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# A comparative study on ranking the banks using Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) approach

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**ABSTRACT:** One of the necessary tools for economic development of a country is an efficient banking system. In this study, two methods of performance evaluation including data envelopment analysis (DEA) and stochastic frontier analysis (SFA) techniques were investigated to determine the best technique having more potential in explaining the performance of banks. For this purpose, a sample of 10 banks in Iran, namely Melli, Tejarat, Saderat, Mellat, Maskan, Keshavarzi, Sanat O Madan, Pasargadae, Karafarin and Saman was studied as the statistical research community (within five years from 2005 to 2010). In the DEA application, the input variables were: the number of branches, total deposits and total costs, and the output variables were: the volume of granted facilities, total investments and total income of banks. However, in the SFA application, the variables of investments, granted facilities, deposits in other banks and activities outside of the balance sheet were the inputs and labor costs, capital costs and total costs were the outputs. The results showed a significant relationship between the two efficiency analyzing approaches and the SFA approach showed a higher accuracy.

***Keywords:*** Accuracy, Bank, Efficiency, Input and Output, Model

***Abbreviation:*** DEA: Data envelopment analysis; SFA: Stochastic frontier analysis; DMU: Discussion Making Unit.

## INTRODUCTION

Bank managers in order to improve their services and to compete with other institutions and banks should increase their units' efficiency (Elisa and Luca, 2007). Based on the researches conducted in industrialized countries, it can be simply stated that, by establishing and implementing a performance evaluation system, and even without any change in the organization or investment, the productivity can be increased by 5% to 10% (Nakhun et al., 2009). It is obvious that, by performing the inefficient units at the efficient frontier, in addition to the above destinations and reducing the costs of services and preventing wastage of economic resources, national interests will also be increased (Safayi and Rahmanpour, 2008). Moreover, the damages of bank branches due to the lack of efficiency in them are greatly reduced, and thus the country's banking system will be more efficient (Emamiye Meybodi, 2005). Accordingly, evaluating the efficiency of units and offering the ways for improving productivity is very important. Therefore, this study is trying to compare the two conventional and superior methods of DEA and SFA and to determine the best method in analyzing the performance of decision making units. Accordingly, 10 banks were selected as the case study and also the representative of Iranian banks and then, the data was collected and analyzed to identify the superior method in calculating the performance of units.

### *Theoretical Foundations*

Factors affecting the performance are divided into two categories. The first group contains the conditions and characteristics, which banks are performing at them. These conditions include bank size, type of services, risk and quality of banking activities. The second category includes environmental and institutional conditions, affecting the performance of the banks. These conditions include macroeconomic conditions, financial depth, market structure, legal framework and public institutions (Memariyani and Saati, 2005). From limited resources

of economics, the investigation of the method of obtaining the maximum value is a result and optimal allocation of limited resources is the objective of this science. Efficiency is therefore defined as the maximization procedure in the micro and macroeconomic scale. Calculation and evaluation of the efficiency of banks is a main pillar of the economy in the current economic status (Fiorentino et al., 2006). A producer is efficient if he/she reaches all the production goals intended for him/her.

There are three type of efficiency, which can be defined as below (Asgharizade and Mollayi, 2005):

***Technical efficiency (TE)***

TE can be defined as the ability of a decision making unit (DMU) (e.g. a bank) to produce a maximum output from a given set of inputs and technology level. The TE score (θ) in the presence of multiple-input and output factors can be calculated by the ratio of the sum of weighted outputs y to the sum of weighted inputs x or in a mathematical expression as follows (Cooper et al., 2004):

$$\theta_j = \frac{u_1 y_{1j} + u_2 y_{2j} + ... + u_s y_{sj}}{v_1 x_{1j} + v_2 x_{2j} + ... + v_m x_{mj}} = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}}$$

where s is the number of outputs, m the number of inputs, n the number of DMUs, $\theta_j$ (j=1, 2, …, n) is the technical efficiency of $DMU_j$, $u_r$ (r = 1, 2, …, s) the weighting of output $y_r$ in the comparison, $v_i$ (i = 1, 2, …, m) the weighting of input $x_i$, and $y_{rj}$ and $x_{ij}$ represent the values of the outputs and inputs $y_j$ and $x_i$ for $DMU_j$, respectively.

***A locative efficiency***

In this type of efficiency, the price of inputs and outputs are considered. So, if a producer according to the prices of inputs and output uses a combination of inputs and outputs such that he has the best possible combination, he is efficient in the basis of allocative efficiency.

***Economic performance***

economic performance based on the technical and allocated efficiencies is defined as below:
Economic performance = Allocatied efficiency × Technical efficiency

Empirical studies have shown that the most practical and useful method for evaluating the performance of an organization is an evaluation based on the measurement of efficiency and productivity (Asgharizade and Mollayi, 2005).

In performance evaluation based on the efficiency and productivity analysis, while comparing the various units of the organization, the decision making units can also be ranked. Currently, non-parametric data envelopment analysis (DEA) and parametric stochastic frontier analysis (SFA) approaches have been introduced to analyze the efficiency of DMUs. But, the superiority of any of these methods have not been investigated and declared completely. The performance evaluation process has some steps that should be done to achieve the desired results. The steps required for the performance evaluation are as follow (Alirezayi and Rezaiyan, 2009): 1- Compilation or review of mission, goals and strategies, 2- Compilation and regulation of efficiency evaluation criteria, 3- Compilation of efficiency criteria related to assessment criteria, 4- notification and prompt of expectations and evaluation criteria to assessed unit, 5- Measurement of actual efficiency, 6- Compare actual efficiency with the benchmark standards, 7-Notification of the assessed unit from the results and how to reach them, 8- Corrective actions for continuous efficiency improvement through performance of self evaluation feedback mechanism.

Investigation of different approaches of efficiency evaluation suggests that the assessment should be proportionate to the growth and development of various dimensions of organizations and it should meet them. Technology development, the role of critical success factors in the performance, domestic and global competitive structure, quality of goods and services provided by the organization and its customers and the market, etc. are the factors that now must be considered in the performance evaluation. Another point should now be consider is the performance management literature; so that, there is a significant relationship between the evaluation results (output) and the evaluation processes and data (input) (Memariyani and Saati, 2005).

Studies have shown that, there is a relationship between the bank's risk management and bank efficiency. Tandlynyn et al. (2007) stated that, the bank efficiency has a negative effect on the risk management and similarly, the risk management also has a negative effect on the bank efficiency (Maria et al., 2010). The results of Cebenoyan et al. (2004) showed that banks which have adequate risk management mechanism will have an increasing efficiency process.

***Literature review***

Alirezayi and Rezaiyan (2009) in the article entitled "Improving the SFA models using DEA: A two-stage approach" stated that among the methods used for the performance evaluation, the nonparametric data envelopment analysis (DEA) and parametric stochastic frontier analysis (SFA) approaches have found

significant applications; however, these methods have advantages and disadvantages including: 1) data envelopment analysis, though, relies on compatibility for low estimates assumptions, but all of these attributes any deviation from the frontier to inefficiency accounts for the disorder and not the measurement error. 2) Although in the stochastic frontier analysis, separating interference and inefficiency are major goals, but this method is not capable of handling this task very well. In this study by using the advantages and eliminating the disadvantages of this method, a two-stage method based on the two above methods are presented and the input and output variables of the DEA model were used in the SFA function as dependent and independent variables. The test results showed improvements in the fusion model.

Wei-Sen Che (2005) in the article entitled "DEA efficiency analysis using ideal DMU" demonstrated that the performance of decision making units (DMU) can be measured from two different perspectives: optimistic and pessimistic, and thus, two different efficiency for each DMU are the best relative performance and the worst relative performance. The conventional method of data envelopment analysis (DEA) is considered just the best relative performance. It is argued here that, both the relative performances should be considered together, and each approach which consideres only one of them, will suffer from bias.

Fiyoritino and Partners (2006) in an article titled "Productivity in German banks: comparison of DEA and SFA" evaluated the efficiency of coordination between the results obtained by two methods the financial economics literature, namely the DEA and SFA . This study examined a sample of 34192 German banks between 1993 and 2004 and analysis of coordination, and came to the conclusion that non-parametric methods are sensitive to measurement errors.

Zhu and Partners (2008) in an article titled "DEA vs. PCA: Detailed study of the economic performance of Chinese cities" compared two methods to promote the integration of multiple inputs and outputs (DMUs), (DEA), (PCA) . The DEA method as a non-statistical method of linear programming to strengthen the input / output and performance ratings (DMUs) uses the method (PCA) as a multivariate statistical method; new values of the compound identified by the input and output uses. Both methods are applied in the real-world data and describe the performance of two cities in China's economy and the complementary results of interaction and coordination of the efficiency. Non-parametric statistical tests in order to give credibility to the rankings achieved by coordination between DEA and PCA have been applied (Safayi and Rahmanpour, 2008).

***Research Questions***

1) How is the performance of banks and bank rankings based on the DEA method?
2) How is the performance of banks and bank rankings based on the SFA method?
3) Is there a significant difference between performance evaluation and bank ranking based on the DEA and SFA methods?

## METHODS OF DATA ANALYSIS

The present study the effectiveness of two different models of parametric (SFA), with an economic basis, and nonparametric (DEA), with the mathematical optimization basis, were examined to evaluate the performance and ranking of banks. In this regard, 10 Iranian banks including Melli, Tejarat, Saderat, Mellat, Maskan, Keshavarzi, Sanat O Madan, Pasargadae, Karafarin and Saman as a statistical research community (within five years from 2005 to 2010) were studied. In the DEA model, the input variables were: number of branches, total deposits and total costs and the output variables were the volume of granted facilities, total income and total investment of banks; while, in the SFA model, the input variables included: investments, granted facilities, deposits in other banks and activities outside of the balance sheet, and the output variables were labor costs, capital costs and total costs. The efficiency of banks was analyzed using Frontier version 4.1 and Deap softwares for the SFA and DEA approaches, respectively. Then for investigating the presence or absence of a significant correlation between the rankings provided by the two methods, the Pearson correlation coefficient was used and the results indicated according to the differences of the methods in performance evaluation and bank rankings, the SFA approach has a relative superiority compared to the DEA method.

## RESULTS AND DISCUSSION

***Results of efficiency calculation using the DEA approach***

The DEA method for estimating the performance of the six variables was used and the variables of volume of bank deposits, collection costs, number of branches were the inputs and the variables of facilities granted and the investment income category were considered as the outputs. The average values of efficiency of 10 banks are presented in Table 1. The results indicated that, except for the banks No. 8 and 9 with the average efficiency of 100% which are classified as fully efficient banks, the remaining banks are classified into the group of inefficient banks and they should identify their reference banks, and so, the optimal values of their inputs and outputs should be specified and the surplus values of the production factors should be calculated for all

branches. Except for the above mentioned fully efficient banks, , bank No. 10 (with an efficiency score of 0.96), and bank No. 7 (with an efficiency score of 0.94) may be classified as the high average efficiency or acceptable efficiency banks; these banks with the average efficiency of more than 90 percent, have a deficiency of maximum 10%; so, they can be perform efficiently by a little optimization of their sources and following their reference banks.

On the other hand, the weakest performance in the studied banks belonged to the performance of the following banks: Bank No. 3 (with a performance score of 0.4) with a 60 percent deficiency, and bank No. 1 (with a performance score of 0.34) with a 66% deficiency. Except for two highly efficient banks, two banks with relatively good performances, and two banks with poor performances, the remaining banks had an average performance on the field of efficiency (with an average efficiency score between 50 to 90 percent).

Table 1. Performance values are calculated using DEA

| No. | Name of Bank | Average performance with DEA |
|---|---|---|
| 1 | Melli | 0.34 |
| 2 | Tejarat | 0.82 |
| 3 | Saderat | 0.4 |
| 4 | Mellat | 0.61 |
| 5 | Maskan | 0.59 |
| 6 | Keshavarzi | 0.64 |
| 7 | Sanat O Madan | 0.94 |
| 8 | Pasargad | 1 |
| 9 | Karafarin | 1 |
| 10 | Saman | 0.96 |

***Results of efficiency calculation using SFA approach***

In the SFA method, for calculating the performance of the banks, from the total variable costs, the outputs (including investments, facilities granted, deposits in other banks and off-balance sheet activities) and the inputs (including labor cost, capital cost and total cost) were used. The performance values for the 10 studied banks were calculated using Frontier software and the corresponding values are presented in Table 2. The results showed that the three banks selected by the statistical community (Mellat, Pasargadae, and Karafarin) with the high average value of a component are banks with the high performance. Other three banks (Melli, Saderat and Maskan) with the average efficiency of less than 0.8 have lower performances. Finally, the banks (Tejarat, Keshavarzi, Sanat O Madan and Saman) with the average efficiency of 0.8 to 1 are classified as the banks with the moderate performance.

Table 2. Performance values are calculated using SFA

| No. | Name of Bank | Average performance with SFA |
|---|---|---|
| 1 | Melli | 0.56 |
| 2 | Tejarat | 0.88 |
| 3 | Saderat | 0.35 |
| 4 | Mellat | 1.252 |
| 5 | Maskan | 0.75 |
| 6 | Keshavarzi | 0.699 |
| 7 | Sanat O Madan | 0.92 |
| 8 | Pasargad | 1.24 |
| 9 | Karafarin | 1.36 |
| 10 | Saman | 0.98 |

Also to answer the question “Is there a significant difference between performance evaluation and ranking of banks based on the DEA and SFA methods?” the Pearson correlation test in SPSS software was used, so that, the efficiency values calculated by DEA and SFA softwares were analyzed, and the results are presented in Table 3. As it is evident from the results of the software, the correlation coefficient between two methods of rankings is zero. In other words, there is a significant difference between the SFA and DEA ranking methods and according to the standard deviation of the rankings methods, the SFA method has a standard deviation equivalent to 0.2 and the DEA method has a standard deviation equivalent to 0.4.

## DISCUSSION AND CONCLUSION

In this article, it was tried to perform a ranking between the DEA and SFA methods in calculating the efficiency of banks to determine which of these two methods are more capable in explaining the performance of banks. According to the results, the ranking of the units was significantly different between the two methods. The DEA method was quite efficient in two banks, two banks had relatively good performances, two banks had poor performances, and the remaining banks had an average performance on the field of efficiency (with an average efficiency score between 50 to 90 percent). In the SFA approach, the banks were classified as 3 high-performance bank, 4 banks with an average efficiency, and 3 banks with lower than average efficiency. Finally,

by using SPSS and Pearson it was determined that using the SFA method is more accurate in assessing the performance of banks and the error level is less. Therefore, the SFA is introduced as a superior method of calculating the efficiency of banks.

Table 3. The performance results with the two methods correlated DEA and SFA

| Std. Error Mean | Std. Deviation | N | Mean | | |
|---|---|---|---|---|---|
| .05168 | .20014 | 10 | .9611 | SFA | Pair 1 |
| .10424 | .40373 | 10 | .9670 | DEA | |

Paired Samples Test

| | Paired differences | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 95% Confidence Interval of the Difference | | | | |
| | Mean | Std. deviation | Std.Error Main | Lower | Upper | t | df | Sig.(2-taileg) |
| Pair SFA-DEA | -.0059 | 0.45054 | 0.11633 | -0.25537 | 0.24363 | -.050 | 14 | 0.96 |

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