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Original article

Ranking and evaluating bank branches using fuzzy data envelopment analysis (case study: Saman bank branches)

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A B S T R A C T

Data Envelopment Analysis (DEA) method is used to evaluate the efficiency of the bank branches. The present paper prioritized the indicators, using fuzzy questionnaires and by gathering the managers' ideas, in order to obtain the most important evaluating indicators. After obtaining these indicators, Data Envelopment Analysis method was used to determine the performance bound interval, regarding the fact that the data are related to a certain period of time and their nature is imprecise and fuzzy. Then, Fuzzy Theory method and Fuzzy Data Envelopment Analysis method were employed to rank the branches, and finally the results were presented.

1. Introduction

Nowadays, measurement has become one of the most fundamental basics of different sciences regarding human achievements. Undoubtedly, science starts when measurement comes into the picture. English physicist Lord Kelvin, regarding the importance of measurement, says: "when we are able to measure and numerically state what we are talking about, we can claim that we know something about it; otherwise our knowledge is flawed and it will never mature" (Rahimi, 2006).

Undoubtedly, the objective of economic growth and development in human societies is to increase the welfare of people and one of the determining factors for measuring the welfare status of a society is the access of society members to the present facilities. In economics, this measurement is called standard of living.

In today's competitive world, creating value and making wealth for stakeholders is one of the major goals for each investor or investee individual and entity.

The management science supports the above-mentioned issues. When we cannot measure something, we cannot control it and when we cannot control something we cannot manage it. The main issue in all the organizational analyses is performance and its improvement requires measurement, hence an organization without a performance measurement system is not thinkable (Rokni Nejad, 2008). Therefore, organizations need a measurement system in order to understand the desirability and appropriateness of their activities, particularly in sophisticated and dynamic environments. On the other hand, the lack of a measurement and control system translates into incoherence among the internal and external environments of that organization, which in turn leads to complications and death of the organization. It is possible that the death of the organization is not felt by its high management since it is very sudden. But studies show that the lack of a feedback system eradicates the possibility of making necessary corrections for growth, development and improvement of the organization's activities, which leads to the death of the organization (Adeli, 2005).

The issues related to performance measurement can be considered from different perspectives. There are two basic viewpoints regarding this issue; namely traditional and modern viewpoints. The traditional viewpoint concerns the judgment and remembering the performance and controlling the entity being evaluated and has a prescriptive style. This viewpoint namely involves the performance of the previous time frame and was created based on the needs of that time frame. The modern viewpoint involves the growth and development of the capacities of the entity being evaluated, improvement and enhancement of individuals, organization and its performance, providing consulting services and the general participation of interested parties, creating motivation and responsiveness in order to improve the quality and optimize the activities and functions. The modern viewpoint is based on identifying weaknesses and strengths in an organization. The context of this viewpoint is the necessities of the contemporary time frame and is developed into a systematic performance measurement using modern methods and techniques. The area covered by the performance measurement can include the general arena of an organization, a unit, a process or the staff.

Banks, as one of the important service entities, are considered the backbone of each economy. Since banks provide different financial and credit services, they have a significant role in economic growth and development. Therefore, there is always the question of how efficient the banks act in an economy and how efficient their services are rendered. The answer to this question can help policy makers to design suitable policies for overcoming the barriers of efficient banking activities and realizing customer satisfaction towards banking services as well as preparing the necessary infrastructure for economic growth and development.

One of the issues related to performance measurement of banks is evaluating and measuring their efficiency. This efficiency criterion determines the general capability of the banks to transform inputs into outputs. By evaluating the efficiency of the banks their capability to use scarce economic resources would be determined and in case of inefficiency, necessary considerations can help increase efficiency. There are several methods for measuring the efficiency of different enterprises including banks. One of the best methods which can calculate and measure the efficiency of enterprises by considering the efficiency of all enterprises is fuzzy data envelopment analysis (FDEA) technique. In this study, using FDEA, the efficiency of 60 branches of Refah Bank in Fars Province, Iran was evaluated and measured by assuming variable to scale.

Many experimental evaluations have to be carried out under estimated and uncertain conditions. This study proposes a type of predictable fuzzy value approach for environmental evaluation of fuzzy and uncertain information in which firstly fuzzy inputs and outputs are evaluated under the predictable values and in the final stage the positive and negative efficiencies are studied under fuzzy uncertain conditions. Ultimately, both types of efficiencies are measured geometrically in order to rank and determine the best performances.

2. Fuzzy set theory

Measuring efficiency has always attracted a lot of attention from researchers due to its importance in performance measurement of a company or an organization. Lotfi A. Zadeh (1965) proposed the fuzzy theory to solve problems in which there were no clear defined criteria (Momeni, 2006). The generality of descriptive terms such as “probably”, “probably it is so”, “not very clear” and “almost dangerous”, which are often seen in every day conversations, indicates that all the descriptions contain some kind of uncertainty. Therefore, the fuzzy theory is used for solving this kind of complications and in the last four decades it has been used in different fields. The fuzzy set theory has grown in different directions and is has been divided into two distinct methods including fuzzy sets as perfectly defined mathematical subjects which are dependent upon laws of classical logic and the linguistic approach (Tzeng, 2006). The most common usage of fuzzy numbers includes trapezoidal and triangular model which is expressed in the following examples:

$$\mu_{\widetilde{A_1}}(X) = \begin{cases} \frac{(x-a)}{b-a}, & a \le x \le b, \\ \frac{d-x}{d-b}, & b \le x \le d, \\ 0, & \text{otherwise}, \end{cases} \qquad (1)$$

$$\mu_{\widetilde{A_2}}(x) = \begin{cases} \frac{x-a}{b-a}, & a \le x \le b, \\ 1, & b \le x \le c, \\ \frac{d-x}{d-c}, & c \le x \le d, \\ 0, & \text{otherwise}, \end{cases} \qquad (2)$$

Triangular and trapezoidal fuzzy numbers are respectively written as (a, b, d), in which a is the left bound, b is the central bound and c is the right bound, and (a, b, c, d), in which a is the left bound, b, c are the central bounds and d is the right bound. It is obvious that triangular fuzzy numbers are a special case of trapezoidal fuzzy numbers in which b=c. For each positive trapezoidal fuzzy number in which $\widetilde{A} = (a_L, a_M, a_N, a_U)$ and $\widetilde{B} = (b_L, b_M, b_N, b_U)$, the addition and multiplication are expressed as $\widetilde{A} + \widetilde{B} = (a_L + b_L, a_M + b_M, a_N + b_N, a_U + b_U)$ and $\widetilde{A} \times \widetilde{B} \approx (a_L b_L, a_M b_M, a_N b_N, a_U b_U)$, respectively.

Assume that we have an n DMUs system in which m is the input and s is the output. If x_{ij}(i = 1,…,m, yrjr=1,…,s and DMUjj=1,…,n is the input and output information, without losing generality, all the input information (x_{ij}) and output information (y_{rj}) are assumed to be uncertain and using trapezoidal fuzzy numbers we will have $\tilde{x}_{ij} = (x_{ij}^L, x_{ij}^M, x_{ij}^N, x_{ij}^U)$ and $\tilde{y}_{rj} = (y_{rj}^L, y_{rj}^M, y_{rj}^N, y_{rj}^U)$. With $x_{ij}^L \ge 0$ and $y_{rj}^L \ge 0$ for $i = 1;\ m, r = 1$ and $s, j, n = 1$, clear information and triangular fuzzy information are considered special cases of trapezoidal fuzzy information: $\tilde{x}_{ij}$ and $\tilde{y}_{rj}$ with $x_{ij}^L = x_{ij}^M = x_{ij}^N = x_{ij}^U$, $y_{rj}^L = y_{rj}^M = y_{rj}^N = y_{rj}^U$ and $x_{ij}^M = x_{ij}^N$, $y_{rj}^M = y_{rj}^N$ the addition of fuzzy numbers’ output weights (FWO) and the addition of fuzzy numbers’ input weights (FWI) from DMU_j are determined using the following formulae:

$$FWO_j = \sum_{r=1}^{s} \tilde{u}_r \tilde{y}_{rj} = \sum_{r=1}^{s} (u_r^L, u_r^M, u_r^N, u_r^U) \times (y_{rj}^L, y_{rj}^M, y_{rj}^N, y_{rj}^U) \qquad (3)$$

$$FWI_j = \sum_{i=1}^{m} \tilde{\nu}_i \tilde{x}_{ij} = \sum_{i=1}^{m} (\nu_i^L, \nu_i^M, \nu_i^N, \nu_i^U) \times (x_{ij}^L, x_{ij}^M, x_{ij}^N, x_{ij}^U) \qquad (4)$$

Based on the addition and multiplication fuzzy operations on two positive fuzzy numbers, formulae (3) and (4) can be written as:

$$FWO_j \approx \left(\sum_{r=1}^{s} u_r^L y_{rj}^L, \sum_{r=1}^{s} u_r^M y_{ij}^M, \sum_{r=1}^{s} u_r^N y_{rj}^N, \sum_{r=1}^{s} u_r^U y_{rj}^U\right) \qquad (5)$$

$$FWI_j \approx \left(\sum_{i=1}^{m} \nu_i^L x_{ij}^L, \sum_{i=1}^{m} \nu_i^M x_{ij}^M, \sum_{i=1}^{m} \nu_i^N x_{ij}^N, \sum_{i=1}^{m} \nu_i^U x_{ij}^U\right) \qquad (6)$$

These can be seen as two trapezoidal fuzzy variables in which the predictable values can be expressed as:

$$E(FWO_j) = \frac{1}{4}\left(\sum_{r=1}^{s} u_r^L y_{rj}^L + \sum_{r=1}^{s} u_r^M y_{rj}^M + \sum_{r=1}^{s} u_r^N y_{rj}^N + \sum_{r=1}^{s} u_r^U y_{rj}^U\right) = \frac{1}{4}\sum_{r=1}^{s}(u_r^L y_{rj}^L + u_r^M y_{rj}^M +$$
urNyrjN+urUyrjU (7)

$$E(FWI_j) = \frac{1}{4}\left(\sum_{i=1}^{m} \nu_i^L x_{ij}^L + \sum_{i=1}^{m} \nu_i^M x_{ij}^M + \sum_{i=1}^{m} \nu_i^N x_{ij}^N + \sum_{i=1}^{m} \nu_i^U x_{ij}^U\right) = \frac{1}{4}\sum_{i=1}^{m}(\nu_i^L x_{ij}^L + \nu_i^M x_{ij}^M + \nu_i^N x_{ij}^N +$$
viUxijU (8)

Accordingly, the efficiency and capability of $\mathrm{DMU_j}$ in a fuzzy environment can be shown as:

$$\theta_j = \frac{E(FWO_j)}{E(FWI_J)} = \frac{\sum_{r=1}^{s}\left(u_r^L y_{rj}^L + u_r^M y_{rj}^M + u_r^N y_{rj}^N + u_r^U y_{rj}^U\right)}{\sum_{i=1}^{m}\left(\nu_i^L x_{ij}^L + \nu_i^M x_{ij}^M + \nu_i^N x_{ij}^N + \nu_i^U x_{ij}^U\right)},\ j = 1, \dots, n \tag{9}$$

This formula indicates a clear function using which $\mathrm{nDMU_s}$ can be easily measured and compared. θ_j Can be calculated using different approaches. In order to evaluate a DMU, in other and better words a $\mathrm{DMU_0}$, for maximizing θ_0 we can do the calculations using an optimistic view and the following programmed and fractional model which provides the best relative solution:

$$\text{Maximize } \theta_0^{best} = \frac{\sum_{r=1}^{s}(u_r^L y_{r0}^L + u_r^M y_{r0}^M + u_r^N y_{r0}^N + u_r^U y_{r0}^U)}{\sum_{i=1}^{m}(\nu_i^L x_{i0}^L + \nu_i^M x_{i0}^M + \nu_i^N x_{i0}^N + \nu_i^U x_{i0}^U)} \tag{10}$$

$$\text{Subject to } \theta_j^{best} = \frac{\sum_{r=1}^{s}\left(u_r^L y_{rj}^L + u_r^M y_{rj}^M + u_r^N y_{rj}^N + u_r^U y_{rj}^U\right)}{\sum_{i=1}^{m}\left(\nu_i^L x_{ij}^L + \nu_i^M x_{ij}^M + \nu_i^N x_{ij}^N + \nu_i^U x_{ij}^U\right)} \le 1,\quad j = 1, \dots, n\ ;\ u_r^U \ge u_r^N \ge u_r^M \ge u_r^L \ge 0,\quad r = 1, \dots, s\ ;$$

$$\nu_i^U \ge \nu_i^N \ge \nu_i^M \ge \nu_i^L \ge 0,\quad i = 1, \dots, m$$

But from a negative view $\theta_0$can be calculated using the following formula which generally gives the worst performance for $\mathrm{DMU_0}$ compared to other cases:

$$\text{Minimize } \theta_0^{best} = \frac{\sum_{r=1}^{s}(u_r^L y_{r0}^L + u_r^M y_{r0}^M + u_r^N y_{r0}^N + u_r^U y_{r0}^U)}{\sum_{i=1}^{m}(\nu_i^L x_{i0}^L + \nu_i^M x_{i0}^M + \nu_i^N x_{i0}^N + \nu_i^U x_{i0}^U)} \tag{11}$$

Subject to:

$$\theta_j^{best} = \frac{\sum_{r=1}^{s}\left(u_r^L y_{rj}^L + u_r^M y_{rj}^M + u_r^N y_{rj}^N + u_r^U y_{rj}^U\right)}{\sum_{i=1}^{m}\left(\nu_i^L x_{ij}^L + \nu_i^M x_{ij}^M + \nu_i^N x_{ij}^N + \nu_i^U x_{ij}^U\right)} \ge 1,\quad j = 1, \dots, n$$

$$u_r^U \ge u_r^N \ge u_r^M \ge u_r^L \ge 0,\quad r = 1, \dots, s$$

$$\nu_i^U \ge \nu_i^N \ge \nu_i^M \ge \nu_i^L \ge 0,\quad i = 1, \dots, m$$

Using the transformation formula (Charnes and Cooper, 1962), the above-mentioned fractional formula can be transformed into a linear one:

$$\text{Maximize } \theta_0^{best} = \textstyle\sum_{r=1}^{s}(u_r^L y_{r0}^L + u_r^M y_{r0}^M + u_r^N y_{r0}^N + u_r^U y_{r0}^U) \tag{12}$$

Subject to

$$\textstyle\sum_{i=1}^{m}\left(\nu_i^L x_{i0}^L + \nu_i^M x_{i0}^M + \nu_i^N x_{i0}^N + \nu_i^U x_{i0}^U\right) = 1,$$

$$\textstyle\sum_{r=1}^{s}\left(u_r^L y_{rj}^L + u_r^M y_{rj}^M + u_r^N y_{rj}^N + u_r^U y_{rj}^U\right),$$

$$-\textstyle\sum_{i=1}^{m}\left(\nu_i^L x_{ij}^L + \nu_i^M x_{ij}^M + \nu_i^N x_{ij}^N + \nu_i^U x_{ij}^U\right) \le 0,\ \ j = 1, \dots, n$$

$$u_r^U \ge u_r^N \ge u_r^M \ge u_r^L \ge 0,\quad r = 1, \dots, s$$

$$\nu_i^U \ge \nu_i^N \ge \nu_i^M \ge \nu_i^L \ge 0,\quad i = 1, \dots, m$$

And

$$\text{Minimize } \theta_0^{best} = \textstyle\sum_{r=1}^{s}(u_r^L y_{r0}^L + u_r^M y_{r0}^M + u_r^N y_{r0}^N + u_r^U y_{r0}^U) \tag{13}$$

Subject to

$$\textstyle\sum_{i=1}^{m}\left(\nu_i^L x_{i0}^L + \nu_i^M x_{i0}^M + \nu_i^N x_{i0}^N + \nu_i^U x_{i0}^U\right) = 1,$$

$$\textstyle\sum_{r=1}^{s}\left(u_r^L y_{rj}^L + u_r^M y_{rj}^M + u_r^N y_{rj}^N + u_r^U y_{rj}^U\right)$$

$$-\textstyle\sum_{i=1}^{m}\left(\nu_i^L x_{ij}^L + \nu_i^M x_{ij}^M + \nu_i^N x_{ij}^N + \nu_i^U x_{ij}^U\right) \ge 0,\quad j = 1, \dots, n$$

$$u_r^U \ge u_r^N \ge u_r^M \ge u_r^L \ge 0,\quad r = 1, \dots, s$$

$$\nu_i^U \ge \nu_i^N \ge \nu_i^M \ge \nu_i^L \ge 0,\quad i = 1, \dots, m$$

If $\theta_0^{best} = 1$, $\mathrm{DMU_0}$ has an optimistic efficiency; otherwise, it will not have an optimistic efficiency and productivity. Accordingly, if $\theta_0^{worst} = 1$, then $\mathrm{DMU_0}$ does not have a pessimistic efficiency; otherwise, it will have a pessimistic productivity. Since both efficiencies have been measured using different approaches with distinct productivity ranges; usually they cannot be compared regarding scale or function range. In other words, pessimistic efficiency θ_0^{worst} would not be less than optimistic efficiencyθ_0^{best}. Based on the theory of Wang, Chin and Young (2007) the optimistic and pessimistic efficiencies measure the $\mathrm{nDMU_s}$ functions in two infinite conditions, which means that they reveal either the best or the worst function. Theoretically, these two efficiencies should be calculated simultaneously in both infinite conditions (the best and the worst) so that a general measurement for the functions of each $\mathrm{nDMU_s}$ can be realized. This function is generally called double frontier analysis (DFA). Finally, Wang et al. propose a geometric mean efficiency index:

$$\theta_j^{Geometric} = \sqrt{\theta_j^{best} \times \theta_j^{worst}}, \quad j = 1, \dots, n \tag{14}$$

And believe that it can calculate a general function of DMU_j. At first, since $\theta_j^{Geometric}$ showed the geometric mean of both efficiencies it was considered as half-efficiency mean. But then since $\theta_j^{Geometric}$ was indeed a combination of optimistic and pessimistic efficiencies, it was considered more logical and understandable than all the other conditions. Therefore, in the current paper we use geometric mean efficiency method for measuring the general function of $nDMU_s$ in a fuzzy environment. It is worth mentioning that clear inputs and outputs should be measured by certain weights which needs fuzzy weights of $nDMU_s$ so that the conditions $\tilde{\nu}_i = (\nu_i^L, \nu_i^M, \nu_i^N, \nu_i^U)$ and $\tilde{u}_r = (u_r^L, u_r^M, u_r^N, u_r^U)$ from $\nu_i^U = \nu_i^N = \nu_i^M = \nu_i^L$ and $u_r^U = u_r^N = u_r^M = u_r^L$ can be prepared for receiving clear inputs and outputs.

If we consider the sets $u_r^U = u_r^N = u_r^M = u_r^L \geq 0$ and $\nu_i^U = \nu_i^N = \nu_i^M = \nu_i^L \geq 0$ for $r = 1, \dots, s$ and $i = 1, \dots, m$ then we reach the conclusion that:

$$\theta_j = \frac{\sum_{r=1}^{s} u_r\left(y_{rj}^L + y_{rj}^M + y_{rj}^N + y_{rj}^U\right)}{\sum_{i=1}^{m} \nu_i\left(x_{ij}^L + x_{ij}^M + x_{ij}^N + x_{ij}^U\right)} = \frac{\sum_{r=1}^{s} u_r E(\tilde{y}_{rj})}{\sum_{i=1}^{m} \nu_i E(\tilde{x}_{ij})}, \quad j = 1, \dots, n \tag{15}$$

Where $E(\tilde{x}_{ij})$ and $E(\tilde{y}_{rj})$ are respectively the predictable values of fuzzy input $\tilde{x}_{ij}$ and fuzzy output $\tilde{y}_{rj}$ which can be considered as defined inputs and outputs for DMU_j. Under these conditions, the formulae for fuzzy and predictable values (12) and (13) are transformed into the formulae for the environmental evaluation of fuzzy information which are presented below:

$$\text{Maximize } \theta_0^{best} = \sum_{r=1}^{s} u_r E(\tilde{y}_{r0}) \tag{16}$$

Subject to

$$\sum_{i=1}^{m} \nu_i E(\tilde{x}_{i0}) = 1,$$
$$\sum_{r=1}^{s} u_r E(\tilde{y}_{rj}) \leq 0, \; j = 1, \dots, n$$
$$u_r, \nu_i \geq 0, \; r = 1, \dots s; \; i = 1, \dots, m$$

And

$$\text{Minimize } \theta_0^{worst} = \sum_{r=1}^{s} u_r E(\tilde{y}_{ro}) \tag{17}$$

Subject to

$$\sum_{i=1}^{m} \nu_i E(\tilde{x}_{i0}) = 1,$$
$$\sum_{r=1}^{s} u_r E(\tilde{y}_{rj}) - \sum_{i=1}^{m} \nu_i E(\tilde{x}_{ij}) \leq 0, \quad j = 1, \dots, n$$
$$u_r, \nu_i \geq 0, \quad r = 1, \dots, s; \quad i = 1, \dots, m.$$

These two linear formulae are less free and flexible than the formulae (12) and (13) in choosing the best and worst values for each DMU. Therefore, calculating θ_0^{best} using formula (16) would not have a larger value than calculating it using formula (12). Accordingly, calculating θ_0^{worst} using formula (17) would not yield a lower value than calculating it using formula (13). Since triangular fuzzy numbers and obvious numbers are special cases of trapezoidal fuzzy numbers, the linear formulae (16), (17), (20) and (21) can also be used for calculating obvious input and output information as well as triangular fuzzy input and output information. For instance, consider triangular fuzzy information. In this case, the linear formulae (12) and (13) are expressed as:

$$\text{Maximize } \theta_0^{best} = \sum_{r=1}^{s} (u_r^L y_{r0}^L + 2u_r^M y_{r0}^M + u_r^U y_{r0}^U) \tag{18}$$

Subject to

$$\sum_{i=1}^{m} \left(\nu_i^L x_{i0}^L + 2\nu_i^M x_{i0}^M + \nu_i^U x_{i0}^U\right) = 1,$$
$$\sum_{r=1}^{s} \left(u_r^L y_{rj}^L + 2u_r^M y_{rj}^M + u_r^U y_{rj}^U\right)$$
$$- \sum_{i=1}^{m} \left(\nu_i^L x_{ij}^L + 2\nu_i^M x_{ij}^M + \nu_i^U x_{ij}^U\right) \geq 0, \quad j = 1, \dots, n$$
$$u_r^U \geq u_r^M \geq u_r^L \geq 0, \quad r = 1, \dots, s$$
$$\nu_r^U \geq \nu_i^M \geq \nu_i^L \geq 0, \quad r = 1, \dots, m$$

$$\text{Minimize } \theta_0^{best} = \sum_{r=1}^{s} (u_r^L y_{r0}^L + 2u_r^M y_{r0}^M + u_r^U y_{r0}^U) \tag{19}$$

Subject to

$$\sum_{i=1}^{m} \left(\nu_i^L x_{i0}^L + 2\nu_i^M x_{i0}^M + \nu_i^U x_{i0}^U\right) = 1,$$
$$\sum_{r=1}^{s} \left(u_r^L y_{rj}^L + 2u_r^M y_{rj}^M + u_r^U y_{rj}^U\right)$$
$$- \sum_{i=1}^{m} \left(\nu_i^L x_{ij}^L + 2\nu_i^M x_{ij}^M + \nu_i^U x_{ij}^U\right) \geq 0, \quad j = 1, \dots, n$$
$$u_r^U \geq u_r^M \geq u_r^L \geq 0, \quad r = 1, \dots, s$$

$\nu_r^U \geq \nu_i^M \geq \nu_i^L \geq 0, \quad r = 1, \dots, m$

And $\tilde{u}_r = (u_r^L, u_r^M, u_r^U)$ and $\tilde{v}_i = (\nu_i^L, \nu_i^M, \nu_i^U)$ are, respectively, triangular fuzzy values for triangular fuzzy input $\tilde{x}_{ij} = (x_{ij}^L, x_{ij}^M, x_{ij}^U)$ and triangular fuzzy output $\tilde{y}_{rj} = (y_{rj}^L, y_{rj}^M, y_{rj}^U)$.

3. Data gathering methods

In order to gather the required data for the different components and aspects of the model, the studies were carried out in a theoretical- survey manner. The theoretical information and foundations were gathered based on laboratory searches and the articles published on the internet. Also the data related to each studied branch was gathered from the documents of the branch. In order to evaluate the more important measures for the branches, after designing the questionnaire, each one of the staff was individually evaluated. At first, in order to harmonize the execution method, some explanations regarding the answers to questionnaires and the necessity to be honest, since there are no right or wrong answers were presented. Then, the staff completed the questionnaire. The financial variables questionnaire for evaluating the financial performance of the bank has four sections including capital structure, profitability, growth and liquidity with 38 components and in order to evaluate the more important measures based on the inputs and outputs, the evaluation model is assessed as follows:

Section	Inputs	Outputs
Capital	Debt ratio	Operating margin
Structure	Ownership ratio	Asset quality
	The ratio of personnel cost to total revenue	Deferred receivables to past due loans
	Depreciation cost and storage	Doubtful receivables cost to loans
	Fixed assets to assets	
	Total number of personnel	
	Total loans to total assets	
Profitability	Operating expenses to total income	Return on assets
	Ownership ratio	Return on equity
	Personnel expenses to total income	Profit margins
	Current fees	Net profit margin
	Fixed assets to total assets	Loans to deposits
	Total number of personnel	Operating income
		Commissions received
		Total loans
		Ancillary revenues
		Credit risk and interest rate of loans
Growth	Ownership ratio	Profit Growth Before Tax Rate
	Personnel expenses to total revenue	Growth rate of loans
	Financing costs	The growth rate of effective deposits
	Fixed assets to total assets	Income growth rate
	Total number of personnel	The share of effective deposits
		Share of loans
		Civil Partnership loans
Liquidity	All the loans to all the deposits	(Balance cash + bonds) to total deposits

Among these 38 presented questions, the questions 3, 19, 20, 21, 22, 27, 32, 33, 34 and 38 measure capital structure; questions 2, 8, 9, 11, 14, 16, 17, 18, 23, 24, 25, 26, 35, 36 and 37 measure profitability; questions 1, 4, 5, 6, 7, 10, 12, 13 and 15 measure growth and finally questions 28, 29, 30 and 31 measure liquidity. In this questionnaire, which is obtained based on the financial standard questionnaire of the bank, the importance of each one of the measures in determining the efficiency of the branches compared to each other is presented qualitatively. This questionnaire was distributed among thee and staff managers as well as executives of some of the branches in the statistical population and regarding the fact that the majority of the questionnaires are qualitative we should first transform their data into quantitative data and then we will be able to use them. But in most cases in order to transform qualitative information into quantitative ones, coefficients are used which are not numerically justified.

4. Conclusions

After gathering the questionnaires, in order to transform qualitative options into quantitative ones, fuzzy logic is used and for each measure, an absolute numeral was obtained for its importance level. The results from the questionnaires and the appropriate absolute numerals for each measure are presented in the following tables.

First of all, 60 branches of Saman Bank whose data was available were chosen (Table 5.1). Then, in order to calculate their efficiency, the desired data were extracted based on input and output criteria and presented in Table 2.5. Then, we noted that the performance of the branches depends on the number of staff, the ratio of total loans to total deposits, the total current fees, the ratio of overdue receivables to the total loans and effective deposits. The information related to inputs and outputs of sixty branches of Saman Bank are presented in Tables 5.2, 5.3, 5.4, 5.5 and 5.6.

Table 1
The List of Saman Bank Branches.

No.	Branch	Measure	No.	Branch	Measure
1	Shiraz	211	31	Qaem- Shiraz	816
2	Marvdasht	251	32	Amirkabir- Shiraz	820
3	Shariati-Shiraz	267	33	Quar	821
4	Kazeroun	313	34	Kazeroon Gate- Shiraz	839
5	Fasa	345	35	Enghgelab- Marvdasht	874
6	Modarres-Shiraz	346	36	Qaani No- Shiraz	918
7	Jahrom	350	37	Karim Khan Zand- Shiraz	921
8	Abadeh	364	38	Teimouri- Shiraz	922
9	Firouzabad	371	39	Mirzaye Shirazi	923
10	Tabriz	372	40	Hedayat- Shiraz	988
11	Eqlid	388	41	Hazrati- Kazeroun	994
12	Laar	441	42	Lamerd	1016
13	Sadi-Shiraz	489	43	Hang- Shiraz	1021
14	Darab	530	44	Pasdaran- Shiraz	1035
15	Palestine- Shiraz	545	45	Sourian- Bavanat	1058
16	Daneshjoo-Shiraz	550	46	Arsanjan	1059
17	Farhangshahr- Shiraz	551	47	Sepidan	1060
18	Bahonar- Shiraz	557	48	Takhti- Shiraz	1090
19	Estahban	574	49	Imam Khomeini Bazaar- Shiraz	1091
20	Nourabad Mamasani	583	50	Imam Khomeini- Firouzabad	1171
21	Moalem- Mrvdasht	601	51	Imam Khomeini- Abadeh	1172
22	Rahmatabad- Shiraz	605	52	Khoram Bid	1206
23	Sibuye Blvd.	632	53	Khonj	1207
24	Eram Blvd. Shiraz	633	54	Hakim- Shiraz	1251
25	Motahari- Shiraz	634	55	Aretesh Sevom- Shiraz	1252
26	Parseh	635	56	30 Meters Sadi Cinema	1253
27	Pezeshkan- Shiraz	637	57	Satarkhan- Shiraz	1342
28	Nasr Blvd. Shiraz	734	58	Qirokarzin	1384
29	Edalat Blvd. Shiraz	773	59	Golestan Town	1385
30	Pasargad	808	60	22 Bahman- Jahrom	1393

Table 2
Inputs; the Number of Staff.

DMUs	Inputs			DMUs	Inputs			DMUs	Inputs		
	L	M	U		L	M	U		L	M	U
211	22	26	27	633	3	4	7	1060	3	4	7
251	14	16	17	634	7	8	10	1090	4	5	8
267	7	9	10	635	4	5	8	1091	5	6	9
313	7	9	10	637	4	5	8	1171	4	5	8
345	9	10	11	734	6	7	10	1172	3	4	7
346	17	19	20	773	5	6	9	1206	3	4	7
350	7	9	10	808	3	4	7	1207	4	5	8
364	6	7	9	816	5	6	9	1251	6	8	9
371	5	6	9	820	6	7	10	1252	7	8	9
372	7	9	11	821	5	6	9	1253	6	7	9
388	8	10	12	839	4	5	8	1342	5	6	8
441	3	4	7	874	10	12	13	1384	2	3	6
489	6	7	9	918	4	5	8	1385	4	5	7
530	8	9	11	921	10	13	14	1393	3	4	7
545	6	7	10	922	8	10	11				
550	5	6	9	923	7	8	10				
551	7	8	10	988	4	5	7				
557	7	9	11	994	4	5	7				
574	5	6	9	1016	5	6	9				
583	7	8	10	1021	3	4	7				
601	7	8	10	1035	8	9	10				
605	5	6	9	1058	4	5	8				
632	8	9	12	1059	2	3	6				

Table 3
Inputs; the Ratio of Total Loans to Total Deposits.

DMUs	Inputs			DMUs	Inputs		
	L	M	U		L	M	U
211	0.5000	0.5513	0.8000	816	0.4000	0.4138	0.8000
251	0.8000	1.3135	1.3500	820	0.5500	0.7340	0.8500
267	0.2700	0.2751	0.8000	821	0.5000	0.6232	0.8000
313	0.8000	1.1537	1.2000	839	0.4500	0.5392	0.8000
345	0.5000	0.8357	0.9000	874	0.7000	0.9935	1.0000
346	0.4500	0.4914	0.8000	918	0.5500	0.7225	0.8500
350	0.8000	1.1134	1.2000	921	0.5000	0.6119	0.8000
364	0.5500	0.8446	0.9000	922	0.9000	1.1003	1.2000
371	0.5700	0.7326	0.8500	923	0.5000	0.6722	0.8000
372	0.8000	1.2568	1.3000	988	0.5000	0.7260	0.8500
388	0.6400	0.8424	0.9000	994	0.5000	0.6662	0.8000
441	0.4000	0.4147	0.8000	1016	0.4500	0.5009	0.8000
489	0.5800	0.6874	0.8000	1021	0.2500	0.2781	0.7000
530	0.5200	0.7227	0.8500	1035	0.5000	0.8421	0.9500
545	0.5700	0.7785	0.8500	1058	1.0000	1.3583	1.4000
550	0.4000	0.4218	0.8000	1059	0.5000	0.6796	0.8000
551	0.5000	0.6076	0.8000	1060	0.5000	0.7660	0.8500
557	1.5000	1.8260	1.9000	1090	0.5000	0.5921	0.8000
574	1.3000	1.3273	1.3500	1091	0.2000	0.2284	0.6500
583	1.5000	1.6045	1.6500	1171	0.9000	1.1597	1.2000
601	0.7500	0.9502	1.0000	1172	0.5000	0.7698	0.9500
605	0.3000	0.3141	0.6000	1206	1.1000	1.7416	1.8000
632	0.5000	0.5520	0.8000	1207	0.4000	0.4828	0.8000
633	0.1900	0.2005	0.5000	1251	0.4000	0.4619	0.8000
634	0.4000	0.4547	0.8000	1252	0.5000	0.7354	0.8500
635	1.0000	1.2411	1.3000	1253	0.3000	0.3429	0.8000
637	1.3000	1.5265	1.5500	1342	0.5000	0.6992	0.9000
734	0.5000	0.5566	0.8000	1384	0.5000	0.7543	0.9500
773	0.5000	0.5811	0.8000	1385	0.2000	0.2872	0.7000
808	1.0000	1.1460	1.2000	1393	0.5000	0.8214	0.9500

Table 4
Inputs; the Total Current Fees (in Million Rial).

DMUs	Inputs			DMUs	Inputs		
	L	M	U		L	M	U
211	300	363	500	816	150	205	300
251	350	477	550	820	100	159	300
267	150	193	350	821	150	207	300
313	177	277	500	839	80	116	200
345	250	349	500	874	250	336	450
346	221	321	500	918	90	119	250
350	291	391	500	921	200	244	350
364	150	191	350	922	220	261	350
371	229	259	350	923	220	267	350
372	191	221	350	988	500	800	1,000
388	280	384	500	994	150	189	300
441	152	172	300	1016	200	229	320
489	100	149	300	1021	100	125	250
530	100	144	300	1035	110	167	300
545	100	127	250	1058	220	258	350
550	450	535	800	1059	150	201	300
551	200	220	300	1060	100	153	300
557	150	183	250	1090	100	128	250
574	150	177	220	1091	150	175	300
583	240	261	290	1171	450	591	800
601	850	881	980	1172	400	427	550
605	978	1,028	1,050	1206	300	348	500
632	10	147	300	1207	300	368	500
633	1,500	1,664	1,700	1251	150	184	320
634	2,500	2,857	3,000	1252	210	264	360
635	350	451	550	1253	170	211	300
637	100	148	250	1342	110	152	300
734	110	169	300	1384	200	273	370
773	120	179	300	1385	600	649	800
808	1,100	1,321	1,350	1393	790	895	1,000

Table 5
Outputs, Effective Deposits.

DMUs	Output			DMUs	Output		
	L	M	U		L	M	U
211	470,397	474,397	490,000	816	150,000	152,920	158,000
251	172,031	177,031	179,000	820	85,000	87,592	90,000
267	129,348	135,348	136,000	821	68,000	69,073	73,000
313	82,172	88,172	89,500	839	80,000	81,630	86,000
345	193,230	199,230	205,000	874	150,000	152,101	157,000
346	155,179	159,179	165,000	918	61,000	62,508	67,000
350	96,000	96,037	98,000	921	270,006	271,896	274,000
364	73,080	73,380	77,000	922	110,000	111,412	120,000
371	110,962	115,962	120,000	923	202,000	204,764	210,000
372	64,000	64,285	67,000	988	47,000	48,661	52,000
388	114,000	114,462	120,000	994	116,000	117,825	120,000
441	50,000	50,476	53,000	1016	82,000	83,113	85,000
489	72,000	72,270	75,000	1021	167,000	168,331	170,000
530	98,000	98,663	100,000	1035	125,718	127,718	130,000
545	122,104	124,104	128,000	1058	36,000	37,425	40,000
550	90,000	90,464	93,000	1059	56,000	56,937	60,000
551	93,000	93,979	96,000	1060	55,000	55,564	59,000
557	122,000	124,149	128,000	1090	57,839	59,839	63,000
574	49,000	49,417	53,000	1091	100,522	102,522	105,000
583	82,000	83,440	86,000	1171	41,000	41,409	46,000
601	62,000	62,503	66,000	1172	55,000	55,939	60,000
605	261,000	263,695	268,000	1206	29,000	29,925	33,000
632	75,083	75,583	77,000	1207	84,000	85,528	89,000
633	100,014	104,014	109,014	1251	150,000	151,377	156,000
634	230,000	231,845	235,000	1252	101,163	103,163	107,000
635	70,000	70,373	75,000	1253	115,000	120,009	125,000
637	89,000	89,248	93,000	1342	152,000	155,692	160,000
734	90,000	90,370	95,000	1384	20,000	20,096	25,000
773	81,000	82,262	86,000	1385	80,000	80,877	85,000
808	31,000	33,389	37,000	1393	23,000	23,147	27,000

Table 6
Outputs; Overdue Receivables to Total Loans (in Million Rials).

DMUs	Output			DMUs	Output		
	L	M	U		L	M	U
211	0.0025	0.0039	0.0055	816	0.0004	0.0009	0.0029
251	0.0085	0.0099	0.0121	820	0.0001	0.0006	0.0026
267	0.3500	0.0050	0.0075	821	0.0135	0.0132	0.0152
313	0.0015	0.0030	0.0050	839	0.0001	0.0015	0.0035
345	0.0055	0.0067	0.0085	874	0.0047	0.0067	0.0087
346	0.0030	0.0045	0.0063	918	0.0013	0.0032	0.0052
350	0.0046	0.0066	0.0085	921	0.0010	0.0030	0.0050
364	0.0001	0.0004	0.0015	922	0.0011	0.0031	0.0051
371	0.0085	0.0103	0.0120	923	0.0070	0.0092	0.0112
372	0.0067	0.0086	0.0102	988	0.0002	0.0014	0.0034
388	0.0030	0.0042	0.0061	994	0.0015	0.0034	0.0054
441	0.0005	0.0010	0.0030	1016	0.0075	0.0094	0.0114
489	0.0055	0.0067	0.0085	1021	0.0035	0.0050	0.0070
530	0.0040	0.0055	0.0084	1035	0.0012	0.0027	0.0047
545	0.0001	0.0003	0.0014	1058	0.0035	0.0051	0.0071
550	0.0001	0.0003	0.0014	1059	0.0170	0.0197	0.0220
551	0.0030	0.0047	0.0061	1060	0.0050	0.0076	0.0095
557	0.0050	0.0067	0.0084	1090	0.0050	0.0072	0.0092
574	0.0190	0.0212	0.0232	1091	0.0120	0.0141	0.0161
583	0.0135	0.0150	0.0180	1171	0.0060	0.0081	0.0101
601	0.0190	0.0205	0.0235	1172	0.0020	0.0041	0.0061
605	0.0050	0.0064	0.0084	1206	0.0095	0.0120	0.0140
632	0.0099	0.0115	0.0135	1207	0.0098	0.0119	0.0139
633	0.0070	0.0087	0.0099	1251	0.0035	0.0054	0.0076
634	0.0020	0.0036	0.0050	1252	0.0002	0.0009	0.0029
635	0.0100	0.0121	0.0141	1253	0.0003	0.0053	0.0073
637	0.0005	0.0009	0.0029	1342	0.0040	0.0065	0.0085
734	0.0120	0.0136	0.0155	1384	0.0008	0.0023	0.0043
773	0.0079	0.0103	0.0123	1385	0.0028	0.0038	0.0058
808	0.0202	0.0227	0.0247	1393	0.0000	0.0000	0.0025

Since inputs and outputs use fuzzy numbers, using the proposed method for the entire sixty branches, the positive and negative items were obtained and presented in Table 5.7.

Table 7
Geometrical Average.

DMUs	Optimistic efficiency (θ_0^{best})	Pessimistic efficiency (θ_0^{worst})	Geometric average efficiency ($\theta_0^{Geometric}$)
211	1.00	1.75	1.32
251	o.45	1.57	0.84
267	o.72	2.39	1.31
313	o.31	1.53	0.69
345	o.60	2.76	1.29
346	0.51	1.17	0.77
350	0.35	1.72	0.78
364	0.30	1.00	0.55
371	0.61	2.88	1.33
372	0.48	1.16	0.75
388	0.36	1.80	0.80
441	0.30	1.91	0.76
489	0.67	1.51	1.01
530	0.73	1.54	1.06
545	0.74	1.00	0.86
550	0.36	1.00	0.60
551	0.38	1.68	0.80
557	0.62	1.84	1.07
574	1.00	1.11	1.05
583	0.70	1.40	0.99
601	0.73	1.13	0.91
605	1.00	6.43	2.54
632	0.95	1.18	1.06
633	1.00	2.28	1.51
634	0.69	1.78	1.11
635	0.54	1.95	1.03
637	0.54	1.00	0.73
734	1.00	1.90	1.38
773	0.76	2.07	1.25
808	0.92	1.00	0.96
816	0.66	2.32	1.24
820	0.52	1.28	0.82
821	0.86	1.74	1.22

In this method, the system's inputs and outputs are respectively entered into the fuzzy value model and predictable model and finally using fuzzy or apparent weights, the optimistic and pessimistic efficiencies of the system are calculated. Then, by considering these efficiencies and calculating the geometrical average, the total and ultimate performance of the system are determined in order to identify the best performances (Table 5.8).

5. Conclusions

Based on Table 6.8, it is clear that the branches 1021, 605 and 1342 have optimistic efficiency. However, the 1342 branch has some weaknesses too. Hence, in general, this branch has not performed as well as the branches 1021 and 605. According to the geometrical efficiency average, we can rank them based on their priority as follows:

$1393 < \cdots < 1091 < 923 < 1059 < 1342 < 605 < 1021$

DMUs	Optimistic efficiency (θ_0^{best})	Pessimistic efficiency (θ_0^{worst})	Geometric average efficiency ($\theta_0^{Geometric}$)
839	0.61	2.27	1.18
874	0.45	1.90	0.92
918	0.49	1.97	0.98
921	0.89	2.27	1.42
922	0.36	1.76	0.80
923	0.77	3.66	1.68
988	0.24	1.53	0.61
994	0.60	3.67	1.48
1016	0.58	2.08	1.10
1021	1.00	7.00	2.65
1035	0.69	1.84	1.13
1058	0.26	1.00	0.51
1059	1.00	2.89	1.70
1060	0.68	2.34	1.26
1090	0.69	1.87	1.14
1091	1.00	2.56	1.60
1171	0.34	1.23	0.65
1172	0.39	2.36	0.96
1206	0.47	1.00	0.69
1207	0.72	2.68	1.39
1251	0.68	3.16	1.47
1252	0.35	1.33	0.68
1253	0.58	2.49	1.20
1342	0.92	3.88	1.89
1384	0.24	1.00	0.49
1385	0.54	2.54	1.17
1393	0.14	1.00	0.37

This ranking is somewhat different than the rankings proposed by Wong et al. based on fuzzy environment evaluation using mathematical principles. The reason behind this difference is that Wong ranked the companies only based on their optimistic efficiency and neglected their weaknesses. The efficiency of these branches has been computed using the linear formulae 20 and 21. In this method, real values are used for all the inputs and outputs. According to the obtained results it is clear that using this method we will reach the same rankings as the previous one for the sixty branches of Saman Bank. However, determining the best performance using this method of evaluation will be much easier and more comprehensive.

Table 8
Rankings for All the Branches.

DMUs	Optimistic efficiency (θ_0^{best})	Pessimistic efficiency (θ_0^{worst})	Geometric average efficiency ($\theta_0^{Geometric}$)	Ranking	DMUs	Optimistic efficiency (θ_0^{best})	Pessimistic efficiency (θ_0^{worst})	Geometric average efficiency ($\theta_0^{Geometric}$)	Ranking
530	0.73	1.54	1.06	30	1393	0.14	1.00	0.37	60
632	0.95	1.18	1.06	29	1384	0.24	1.00	0.49	59
557	0.62	1.84	1.07	28	1058	0.26	1.00	0.51	58
1016	0.58	2.08	1.10	27	364	0.30	1.00	0.55	57
634	0.69	1.78	1.11	26	550	0.36	1.00	0.60	56
1035	0.69	1.84	1.13	25	988	0.24	1.53	0.61	55
1090	0.69	1.87	1.14	24	1171	0.34	1.23	0.65	54
1385	0.54	2.54	1.17	23	1252	0.35	1.33	0.68	53
839	0.61	2.27	1.18	22	313	o.31	1.53	0.69	52
1253	0.58	2.49	1.20	21	1206	0.47	1.00	0.69	51
821	0.86	1.74	1.22	20	637	0.54	1.00	0.73	50
816	0.66	2.32	1.24	19	372	0.48	1.16	0.75	49
773	0.76	2.07	1.25	18	441	0.30	1.91	0.76	48
1060	0.68	2.34	1.26	17	346	0.51	1.17	0.77	47
345	o.60	2.76	1.29	16	350	0.35	1.72	0.78	46
267	o.72	2.39	1.31	15	388	0.36	1.80	0.80	45
211	1.00	1.75	1.32	14	551	0.38	1.68	0.80	44
371	0.61	2.88	1.33	13	922	0.36	1.76	0.80	43
734	1.00	1.90	1.38	12	820	0.52	1.28	0.82	42
1207	0.72	2.68	1.39	11	251	o.45	1.57	0.84	41
921	0.89	2.27	1.42	10	545	0.74	1.00	0.86	40
1251	0.68	3.16	1.47	9	601	0.73	1.13	0.91	39
994	0.60	3.67	1.48	8	874	0.45	1.90	0.92	38
633	1.00	2.28	1.51	7	808	0.92	1.00	0.96	37
1091	1.00	2.56	1.60	6	1172	0.39	2.36	0.96	36
923	0.77	3.66	1.68	5	918	0.49	1.97	0.98	35
1059	1.00	2.89	1.70	4	583	0.70	1.40	0.99	34
1342	0.92	3.88	1.89	3	489	0.67	1.51	1.01	33
605	1.00	6.43	2.54	2	635	0.54	1.95	1.03	32
1021	1.00	7.00	2.65	1	574	1.00	1.11	1.05	31

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