiate between innocent debtors and delinquent debtors, we suggest the following measures to be taken. Firstly, under the direct supervision of the Central Bank, it is necessary to develop a comprehensive interbank information system where all customers' credit data and related financial information are recorded so that the banks would not allocate loans to ineligible applicants by mistake. Secondly, regulatory bodies should pay more attention to the process of granting facilities to eligible candidates who have no intention of repaying the loan.

Although private banks have a weak performance in terms of Asset quality and certain measures must be taken in order to improve the current situation, their performance is acceptable in terms of Management and Capital adequacy. Other measures can be taken to improve the performance of banks in terms of the other indicators and increase the satisfaction of investors. These include assignment of key decision-making responsibilities, such as those regarding interest rate of investment deposits and service commissions, to the bank's board of directors, constant supervision of the Central Bank over private banks, and enactment of a new set of bankruptcy regulations for banks with high-risk behaviors. As previously stated, the first step toward improvement involves assessment of the current situation and defining the strengths and weaknesses of the private banking system. And the second step consists of using

the results to plan goals, strategies, and tasks in order to practically upgrade the current status. For this purpose, the present study introduces several improvement measures within a SWOT matrix.

7. Conclusion

Since economic issues are one of the most important concerns throughout the world, it is vital to assess the performance and financial soundness of banks. In this study, 11 Iranian banks were evaluated based on the six indicators of CAMELS model: Capital adequacy, Asset quality, Management, Earning, Liquidity, and Sensitivity to market risk. Each indicator in turn consists of a variety of ratios.

The BWM was used to determine the weight of each indicator. According to the results, Management, Capital adequacy, and Asset quality received the greatest weight, and Sensitivity to market risk received the least weight.

To determine the efficiency scores and rankings of the banks, we applied the DEA method, which identified Banks B1 and B2 as having the best and poorest performance, respectively. After removing each indicator and recalculating the resulting efficiency scores, we determined the appropriate or inappropriate performance of the banks in terms of each selected indicator. The results revealed that the Iranian private banking system performs best in terms of Capital adequacy and Management indicators, but it is associated with a poor performance as far as Asset quality is concerned.

Given that the data met the three conditions of independence, normality, and homogeneity, parametric statistical tests were used to examine the intuitive results. However, if any data did not meet these conditions, non-parametric tests were used to analyze them. A PCA model was implemented to validate the results of data envelopment analysis. Furthermore, a number of experts in the field of bank performance evaluation were consulted to present their recommendations to managers and executives of Iranian private banks. These opinions were integrated with the findings mentioned above so as to develop a SWOT analysis matrix and suggest improving measures for the target banks.

Due to the lack of accurate and reliable data on Iranian state-owned banks, this study could only evaluate the performance of private banks in Iran. As part of future research, one can adopt the framework proposed in this study to define indicators corresponding to each research area to assess the performance of different organizations. The interactions between the indicators can also be calculated. It is also possible to extend this study by including inflation in a mathematical model that would evaluate performance over time. Finally, considering the uncertainties in the collected data and using fuzzy methods to evaluate the performance of banks can be other attractive directions for future research.

Supplementary data is available at:

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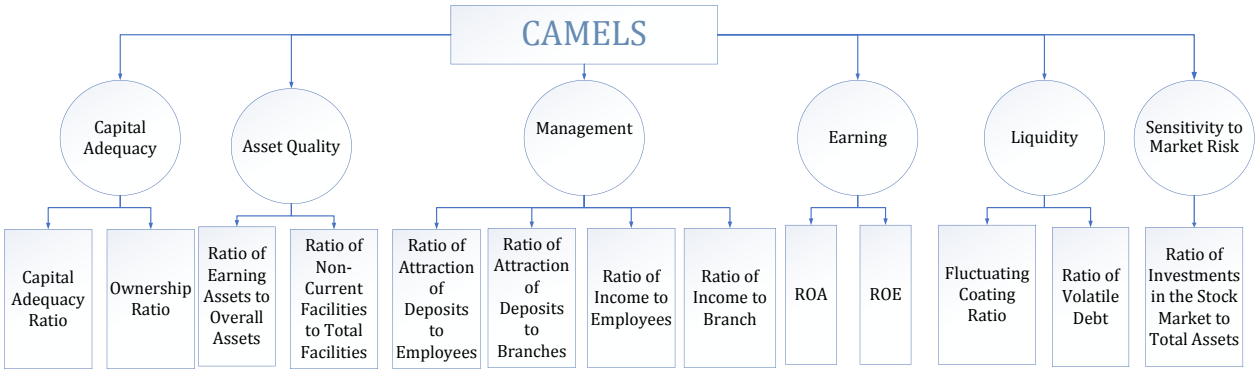


Figure 1. *CAMELS indicators*

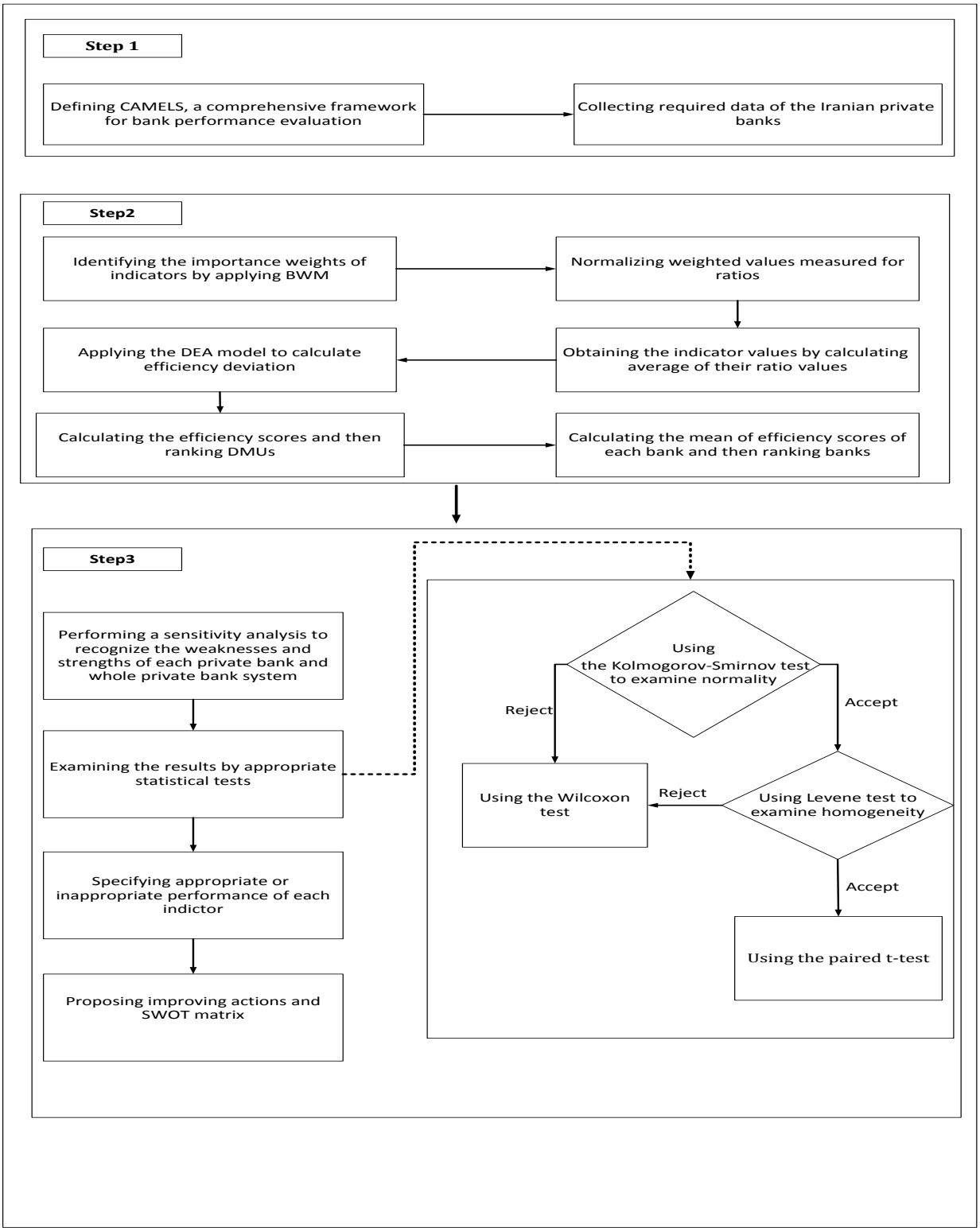


Figure 2. *Flowchart of implementation of the proposed method of bank performance evaluation*

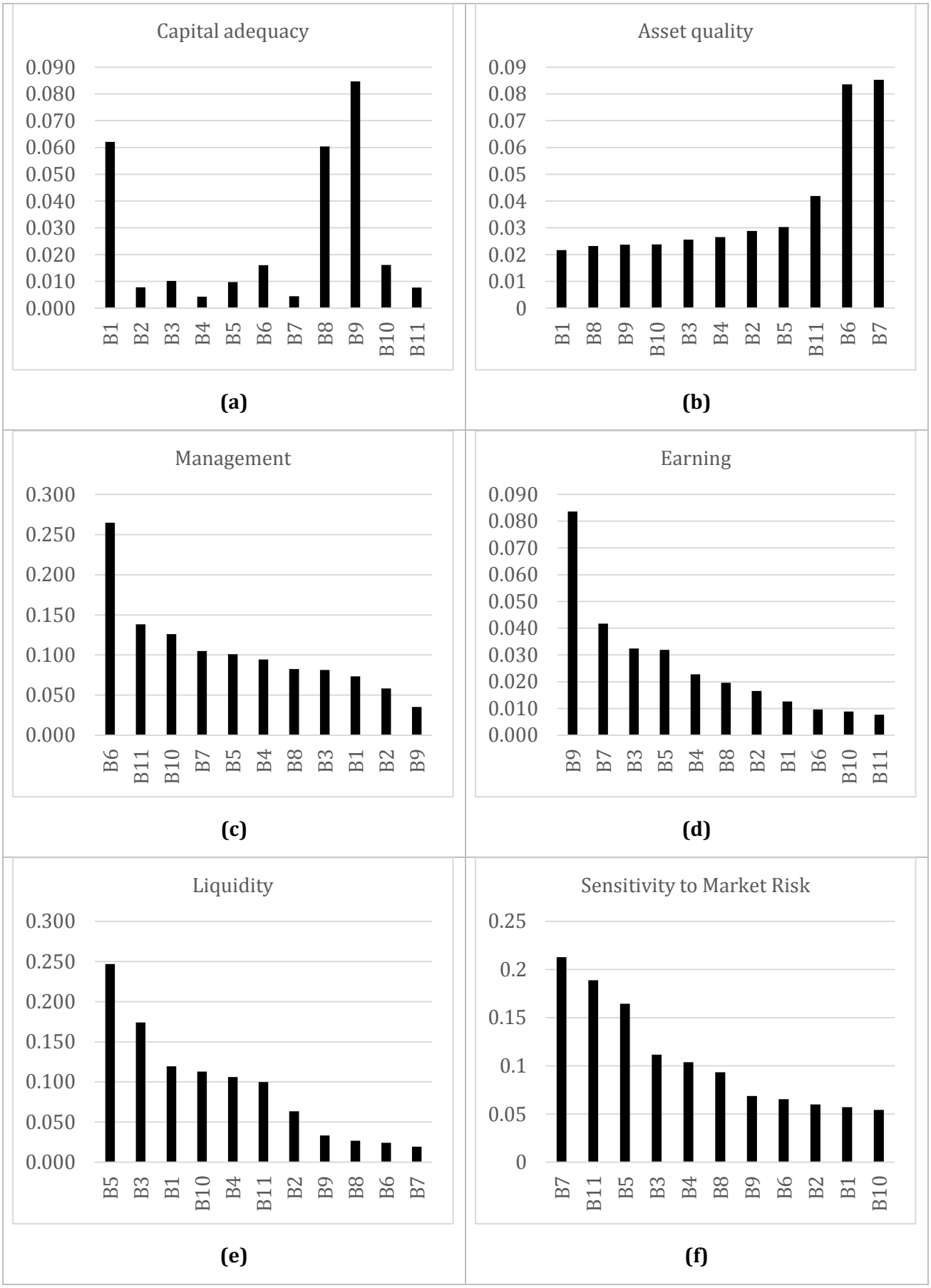
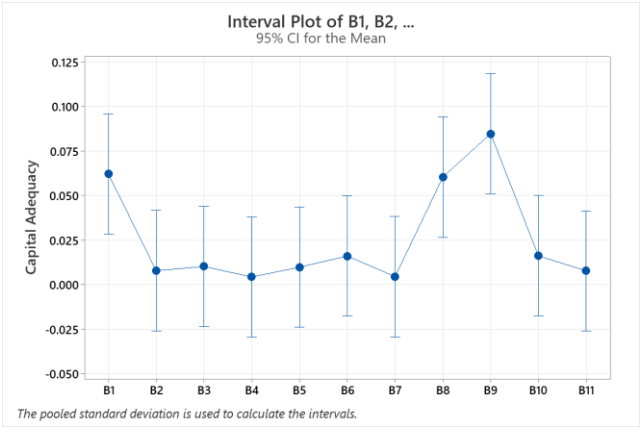
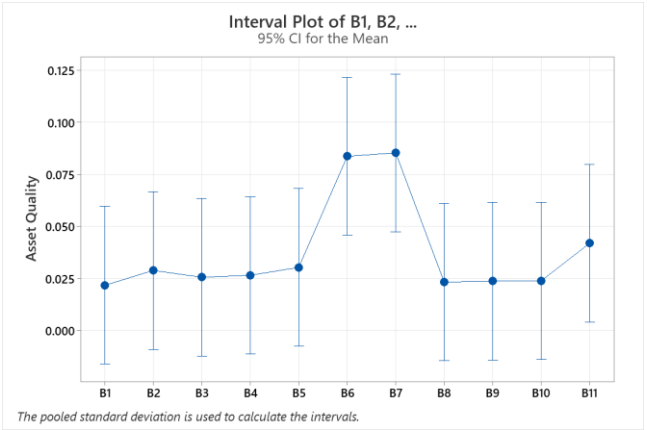


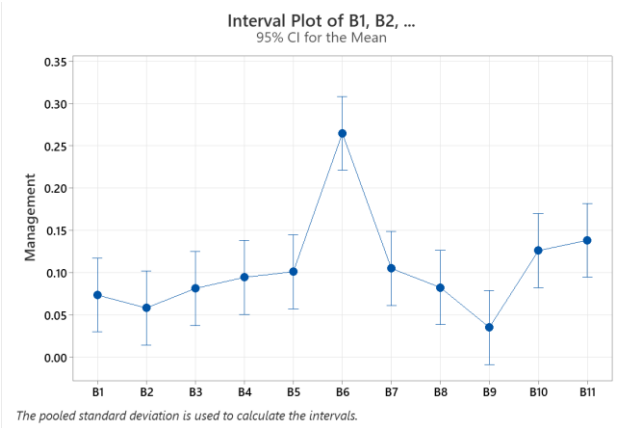
Figure 3*. The performance of each bank in (a) Capital adequacy, (b) Asset quality, (c) Management, (d) Earning, (e), Lliquidity, (f) Sensitivity to market risk indicators separately*



(a)



(b)



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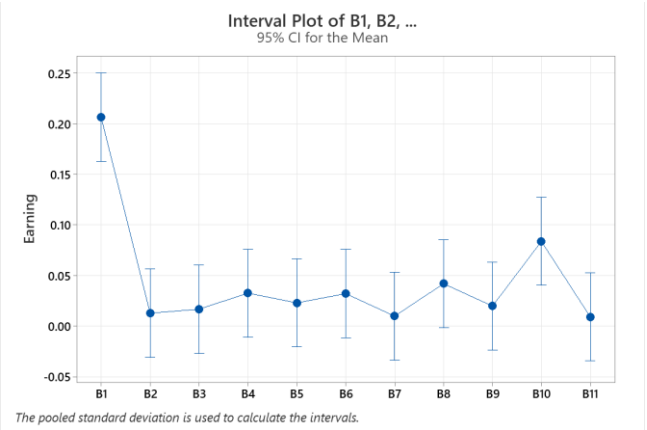
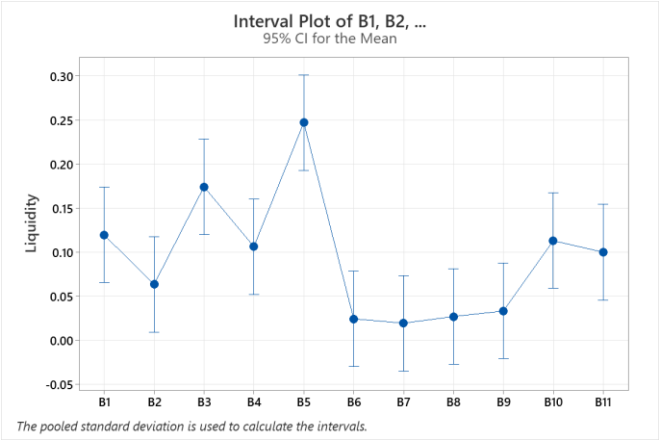


(d)



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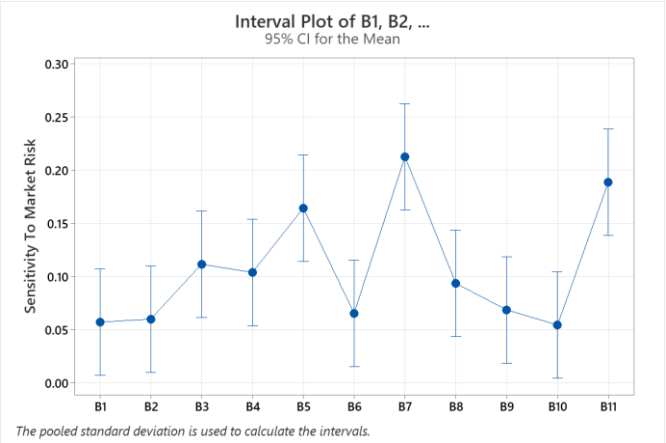


(f)

Figure 4*. The results of the ANOVA test in (a) Capital adequacy, (b) Asset quality, (c) Management, (d) Earning, (e) Liquidity, (f) Sensitivity to market risk indicators separately*

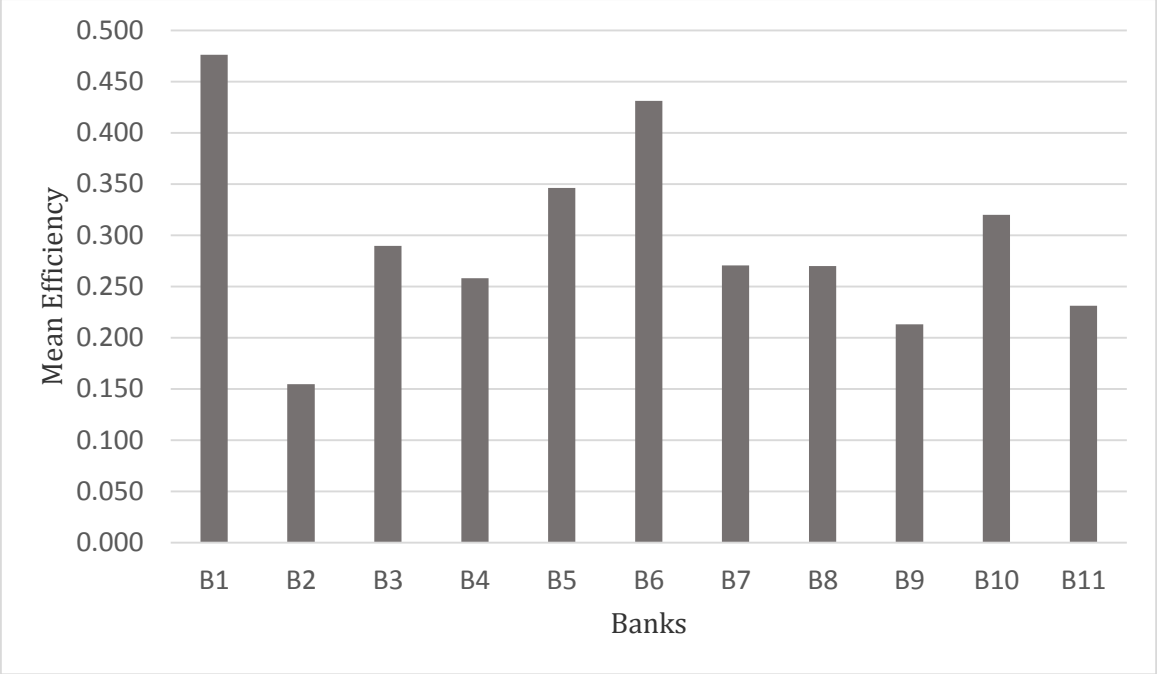


***Figure 5**. Mean efficiency of each bank*

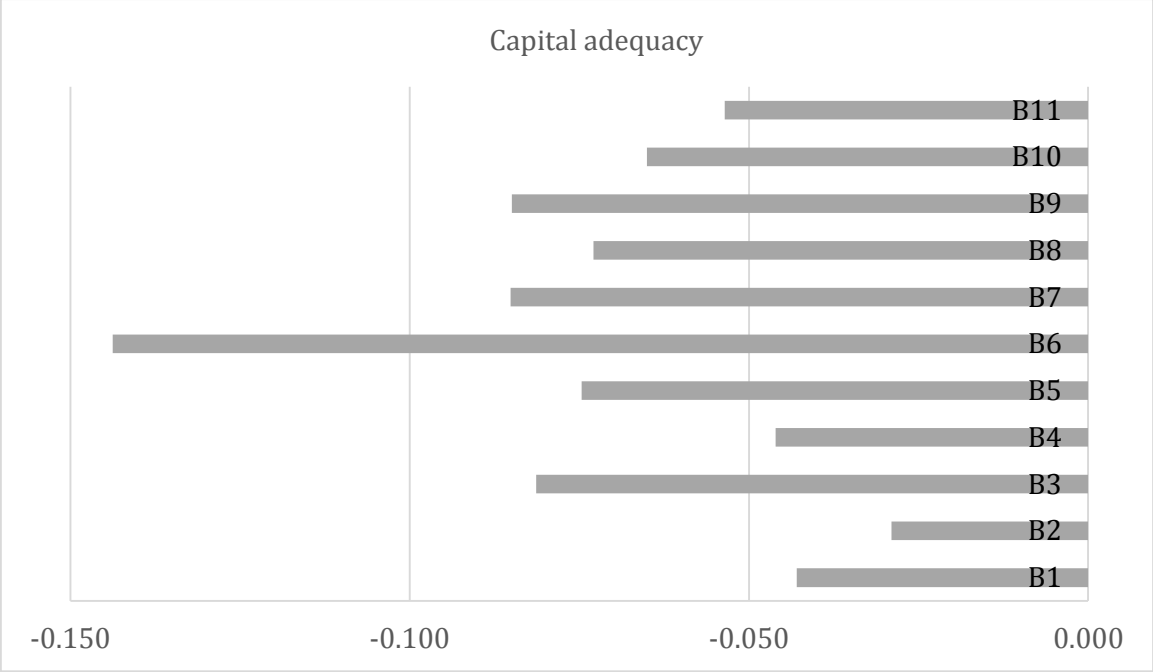


Figure 6 *.The results of sensitivity analysis of Capital adequacy*

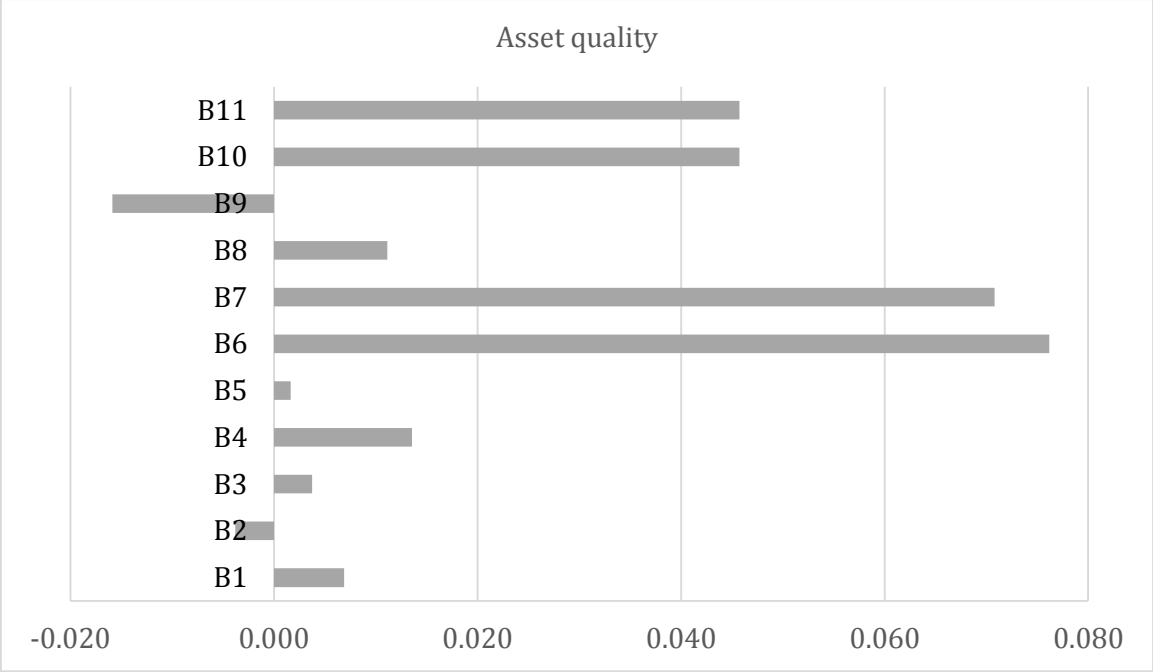
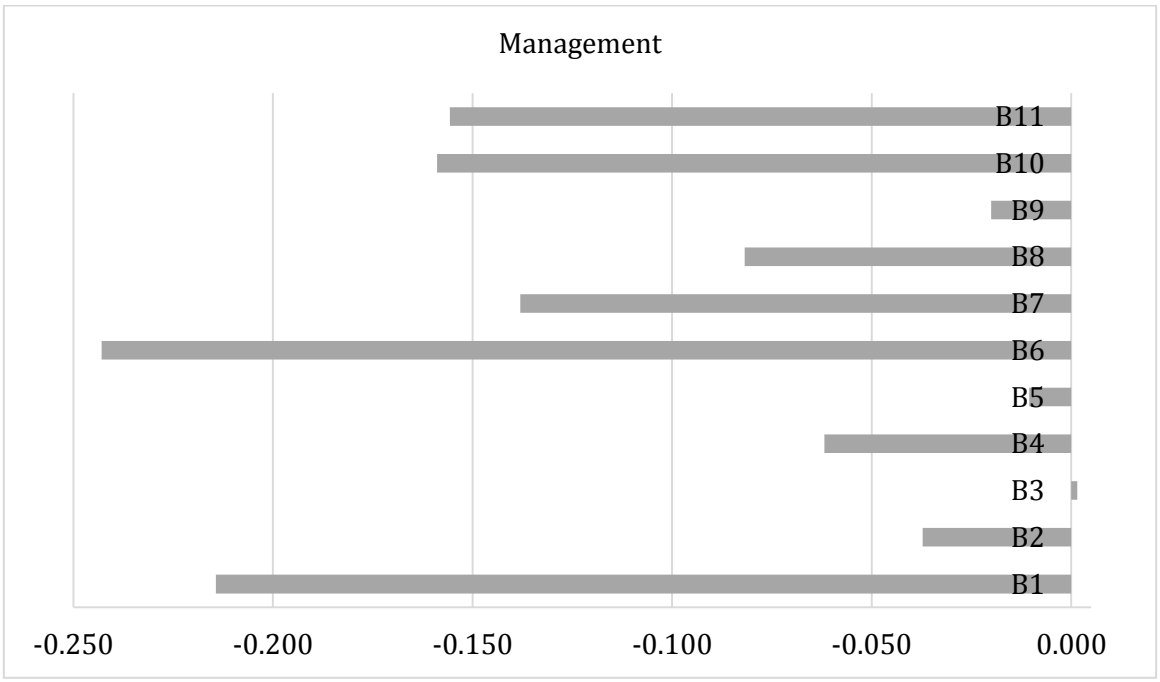


Figure 7. *The results of sensitivity analysis of Asset quality*



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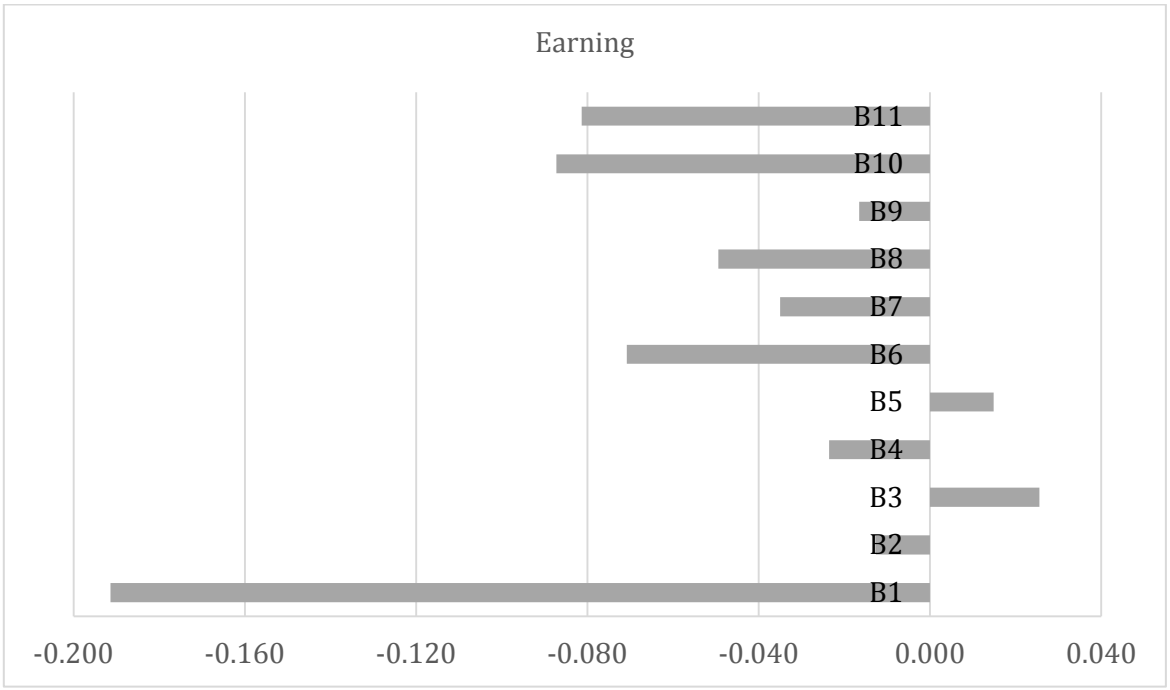

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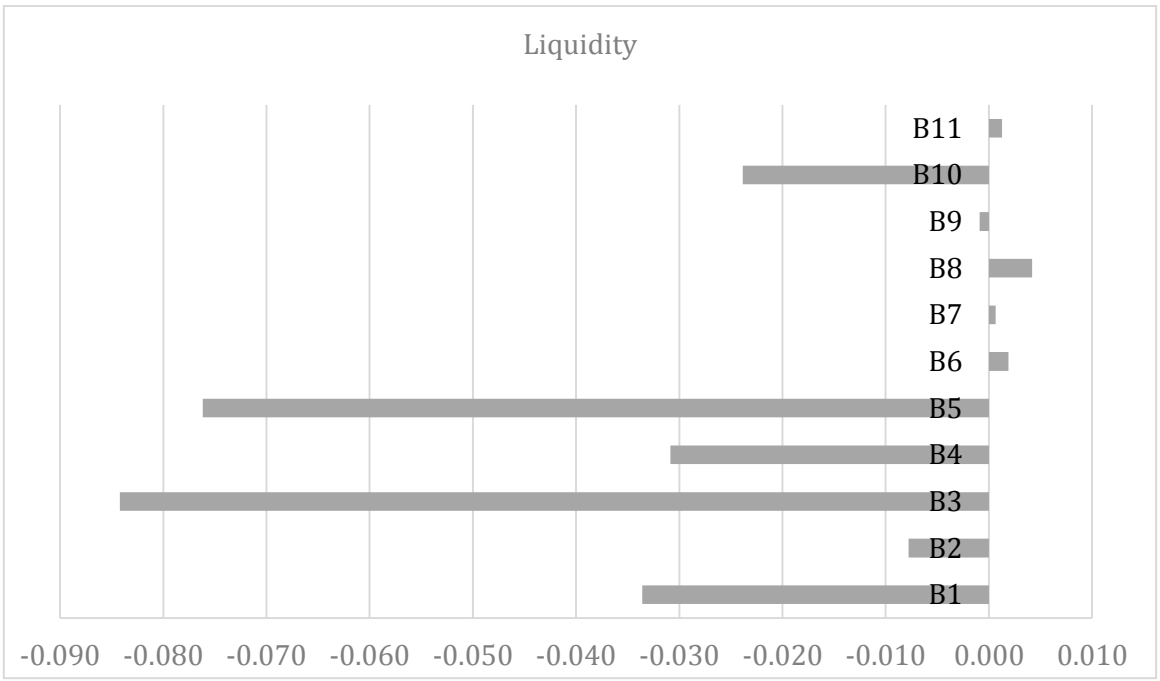


Figure 10 .*The results of sensitivity analysis of Liquidity*

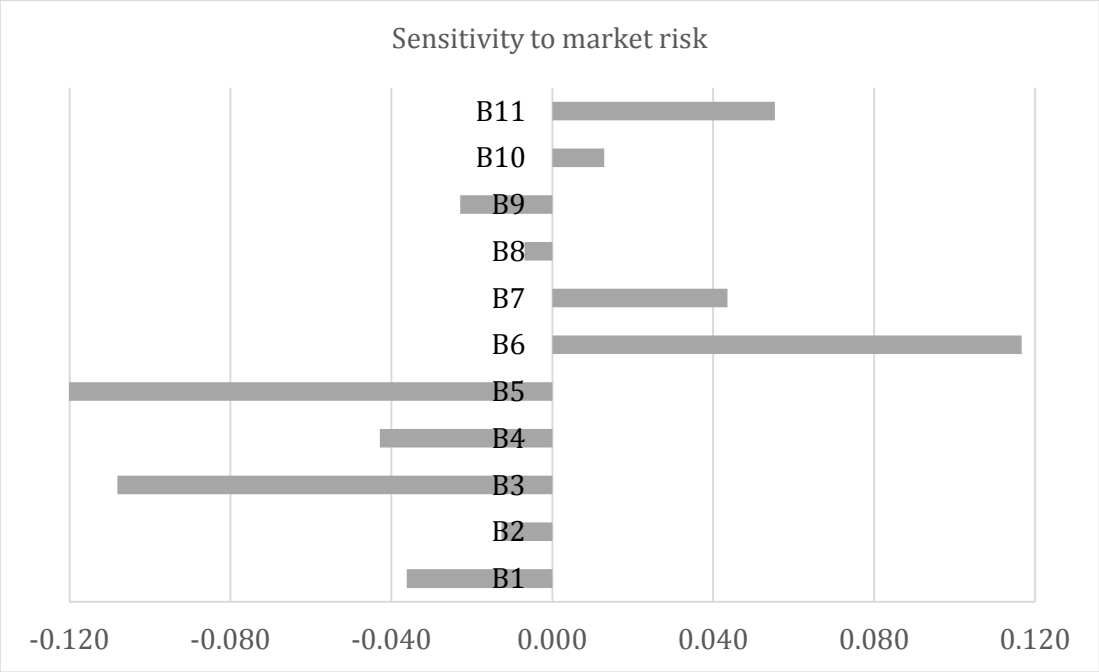
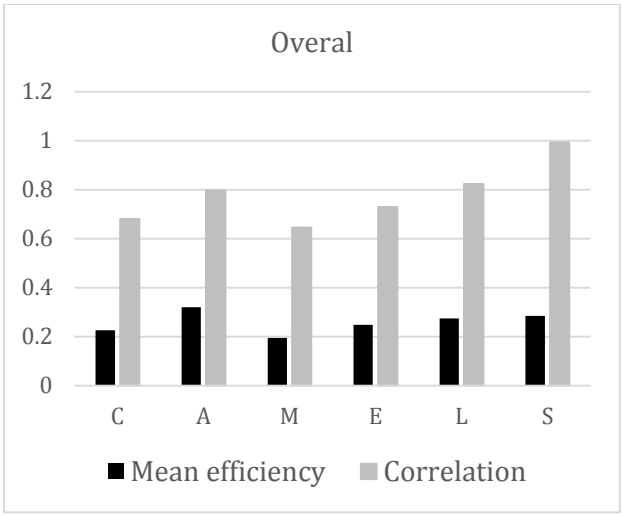
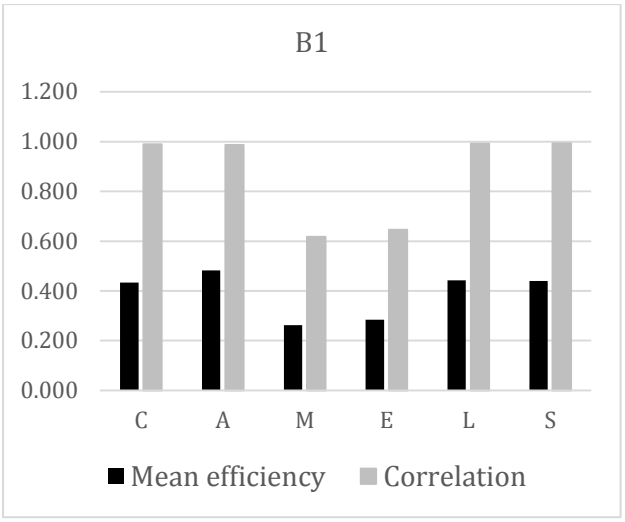


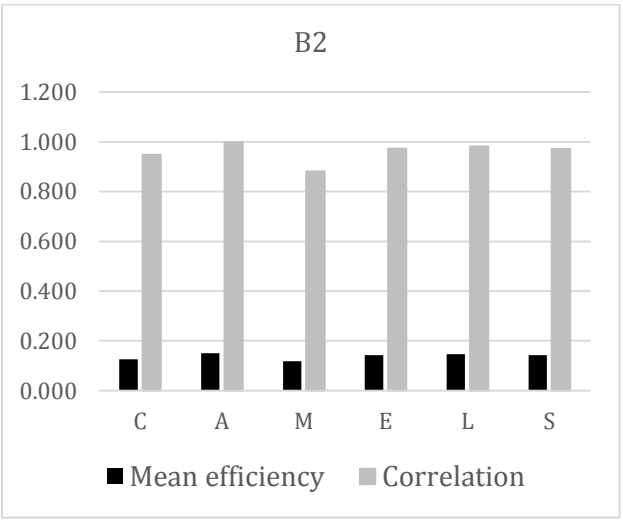
***Figure 11**. The results of sensitivity analysis of Sensitivity to market risk*


Overal
1.2
1
0.8
0.6
0.4
0.2
0
C A M E L S
Mean efficiency
Correlation

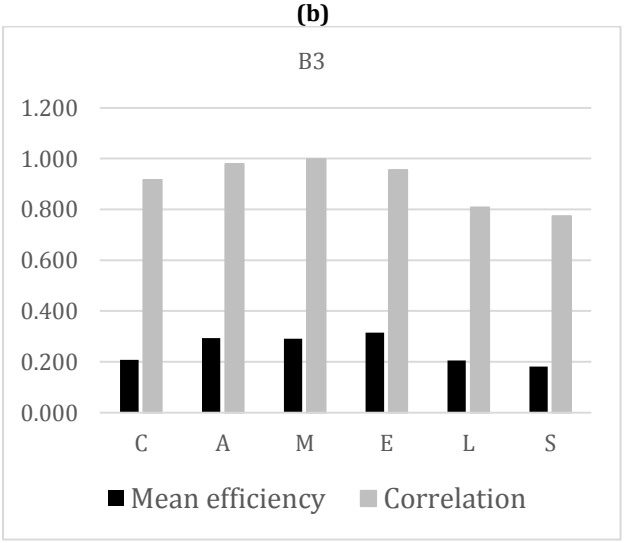
(a)


B1
1.200
1.000
0.800
0.600
0.400
0.200
0.000
C A M E L S
Mean efficiency
Correlation

(b)


B2
1.200
1.000
0.800
0.600
0.400
0.200
0.000
C A M E L S
Mean efficiency
Correlation

(c)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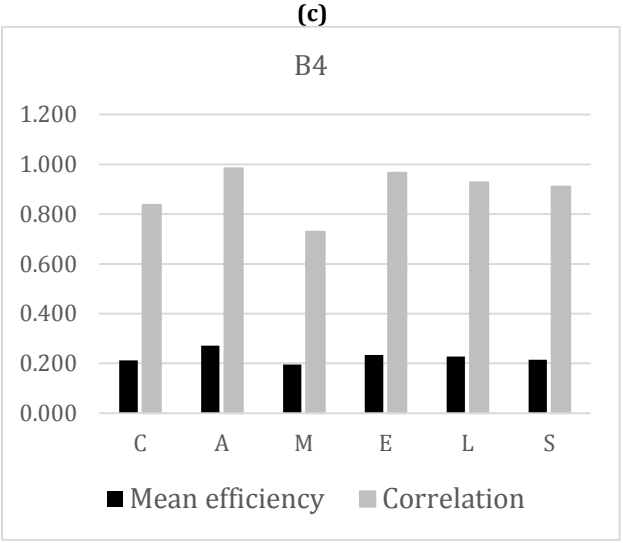
1.000
0.800
0.600
0.400
0.200
0.000
C A M E L S
Mean efficiency
Correlation

(d)


B4
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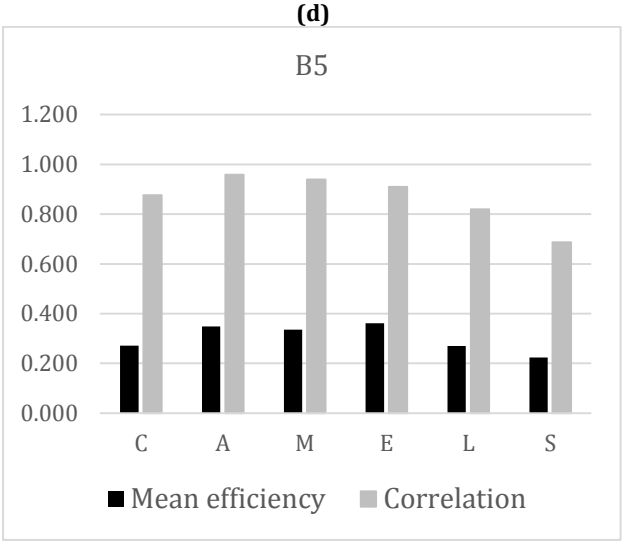
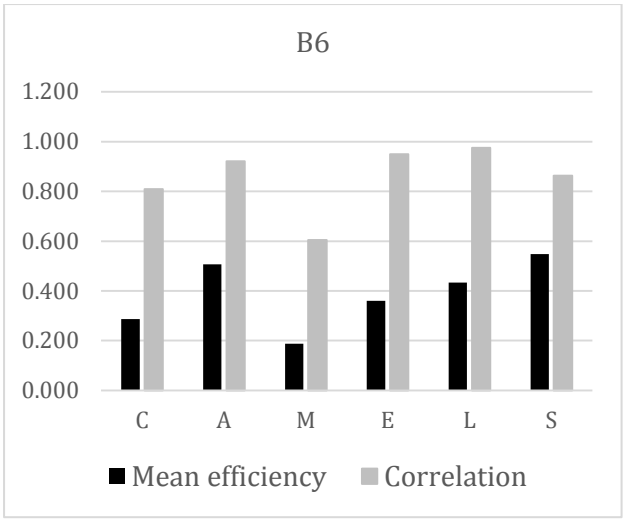
1.000
0.800
0.600
0.400
0.200
0.000
C A M E L S
Mean efficiency
Correlation

(e)


B5
1.200
1.000
0.800
0.600
0.400
0.200
0.000
C A M E L S
Mean efficiency
Correlation

(f)



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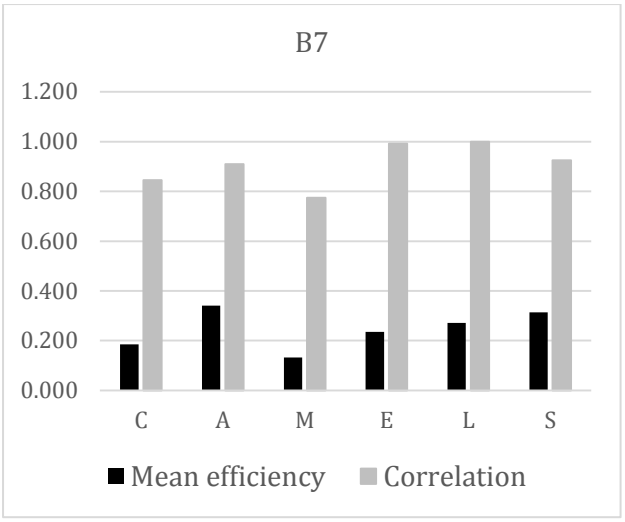

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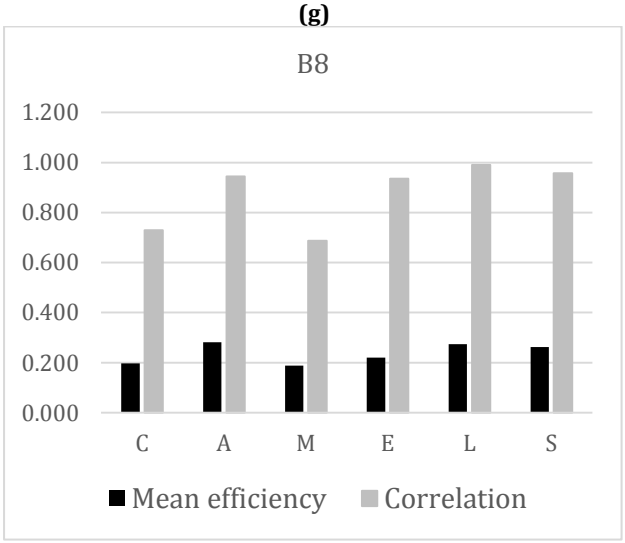
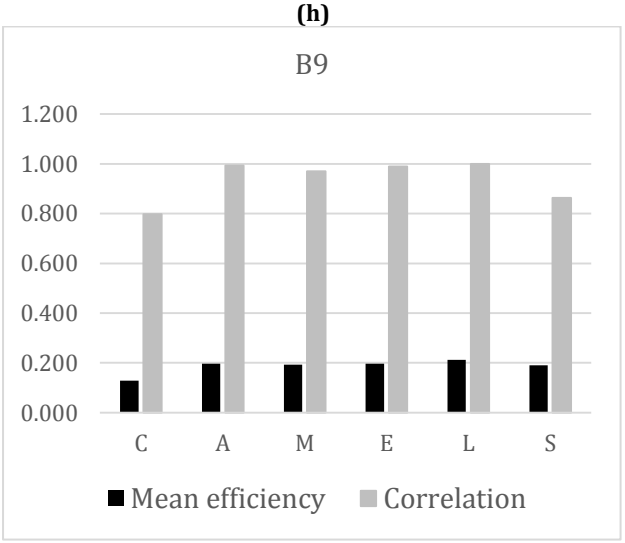


(i)



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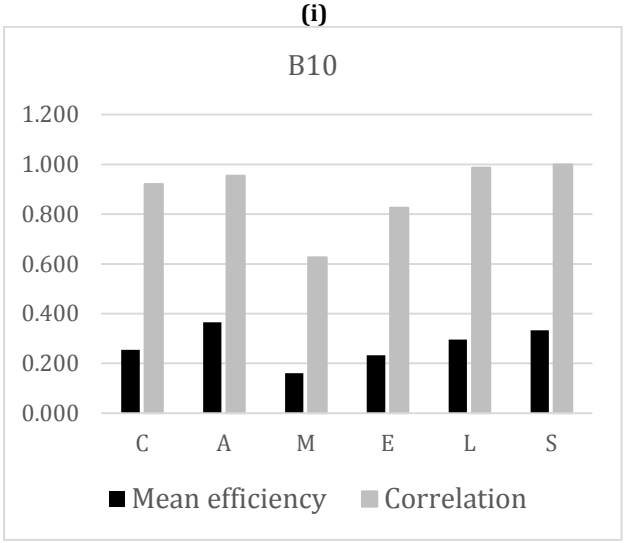
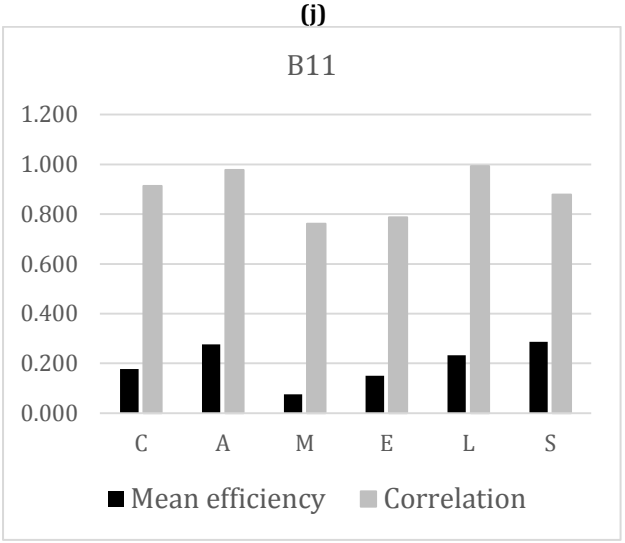


(k)



(l)

Figure 12. *The results of the correlation analysis and mean efficiency of (a) all private banks, (b) B1, (c) B2, (d) B3, (e) B4, (f) B5, (g) B6, (h) B7, (i) B8, (j) B9, (k) B10, and (l) B11; in which "C", "A", "M", "E", "L", and "S" are the abbreviations*

***Table 2**. Features of this study compared to other studies*

Article	Real case study	Indicators	Method	Solution approach		Analysis		Improvement actions
				Quantitative	Qualitative	Raw data	Data obtained from model	
DeYoung and Rice [12]	U.S. commercial banks	Noninterest income	Econometric model	✓	-	-	✓	-
Davis and Albright [5]	-	Balanced scorecard	Empirical analysis	-	✓	-	✓	-
Pastor, Lovell [13]	European savings bank	Revenue and customer indicators	DEA and FDH	✓	-	-	✓	-
Dincer, Gencer [6]	Turkish banks	CAMELS	Performance evaluation based on indicators	-	✓	-	✓	-
Ongore and Kusa [8]	Kenya commercial banks	CAMEL	Regression model	✓	-	-	✓	-
Wong, Deng [14]	ASEAN banks	CAMEL	DEA/Monte Carlo simulations and a genetic algorithm	✓	-	-	✓	-
Makinen and Solanko [10]	Russian banks	CAMEL	Linear probability model	✓	-	-	✓	-
Slam and R. M [7]	Bangladeshi private commercial banks	CAMEL	Performance evaluation based on indicators	✓	-	-	✓	-
Shaddady and Moore [4]	European countries banks	CAMELS/CPM/Private monitoring index/Governance index/Business freedom index	DEA/quantile technique	✓	-	-	✓	-

Bashatweh and Ahmed [11]	Jordanian banks	CAMELS	Performance evaluation based on indicators	-	✓	✓	✓	✓
Ledhem and Mekidiche [9]	Islamic banks in Malaysia, Indonesia, and Brunei	CAMELS	Endogenous growth model	✓	-	-	✓	-
Zhong, Wang [15]	China's regional rural commercial banks	The number of employees, fixed assets, intermediate business expenses	SBM-DEA and neural network	✓	-	-	✓	-
Wei, Ye [16]	China's provincial rural banks	Malmquist index	Machine Learning Approach	✓	-	-	✓	-
Yu, Lin [17]	Taiwanese bank	Deposit, lending, period, deposit-period and lending-period efficiencies	Dynamic network data envelopment analysis	✓	-	-	✓	-
Akindutire, Adesina [18]	Nigerian banks	Bank stability	Non-linear auto regressive lag model	✓	-	-	✓	-
Antao and Karnik [19]	Asian banks	Noninterest income	GMM estimation approach	✓	-	-	✓	-
The present study	**Iranian private banks**	**CAMELS**	**DEA, BWM, SWOT, statistical methods, and PCA**	✓	✓	✓	✓	✓

***Table 2**. BMW results of indicators*

	Capital adequacy	Asset quality	Management	Earning	Liquidity	Sensitivity to market risk	Consistency ratio
Weight	0.169	0.157	0.384	0.141	0.093	0.056	0.047

***Table 3**. The Coefficient of variation of banks*

Indicator	Coefficient of variation of banks										
Capital adequacy	1.122	0.145	0.219	0.425	0.304	0.992	0.388	3.294	0.140	0.731	1.536
Asset quality	0.217	0.090	0.110	0.145	0.173	2.059	1.733	0.202	0.064	0.210	1.659
Management	0.480	0.336	0.419	0.279	0.476	0.630	0.949	1.555	0.862	0.411	0.783
Earning	1.085	0.911	0.783	2.593	0.713	0.569	1.028	2.578	1.822	0.723	0.769
Liquidity	0.834	0.737	1.020	1.641	0.688	0.590	0.713	0.563	0.784	0.578	0.863
Sensitivity to market risk	0.884	0.483	0.442	0.483	0.468	0.848	1.045	0.426	0.422	1.340	0.822

***Table 4**. The results of sensitivity analysis of all private banks in general*

Omitted indicator	$\mu_1 - \mu_2$	Hypothesis test	P-value of Wilcoxon test
Capital adequacy	0.064	$H_0 : \mu_1 = \mu_2$ $H_1 : \mu_1 \neq \mu_2$	0.000
Asset quality	-0.008	$H_0 : \mu_1 = \mu_2$ $H_1 : \mu_1 \neq \mu_2$	0.370
Management	0.0829	$H_0 : \mu_1 = \mu_2$ $H_1 : \mu_1 \neq \mu_2$	0.000
Earning	0.039	$H_0 : \mu_1 = \mu_2$ $H_1 : \mu_1 \neq \mu_2$	0.000
Liquidity	0.024	$H_0 : \mu_1 = \mu_2$ $H_1 : \mu_1 \neq \mu_2$	0.000
Sensitivity to market risk	0.032	$H_0 : \mu_1 = \mu_2$ $H_1 : \mu_1 \neq \mu_2$	0.000

μ_1 and μ_2 refer to the mean performance scores before and after removing the indicator, respectively.

***Table 5**. The results of sensitivity analysis of each private bank individually*

Omitted indicator	$\mu_1 - \mu_2$										
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11
Capital adequacy	0.043	0.029	0.081	0.046	0.075	0.144	0.085	0.073	0.085	0.065	0.054
Asset quality	-0.007	0.004	-0.004	–0.014	–0.002	–0.076	–0.071	–0.011	0.016	–0.046	–0.046
Management	0.214	0.037	-0.001	0.062	0.010	0.243	0.138	0.082	0.020	0.159	0.156
Earning	0.191	0.013	-0.026	0.024	–0.015	0.071	0.035	0.049	0.016	0.087	0.081
Liquidity	0.034	0.008	0.084	0.031	0.076	–0.002	–0.001	–0.004	0.001	0.024	–0.001
Sensitivity to market risk	0.036	0.013	0.108	0.043	0.123	–0.117	–0.044	0.007	0.023	–0.013	–0.055
	P-value of the Wilcoxon test/ paired t-test.										
Capital adequacy	0.004*	0.000	0.004	0.012*	0.001*	0.001*	0.334*	0.140*	0.001*	0.000	0.031
Asset quality	0.422*	0.309	0.653	0.100*	0.814	0.263	0.016*	0.198*	0.017*	0.002	0.955*
Management	0.001*	0.000	0.460*	0.011*	0.599	0.001*	0.037*	0.004*	0.253	0.000	0.074
Earning	0.002*	0.003	0.820*	0.015*	0.396	0.001*	0.039*	0.001*	0.147	0.000	0.147
Liquidity	0.016*	0.061	0.002*	0.015*	0.005*	0.074	0.196*	0.638*	0.362	0.006	0.008*
Sensitivity to market risk	0.008*	0.037	0.008*	0.088*	0.001*	0.005	0.005*	0.048*	0.009	0.379	0.156*

Table 6. *Improving Measure*

Indicator	Improving actions
Asset quality	● Enforcing stricter rules, such as requiring stricter guarantees for repaying loans on time ● Imposing daily penalties for each day of delay in returning the loan ● Focusing more on online services, thereby reducing the number of bank branches nationwide
Sensitivity to market risk	● Not investing a sufficient percentage of assets in securities ● Not investing a large percentage of assets in securities ● Choosing a diversified portfolio of stocks in different sectors ● Investing more in fixed income and low-risk securities and funds than in high-risk equities

Table 7*. SWOT matrix*

SWOT	**Strengths:** ● Management ● Earning	**Weakness:** ● Asset quality ● Sensitivity to market risk
Opportunities: ● The prospect of reforms in the banking sector in the next presidential administration ● Customers' increasing tendency to use electronic banking services due to social-distancing limitations caused by COVID-19 ● The emergence of independent credit-rating agencies ● Creation of attractive investment opportunities for potential investors in other businesses ● Increased desirability of investment banking due to lower capital market returns	**SO strategies:** ● Increasing investments in e-banking infrastructure development to reduce staff costs and branches, increase customer satisfaction and fee income, and ultimately improve the bank's profitability ● Identifying attractive banking benefits to mobilize financial resources from COVID-19-affected groups ● Developing a bank restructuring plan to increase the share of salary income and reduce the bank's employee costs	**WO strategies:** ● Using the services of credit rating agencies to assess the risk of customers before providing them with facilities ● Increasing the facilities provided to IT companies to reduce the risk of non-return due to the growth of their profitability as a result of COVID-19 conditions
Threats: ● Increased US sanctions against Iran ● Risk of lack of support for foreign software purchased in previous years ● Risk of credit for business groups vulnerable to COVID-19 ● Rules and legal obligations of the Government and Parliament to banks ● Determination of interest rates paid to depositors and interest income granted to them ● Decrease in capital market yields in recent months	**ST strategies:** ● Management support of domestic experts by contracting with domestic software companies to reduce dependence on foreign countries ● Consultation with banking associations to determine customer's risk-based interest rates	**WT strategies:** ● Reducing the bank's investment in the capital market and transferring the remaining resources to banking activities ● Changing the prioritization of facilities to less-vulnerable groups in order to increase the quality of credit assets