J. Basic. Appl. Sci. Res., **3(3)881-888, 2013**

ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Application the Nonparametric Analysis of Interval Data Envelopment Analysis (IDEA) and Window Data Envelopment Analysis (WDEA) for the Assessment of Financial Efficiency

(Case Study: The Bank Accepted in the Tehran Stock Exchange)

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ABSTRACT

Today, the growing and increasingly important community organizations, performance appraisal, it is highly regarded as a measure of organizational performance and various indicators suggest that the efficiency is of these measures. Efficiency can be in a firm's ability to obtain maximum output from a given set of inputs with known technology and or firm's ability to produce specific outcomes defined minimum set of inputs available. Data envelopment analysis (DEA) has been a very popular method for measuring and benchmarking relative efficiency of peer decision making units (DMUs) with multiple input and outputs. However, one of problems that is inability of decision-maker in involving risk and a lack of certainty and the time factor in the results. In this regard, this study of two techniques of interval DEA and the window DEA has been used this shortcoming and has been used of this techniques to evaluate the financial performance of banks accepted in Tehran Stock Exchange during period 2005-2009. The Ranking results of these two techniques showed that the entrepreneurship Bank have the best condition than other The Banks accepted in the Tehran Stock Exchange.
KEYWORDS: Efficiency, Interval Data Envelopment Analysis, Window Data Envelopment Analysis, The Bank accepted in the Tehran Stock Exchange.

1. INTRODUCTION

In the past decades, the managerial and academic literature has increasingly focused on the issue of measuring organizations' performance, since it leads to the motivation of personnel, supporting decision-making, improvement in organizational learning, and continuous improvement and increase in communication and coordination (Chiza et al. 2009). Also, the evaluation of companies has a very important role in the respective industry. Introduction of top companies in the industry, determines their position in a competitive environment based on different parameters and variables. On one hand, this has bottom companies recognize their distance with top ones and apply an appropriate strategy to get closer to them, and on the other hand, it has top companies establish their advantage through defining proper plans and strategies (Elmashala et al. 2010). According to the increasing growth and importance of organizations in society, considerable attention has been paid to their performance and different parameters such as efficiency have been considered as the criteria for organizations' performance. Efficiency could be defined as the potential of an enterprise in achieving the highest output from a collection of specified inputs, assuming a given technology or the potential of an enterprise in producing a specified return with the least number of inputs available (Farrel, 1957). Today, efficiency is considered as a culture and outlook in all the areas of human life and work, and is a factor of economic progress and development. On the other hand, developing the models of measuring efficiency has always been a matter of importance for the practitioners of this field. Presented by Charnz et al in 1978, Data envelopment analysis is one of the mostly used methods in measuring the relative efficiency of a collection of decision-making units correspondent to similar inputs and outputs (Charnz et al. 1957). Data envelopment analysis is one of the fastest growing fields in management and operational research, and is used to measure the efficiency of governmental and private-sector organizations (Ball et al. 2010). Up to now numerous researches have been done on the use of this technique in several areas such as stock exchanges. However, one of the problems with this technique is that the decision-maker cannot include risk factors, uncertainty, and time factors in the produced results. Interval data envelopment analysis is a useful tool in measuring the efficiency of several enterprises when there are risk factors, uncertainty, and imprecise data. On the other hand, window data envelopment analysis is a method that allows managers to calculate the efficiency during a length of time. Therefore, in this research, the two techniques mentioned above were used to measure the financial efficiency of the banks admitted to Tehran Stock Exchange from 2005 to 2009.

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2. THEORETICAL FRAME

In this part, first the research literature, and then the research terminology were introduced.

2.1. Research Literature

It was necessary in this part that researches with the same subject as the current research were reviewed. Besides this, those researches with the same goals and variables as the current research were also reviewed.

Steam et al. (2000) presented a two-stage model for thorough ranking of organizational units having multiple inputs and outputs. In the first stage, a data envelopment analysis model was designed for the comparison of each pair of units, and in the second stage, based on the outcome of the first-stage model, a paired comparison matrix of decision-making units was formed, and based on analytic hierarchy process, the final weight of each of organizational units was calculated. Ruling out the commentators' guesses on one hand and allowing for the thorough ranking of organizational units on the other hand, this two-stage model has resolved little weak points in each of the analytic hierarchy process and data envelopment analysis models. In their research, Haloux et al. (2004) have reviewed the efficiency of Greek banks from 1997 to 1999 using financial ratios and data envelopment analysis. Their results compared against the wide analysis of financial ratios showed that data envelopment analysis, complementing ratios analysis, could be used to measure the performance of organizations. In order to assess corporal bonds, Malhatra et al. (2007) used data envelopment analysis. They used 2 and 6 financial ratios as the input and output of the model, respectively. Their notion of choosing in choosing input and output ratios was that these ratios could better show the financial power of a burrower repaying his debt and the interest on it. Decision-making units were composed of 34 companies. Results showed that 8 of these companies were more efficient than others in repaying their debt and its interest. In their research to measure the technical efficiency of 117 branches of a specific bank in Taiwan, Tyron et al. (2009) used data envelopment analysis CCR model. They recognized 9 branches as efficient and specified an average score of 54% for efficiency. In his research to design a model for measuring efficiency in Arabic banks, Mustafa (2009) used Neuro-DEA model. The results of his research showed that because of their flexibility and high strength in model making, neural networks models have a strong potential for ranking Arabic banks relative efficiencies. Ricardo (2009) measured the quality management of banks in Brazil using data envelopment analysis technique. In his research, Ricardo evaluated 50 banks in Brazil from 1995 to 2006 in respect to inputs such as the number of personnel, working costs, the number of branches, and capital costs, and outputs like the rate of deposits and interest income. Kao and Liu (2009) used data envelopment analysis to measure the efficiency of commercial banks in Taiwan. They used computer simulation in their research to measure each bank's efficiency where 6 variables of the number of personnel, physical capital, purchased cash, deposits, short-term loans, and long term loans were considered as inputs and outputs of the data envelopment analysis technique.

According to numerous researches done on the use of data envelopment analysis technique in financial institutions, one of the problems with these researches is that the decision-maker cannot include risk factors, uncertainty, and time factors in the produced results. In order to resolve this defect, the current research used two techniques of window and interval data envelopment analyses to measure the financial efficiency of the banks admitted to Tehran Stock Exchange.

2.2. Research Terminology

In this part, first, two techniques of interval and window data envelopment analyses were introduced, and then research variables were explained. Data Envelopment Analysis (DEA) assumes that there are n DMUs (Decision Making Unit, DMU) whose whole set is denoted by j (j=1,2,…,n). The performance of each DMU is characterized by its production process of m inputs (Xij for i=1,2,…,m) to yield s outputs (Yrj for r=1,2,…,s). It is also assumed that all DMUs have input and output vectors and all the components of these vectors are positive (Yaghoubi & Bashiri, 2012).

2.2.1. Interval Data Envelopment Analysis

Data envelopment analysis is one of the nonparametric planning techniques widely used to measure the efficiency of similar units. This technique aims at attaining a relative efficiency for the similar decision-making units that have multiple inputs and outputs. Assuming that there are n decision-making units with m input(s) and s output(s), the relative efficiency of each of the decision-making units is achieved through the fractional planning model below (Charnz et al. 1978):

$$
\begin{aligned}
&Max\ z = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \\
&\qquad \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1 \qquad j = 1, 2, \dots, n \\
&\qquad u_r \ge 0, \qquad\qquad r = 1, 2, \dots, s \\
&\qquad v_i \ge 0, \qquad\qquad i = 1, 2, \dots, m
\end{aligned}
\tag{1}
$$

Where j is the parameter of decision-making ($j = 1, \ldots, n$), r the parameter of output ($r = 1, \ldots, s$), i the parameter of input ($i = 1, 2, \ldots, m$), y_{rj} the value of r^th^ output for the j^th^ unit of decision-making, x_{ij} the value of i^th^ input for the j^th^ unit of decision-making, u_r the weight dedicated to r^th^ output, v_i the weight dedicated to i^th^ input, and z the efficiency score of the unit being measured. In the above model, the efficiency score of each unit being measured is achieved through dividing the sum of outputs' weight by the sum of inputs' weight. This score could be equal or less than 1. If it is equal to one, the unit will be considered as efficient, and if it's less than one, the unit will be thought as inefficient. According to the fact that model 1 is non-linear, solving it would be hard job, so, the model should converted to a linear model as model 2:

$$
\begin{aligned}
&\text{Max} = \sum_{r=1}^{s} u_r y_{ro} \\
&\text{st:} \\
&\qquad \sum_{i=1}^{m} v_i x_{io} = 1 \\
&\qquad \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, \qquad j = 1, 2, \ldots, n \\
&\qquad u_r \ge 0, \qquad r = 1, 2, \ldots, s \\
&\qquad v_i \ge 0, \qquad i = 1, 2, \ldots, m
\end{aligned}
\tag{2}
$$

Model 2 is a basic and primary model for measuring the efficiency of decision-making units, but since in real life situations, a decision-maker has to face risk factors and uncertainty, no precise and reliable value could be specified for inputs and outputs. This decreases the model validity. In order to correct such defect, Wong (2005) suggested the interval data envelopment analysis model. As it's obvious from Table 1, the values of inputs and outputs are within an interval (Wong et al. 2005).

Table 1: The structure of inputs and outputs for the interval data envelopment analysis model

DMU_j	x_1	x_2	$\cdots$	x_m	y_1	y_2	$\cdots$	y_s
DMU_1	$[x_{11}^L, x_{11}^u]$	$[x_{12}^L, x_{12}^u]$	$\cdots$	$[x_n^L, x_n^u]$	$[y_{11}^L, y_{11}^u]$	$[y_{12}^L, y_{12}^u]$	$\cdots$	$[y_s^L, y_s^u]$
DMU_2	$[x_{21}^L, x_{21}^u]$	$[x_{22}^L, x_{22}^u]$	$\cdots$	$[x_{2n}^L, x_{2n}^u]$	$[y_{21}^L, y_{21}^u]$	$[y_{22}^L, y_{22}^u]$	$\cdots$	$[y_{2s}^L, y_{2s}^u]$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
DMU_n	$[x_m^L, x_m^u]$	$[x_{m2}^L, x_{m2}^u]$	$\cdots$	$[x_{mn}^L, x_{mn}^u]$	$[y_m^L, y_m^u]$	$[y_{m2}^L, y_{m2}^u]$	$\cdots$	$[y_{ms}^L, y_{ms}^u]$

In Table 1, x_{ij}^L and y_{ij}^L, indicating the lower limit, and x_{ij}^U and y_{ij}^U, indicating the upper limit, are for outputs and inputs in the j decision-making unit, respectively. The lower limit indicates the least and the the upper limit the most data collected in the interval being studied for inputs and outputs (Dispotiz et al. 2002). Now if instead of precise and definite values, we have imprecise and interval ones for inputs and outputs, then to calculate the efficiency of decision-making units, equation 3 should be used.

$$
\tilde{\theta}_j = \frac{\sum_{r=1}^{s} u_r [y_{rj}^L, y_{rj}^U]}{\sum_{i=1}^{m} v_i [x_{ij}^L, x_{ij}^U]} = \frac{[\sum_{r=1}^{s} u_r y_{rj}^L, \sum_{r=1}^{s} u_r y_{rj}^U]}{[\sum_{i=1}^{m} v_i x_{ij}^L, \sum_{i=1}^{m} v_i x_{ij}^U]} = \left[\frac{\sum_{r=1}^{s} u_r y_{rj}^L}{\sum_{i=1}^{m} v_i x_{ij}^U}, \frac{\sum_{r=1}^{s} u_r y_{rj}^U}{\sum_{i=1}^{m} v_i x_{ij}^L}\right] \tag{3}
$$

According to model 3, decision-making units have two types of efficiency: lower limit and upper limit efficiencies. In order to calculate the efficiency of these limits, two fractional planning models shall be calculated for a given decision-maker. The fractional planning model for the calculation of a decision-making unit's lower and upper limits could be defined as no.4 and 5 models.

$$Max\ \theta_{j0}^{U} = \frac{\sum_{r=1}^{s} u_r y_{rj0}^{U}}{\sum_{i=1}^{m} v_i x_{ij0}^{L}} \qquad \frac{\sum_{r=1}^{s} u_r y_{rj}^{U}}{\sum_{i=1}^{m} v_i x_{ij}^{L}} \le 1 \qquad u_r, v_i \ge 0 \qquad j = 1, 2, \dots, n \tag{4}$$

$$Max\ \theta_{j0}^{L} = \frac{\sum_{r=1}^{s} u_r y_{rj0}^{L}}{\sum_{i=1}^{m} v_i x_{ij0}^{U}} \qquad \frac{\sum_{r=1}^{s} u_r y_{rj}^{U}}{\sum_{i=1}^{m} v_i x_{ij}^{L}} \le 1 \qquad u_r, v_i \ge 0 \qquad j = 1, 2, \dots, n \tag{5}$$

In order to solve the above non-linear models (no.4 and 5), they should be converted to linear models as no.5 and 6 models.

$$Max\ \theta_{j0}^{U} = \sum_{r=1}^{s} u_r y_{rj0}^{U} \qquad st: \sum_{i=1}^{m} v_i x_{ij0}^{L} = 1 \qquad \sum_{r=1}^{s} u_r y_{rj}^{U} - \sum_{i=1}^{m} v_i x_{ij}^{L} \le 0 \qquad j = 1, \dots, n \quad u_r, v_i \ge 0, \tag{5}$$

$$Max\ \theta_{j0}^{L} = \sum_{r=1}^{s} u_r y_{rj0}^{L} \qquad st: \sum_{i=1}^{m} v_i x_{i0}^{U} = 1 \qquad \sum_{r=1}^{s} u_r y_{rj}^{U} - \sum_{i=1}^{m} v_i x_{ij}^{L} \le 0 \qquad j = 1, \dots, n \quad u_r, v_i \ge 0 \tag{6}$$

The value of efficiency attained though model 5 indicates the upper limit for a given decision-making unit, and is equal or less than 1. On the other hand, the value of efficiency gained through model 6 indicates the lower limit for the decision-making unit, and should be always greater than 0. Solving the two linear planning models mentioned above for each of the decision-making units, gets an efficiency interval for each of the models. In order to determine and measure the efficiency rate for each of the decision-making units, equations no.7, 8 and 9 are used:

$$E^{++} = \{ j \in J \mid \theta_j^{L} = 1 \} \tag{7}$$
$$E^{+} = \{ j \in J \mid \theta_j^{L} < 1\ and\ \theta_j^{U} = 1 \} \tag{8}$$
$$E^{-} = \{ j \in J \mid \theta_j^{U} < 1 \} \tag{9}$$

According to the above equations, if $\theta_j^{L} = 1$, the j[th] unit of decision-making is efficient assuming all the values in the inputs and outputs interval, but if $\theta_j^{L} < 1\ and\ \theta_j^{U} = 1$, the j[th] unit of decision-making is only efficient when assuming the upper limit values of the inputs and outputs interval, and if $\theta_j^{U} < 1$, the j[th] unit of decision-making is not efficient assuming any of the values within the inputs and outputs interval. In the end, equation 10 will be used to rank decision-making units based on their efficiency.

$$MIN_i\{MAX\ (DMU_i)\} = MIN_i\left\{MAX\left\{MAX_{i \ne j}(\theta_j^{U}) - \theta_j^{L}, 0\right\}\right\} \quad i, j = 1, 2, \dots, n \tag{10}$$

2.2.2. Window Data Envelopment Analysis

The main characteristics of the data envelopment analysis methods is that they are static and do not consider the time factor in calculations. This may result in deviation because in dynamic conditions it may lead into the limited use of the resources which are needed for profitability in future periods (Dastgir et al, 2012). In studying data envelopment analysis models and measuring decision-making units, each unit of decision-making is measured only in a specific time, but in actual studies, observation of decision-making units often occurs in a time interval and in the form of time series data. This comes very important when we are to study the efficiency of a decision-making unit in a time interval and specify its variations. In this case, the behavior of a decision-making unit in a time interval could be studied when it differs from time to time. The advantage of this is that the performance of a decision-making unit in a time interval could be determined and compared against the performance of the same unit in another time interval or the performance of other decision-making units. To formulate what we just said, assume that there are N decision-making units in the time interval of $T \to (t = 1, \dots, T)$ and all of them user units of input to produce s units of output. Therefore, the sample contains $T \times N$ observations, and an observation of n in the time interval of t, that is DMU_t^{n}, has a r dimensional axis of inputs, that is $X_t^n = (x_{1t}^n, x_{2t}^n, \ldots, x_{rt}^n)$, and an s dimensional axis of outputs, that is $Y_t^n = (Y_{1t}^n, Y_{2t}^n, \ldots, Y_{rt}^n)$. The window, starting from k time ($1 \leq k \leq T$) and having a width of w ($1 \leq w \leq T - K$), is assigned K_w and has $N \times W$ observations. The inputs and outputs matrix for the window analysis could be seen in the following axes (Snajpata, 1995).

$$X_{kw} = (x_k^1, x_k^2, \ldots, x_k^n, x_{k+1}^1, x_{k+2}^2, \ldots, x_{k+1}^N, x_{k+w}^1, x_{k+w}^2, \ldots, x_{k+w}^N)$$
$$Y_{kw} = (y_k^1, y_k^2, \ldots, y_k^n, y_{k+1}^1, y_{k+2}^2, \ldots, y_{k+1}^N, y_{k+w}^1, y_{k+w}^2, \ldots, y_{k+w}^N)$$

The input-oriented window analysis for DMU_t^n assuming the Constant Return to Scale (CRS) is defined as the equation below:

$$\begin{aligned} &\theta_k' = MIN_{\theta,\lambda}(\theta) \\ &st: \\ &-X_{kw}\lambda + \theta x_t' \geq 0 \ \rightarrow t = 1,2,\ldots,T \\ &-Y_{kw}\lambda - Y_t' \geq 0 \ \rightarrow t = 1,2,\ldots,T \\ &\lambda_n \geq 0 \end{aligned} \qquad (11)$$

2.2.3. Research Variables

The first step to measure the relative efficiency using data envelopment analysis models is to identify the model's input and output variables. Input and output are the factors the addition of one unit of them to the system decreases and increases efficiency, respectively, supposing that other variables do not change (Sirpolos and Teziokedis, 2010). In the current research, the selection of input variables and financial outputs was done according to the past researches, the opinions of a number of experts, and using multi-criteria decision-making techniques. In the end, the parameters of total assets, and debts and deposits in banks or institutions were used as the input, and the parameters of shareholders' return, net income margin, and assets return as the output of the data envelopment analysis models.

3- METHODOLOGY

The current research was practical in aim and explanatory-mathematical in the way it was implemented. Two models of interval and window data envelopment analysis were used in this research for measuring the financial efficiency of the banks admitted to Tehran Stock Exchange. The current research methodology could be divided into some major stages. In the first stage, by studying the research literature and similar researches, 7 financial inputs and 7 financial outputs influential in measuring the performance of banks were identified. Making use of the opinions of a number of experts and multi-criteria decision-making techniques, the weight of these inputs and outputs were determined, and 3 inputs and 3 outputs were finally chosen to be used in data envelopment analysis models. After doing so, the needed raw data was gathered from the database of Securities Assessment Organization, and the initial model was developed in the form of data envelopment analysis model, and solved. The statistical population and sample for this research contained all the banks admitted to Tehran Stock Exchange. The population actually contained Parsian, Eghtesad Novin, Karafarin, Sina, Saderat, Tejarat, and Mellat banks, and the time interval for this research was a five-year period from March 2005 to March 20, 2010. Since all the admitted banks to the exchange were studied in this research, the research sample thoroughly overlapped the population, therefore, no specific sampling method was used. Please note that Excel and WinQSP software were used in this research for data analysis.

4. DATA ANALYSIS

It should be noted that to measure the financial efficiency of the banks admitted to Tehran Stock Exchange in this research, an output-oriented approach was applied assuming the Variable Return to Scale (VRS) in the window and interval data envelopment analyses. The reason behind the application of an output-oriented approach was that although a specific amount of resources is given to banks, they are expected to return the highest output. So, banks have not much role in determining the rate of their inputs, but their outputs depend on their activity and the way they dedicate resources to different sectors. That's why output-oriented models are more appropriate for measuring their performance. The reason behind application of Variable Return to Scale was that there was no reason leading to the fact that there was Constant Return to Scale in the performance of the banks admitted to Tehran Stock Exchange, therefore, the value of return had to be freely scaled so that the type of return with the scale of bank units was determined in data envelopment analysis models. Table 2 shows the results of using interval data envelopment analysis model in measuring the relative financial efficiency of the chosen banks.

Table 2: The results of measuring efficiency using the interval data envelopment analysis technique

Row	DMU	Upper limit	Lower limit	Type of Efficiency	Rank
1	Parsian	1	0.61	E^{+}	2
2	Eghtesad Novin	0.917	0.53	E^{-}	3
3	Karafarin	1	0.819	E^{+}	1
4	Sina	1	0.493	E^{+}	4
5	Saderat	0.431	0.107	E^{-}	6
6	Tejarat	0.372	0.185	E^{-}	5
7	Melli	0.254	0.079	E^{-}	7

As Table 2 shows, Karafarin and Melli banks have the highest and lowest relative financial efficiency, respectively. Also, since $\theta_j^L \neq 1$, none of the banks admitted to Tehran Stock Exchange are thoroughly efficient, and since $\theta_j^L < 1 \; and \; \theta_j^U = 1$, Parsian, Sina, and Karafarin banks have a potential efficiency that in case they use the highest number of inputs and gain the highest number of outputs named for those inputs, they could actualize their potential financial efficiency or in other words reach complete efficiency. Meanwhile, since the upper limit of efficiency for Eghtesad Novin, Saderat, Tejarat, and Melli banks is less than 1, these banks don't even have potential efficiency. In the next stage, window analysis approach was used to measure the financial efficiency of the banks admitted to the exchange. The data of 7 banks admitted to the exchange (N=7) for a 5 year interval (P=5) was at hand to do the window analysis. To start with, a 2 year interval analysis (W=2) was chosen as the study interval. Each unit of decision-making (bank) was placed at the beginning of the window for a 2 year interval as a distinct unit of decision-making during a year, and then the analysis was done on 14 units of decision-making in the mentioned interval ($N \times W = 2 \times 7 = 14$). Then the window was shifted one (2 year) interval forward, and the analysis was done for the next 2 year interval on the 14 decision-making units, again. This sequence continued and each time the window was shifted one interval forward until the last analysis on the 14 decision-making units was done for the 4th window, and the final interval. Table 3 shows the features of these windows.

Table 3: The window features of this study

DMU	Window 1			DMU	Window 2			DMU	Window 3			DMU	Window 4	
1	1384	1385	⇒	1	1385	1386	⇒	1	1386	1387	⇒	1	1387	1388
2	1384	1385		2	1385	1386		2	1386	1387		2	1387	1388
3	1384	1385	⇒	3	1385	1386	⇒	3	1386	1387	⇒	3	1387	1388
4	1384	1385		4	1385	1386		4	1386	1387		4	1387	1388
5	1384	1385		5	1385	1386		5	1386	1387		5	1387	1388
6	1384	1385	⇒	6	1385	1386	⇒	6	1386	1387	⇒	6	1387	1388
7	1384	1385		7	1385	1386		7	1386	1387		7	1387	1388

After solving about 56 linear planning models with 6 decision variables and 15 constraints, the results of measuring the financial efficiency model based on the window analysis method were put in Table 4. As it could be seen, in this table, rows are dedicated to windows and columns to studied years.

Table 4: The results of measuring efficiency using the window data envelopment analysis technique

		84	**85**	**86**	**87**	**88**	**Average Efficiency in each Window**	**Rank**
Parsian	Window 1	1	0/964				0/982	
	Window 2		0/989	1			0/994	
	Window 3			1	0/842		0/921	
	Window 4				0/727	0/657	0/692	
	Average Efficiency per year	1	0/976	1	0/784	0/657	**0/897**	**3**
Eghtesade Novin	Window 1	1	0/916				0/958	
	Window 2		0/908	0/612			0/76	
	Window 3			0/631	0/649		0/64	
	Window 4				0/56	0/621	0/59	
	Average Efficiency per year	1	0/912	0/62	0/605	0/62	**0/737**	**4**
K ar af	Window 1	1	1				1	
	Window 2		1	1			1	

	Window 3			1	1		1	
	Window 4				1	1	1	
	Average Efficiency per year	1	1	1	1	1	**1**	**1**
Sina	Window 1	1	1				1	
	Window 2		1	1			1	
	Window 3			1	1		1	
	Window 4				1	0/639	0/82	
	Average Efficiency per year	1	1	1	1	0/639	**0/955**	**2**
Saderat	Window 1	0/166	0/173				0/169	
	Window 2		0/163	0/144			0/153	
	Window 3			0/122	0/491		0/306	
	Window 4				0/424	0/393	0/408	
	Average Efficiency per year	0/166	0/168	0/133	0/458	0/393	**0/259**	**7**
Tejarat	Window 1	0/391	0/461				0/426	
	Window 2		0/445	0/774			0/609	
	Window 3			0/485	0/426		0/455	
	Window 4				0/326	0/319	0/322	
	Average Efficiency per year	0/391	0/453	0/629	0/376	0/319	**0/453**	**5**
Melli	Window 1	0/407	0/201				0/304	
	Window 2		0/193	0/303			0/248	
	Window 3			0/21	0/228		0/269	
	Window 4				0/196	0/257	0/226	
	Average Efficiency per year	0/407	0/197	0/256	0/262	0/257	**0/261**	**6**

As it's obvious from Table 4, Karafarin Bank was in a total financial efficiency level compared to other competing banks in 2005, 2006, 2007, 2008, and 2009. The average of Karafarin Bank's financial efficiency was 100% in the interval studied. According to the averages of other banks' financial efficiencies in the above-mentioned interval, Karafarin Bank ranks highest among the other banks. Sina Bank was in a total financial efficiency level in 2005, 2006, 2007, and 2008, but in 2009, it's inefficient compared to other competing banks. The average of Sina Bank's efficiency was 0.955 that indicates the bank's inefficiency in a general measurement. Parsian Bank was inefficient compared to other banks in the study in all the fiscal years except for 2005 and 2007. Eghtesad Novin Bank was also inefficient compared to other banks in all the fiscal years except for the fiscal year of 2005. Other banks – Saderat, Melli, and Tejarat – were financially inefficient in all the fiscal years mentioned above. According to the results of Table 4, the results of financial efficiency of the banks being studied could be compared in respect to the average of each window. Karafarin Bank was in a total financial efficiency level in all the windows. Sina Bank was in a total financial efficiency level in all the windows except for the 4th window. For Parsian, Eghtesad Novin, Tejarat, and Melli banks, a decreasing rate was observed in their windows' averages, but for Saderat Bank this rate was increasing. Based on the results of Table 4, the banks being studied using the window data envelopment analysis technique were ranked in the following order: Karafarin, Sina, Parsian, Eghtesad Novin, Tejarat, Melli, and Saderat.

5. Conclusion and Suggestions

According to the increasing growth and importance of organizations in society, considerable attention has been paid to their performance and different parameters such as efficiency have been considered as the criteria for organizations' performance. Therefore, in the current research the non-parametric technique of data envelopment analysis was used as an effective tool for measuring the efficiency of the decision-making units that have several similar outputs and inputs. However, one of the problems with this technique is that the decision-maker cannot include risk factors, uncertainty, and time factor in the results produced. In order to resolve this defect, the current research used two techniques of window and interval data envelopment analyses to measure the financial efficiency of the banks admitted to Tehran Stock Exchange .Studying the research literature and similar researches and making use of the opinions of a number of experts and multi-criteria decision-making techniques, 3 inputs and 3 outputs were finally chosen to be used in data envelopment analysis models. After choosing the final inputs and outputs, and collecting the respective data, the initial model was developed in the form of window and interval data envelopment analysis models, and solved. Using the interval data envelopment analysis technique, the banks were ranked in the following order: Karafarin, Parsian, Eghtesad Novin, Sina, Tejarat, Saderat, and Melli, and using window data envelopment analysis technique, they were ranked in this order: Karafarin, Sina, Parsian, Eghtesad Novin, Tejarat, Melli, and Saderat. The advantage this research has over the researches of Haloux et al. (2004), Malhatra et al. (2007), Ricardo (2009), and Kao and Liu (2009) is that it includes risk and time factors in data envelopment analysis models to measure the efficiency of decision-making units. According to the fact that the data in this study belong to the financial performances in previous years, and also that all the measurement criteria were not included because of data limitations, it is suggested that a greater number of more up-to-date inputs and outputs will be used for the model, so that more precise measurements would be done on the performance of banks admitted to Tehran Stock Exchange. It is also suggested that the two techniques introduced in this research (window and interval DEA) will be used to measure the efficiency of other industries in the exchange.

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