Analyzing Financial Statements by Using Window Data Envelopment Analysis Model (Output Oriented BCC) Evidence from Iran

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ABSTRACT

Analyzing financial statements has always been one of the main concerns of users of financial data in companies. These users have always searched to assess firms' performances in the best way. Data envelopment analysis model is one of the methods used to achieve it. But the disadvantage of this method is that it assesses the performance only within a certain time period and statically. Thus, this research is aimed at studying the financial statements' analysis of companies accepted in Tehran Stock Exchange by using *window data envelopment analysis model*. The main reason to use this new model is to study the performances of firms during different time periods. Thus, we have chosen 100 firms from among those firms as our sample during the time period between 2005 and 2010. The results of our research show that from among the sample firms, none of the firms has retained %100 of its performance efficiency during the time period mentioned.

KEYWORDS: *BCC model, Envelopment analysis of data, Financial statement analysis, Window data envelopment analysis.*

INTRODUCTION

Financial statements show the summary of operational activities, financial supplies and firm's investments during a financial time period. Financial statements analysis helps the decision makers to have a general overview about the company safety and its competitive status. Often the managers should recognize the capacities and the opportunities of the companies which can result in the maintenance of the present situation and identify the weak points which should be modified. The potential creditors decide about giving loans or credits and also the amount of yield by using financial statements' analysis (Khajavi & et al., 2010). The analysis of financial statements entails the assessment of three characteristics of liquidity, profitability and liability payout of the business entity. On the whole, 3 different types of financial statements analysis based on the viewpoint of the researcher are as follows (Khajavi & et al., 2010):

1. **Credit Analysis**: It is often done by the banks and financial entities and the creditors. Their main concern is the liquidation and the power of paying out the debts by the borrower in short time. Thus, these entities emphasize more on testing the balance sheet, controlling liquidity power and the capability of paying out the debt in a short period of time. Also these analysts mostly use the current ratio, the immediate ratio, and the appropriateness of the flowing capital.

2. **Investment Analysis**: The stockholders and investors in a firm often search for the power of liquidation and the power of earning elimination. Thus, this group of analysts assesses income statements to assess the profitability of the company to be able to predict the trend of long-term and short-term earnings and the firm's profitability and start to sell or invest on its stocks.

3. **Managers' Analysis**: Also the firm managers make benefits of analyzing financial statements. They use this analysis to scale the expenses and costs, operations' efficiency, and extracting the data appropriate for logical business decision makings.

Using financial ratios is one of the most common methods of analyzing financial statements which are calculated by using balance sheet, income statement and the statement of cash flows. The analysis is done by using mathematical equations and in fact shows the relationships among the data of financial statements. These ratios are generally categorized as liquidation, efficiency (of activity), debt (leverage), and profitability.

The ratios' analysis is used to achieve several goals because of the ease of comprehension and varied information and it is an important tool in order to recognize the financial status of a business entity. But these methods encounter very serious limitations, some of which are: abandoned and old data in financial statements, measuring the items based on historical cost, different interpretations by different people, changes in technology, change in accounting policies, change in accounting standards, firm size, and capital structure. The

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analysis of the ratios is useful, but the analysts should be aware of these limitations and implement the needed adjustments. There are several approaches to assess the performance. Although the calculation of a set of financial ratios is relatively easy, the relationship between these ratios can be completely complicated. Also, while financial ratios prepare information about the totality of financial performances of an organization, they present limited information regarding the amount of performance which should be improved or a domain or field in which the improvement should be utilized to improve or modify it. A lot of studied have been carried out regarding the alternative methods for ratios in order to analyze financial statements so far. One of these methods which has changed into a widely used method in the field and is based on a linear programming is data envelopment analysis (DEA) method which has been first presented by Charnes & et al. (1978).

This method is a non-parametric method and is used to assess the relative efficiency of decision making units (DMU), who do the same tasks such as measuring and comparing the relative efficiency of organizational units such as governmental offices, a ministry, schools and … . Also data envelopment analysis is widely used in sampling, continuous improvement, and strategic analysis. When there are different activities and environmental factors, data, and several earnings, a usual efficiency scale would no longer be an appropriate one (Momeni, 2010).

In fact data envelopment analysis determines efficiency borders by using the organizations' and manufacturing units' information as decision making units. The border above is formularized in the form of frames and organizations based on the data and based on the successive linear programming results. In fact, the degree of the lack of efficiency of every decision making unit is equal to the distance between the unit and the efficiency border (Azar & et al., 2007). A lot of studies have been carried out about data envelopment analysis in different areas. One of them is helping to a better analysis of financial statements. In fact, this method is a complementary effort to complete the traditional methods in analyzing financial statements. Some of these researches are: Worthinton (1998), Bowlin (1999), Feroz & et al. (2003), Wu & et al. (2005), and Malhotra & et al. (2008).

Data envelopment analysis optimizes the performance criteria of every decision making unit and chooses the best possible performance for each decision making unit related to all other observed criteria, unlike the traditional approaches of efficiency which concentrate on the averages and estimations of parameters and use only an optimum regression equation for each decision making unit. Data envelopment analysis can be considered as a powerful instrument when it is used wisely. This technique can direct models with several inputs and outputs and there is no need to presuppose a function form related to inputs and outputs. In data envelopment analysis, decision making units are compared directly against another unit or a combination of units and inputs and outputs can have different units (Ali Khan & et al. 2011). The first study which shows the usefulness of data envelopment analysis in several concepts of decision makings such as assessing the profit efficiency dates back to American Occupational Safety & Health administration (OSHA). This method, like other methods, has some advantages and limitations in itself. Some of the fundamental advantages of this method are: it is not sensitive to the unit of measurement; it is more capable of generalization. Some of the basic disadvantages of this method are: it is not possible to compare the qualitative variables of decision making units, only a certain period of time is considered in calculations, and the time factor is not taken into consideration. Also the models mentioned have serious limitations due to the lack of considering one or some inputs (outputs) in assessing a certain decision making unit.

To remove this problem, a new method called window data envelopment analysis (WDEA) was introduced during the recent decade and it divides the time periods into shorter periods (windows) and considers each window as a separate unit. In fact, this new approach creates a better comparability of the decision making units by considering each window as an independent unit during the different time periods. Some researches have been done in this field and of course the analysis of financial statements in these researches has been done rarely. But, most researches about financial statement analysis using DEA, The limited population has only covered and most of them have used a static DEA, that does not change in time. But this research, for the first time using a window analysis in DEA in financial statement analysis in a sample of entire firms in Tehran Stock Exchange.

In this research we have tried to use window data envelopment analysis instead of simple data envelopment analysis, regarding the review of the theoretical fundamentals of the previous studies, to take the time factor into consideration. The reason to choose this method is the changing conditions of Tehran Stock Exchange. In fact, this research is trying to study the effect of time on the analysis of financial ratios. In other words, this research is trying to find the answer to this question: "Is window data envelopment analysis (WDEA) able to analyze financial statements of firms accepted in Tehran Stock Exchange appropriately?

1. LITERATURE REVIEW

Hamasi & et al. (2011) studied the performance of wood industries in Iran in a research entitled: "DEA window analysis of wood industries' performance". They selected and tested 10 firms between 2001 and 2006 by using WDEA. The results of their study showed that all 10 firms under investigation have had a static

efficiency degree. But the trend and the fixed behavior of these firms showed that almost half of decision making units were positive.

Gu & Yue (2011) studied the relationship between efficiency changes and stock return of banks accepted in China Stock Exchange. Their research contained 3 independent parts. First they estimated the efficiency of the banks accepted in China Stock Exchange by using WDEA and used the seasonal data during the time period between 2008 and 2010. Then they calculated the stock return of these banks for the total seasons of the research. And finally they studied the relationship between seasonal changes of efficiency and their stock returns. The results of their research showed the changes of net technical efficiency along with stock return besides expressing the positive and strong relationship between technical efficiency and stock return.

Ali Khan & et al. (2011) analyzed financial statements by using window data envelopment analysis in medicine firms in India (33 firms). They studied the related data in the firms mentioned during the 5 years period between 2000 and 2004. They divided the period into windows of 3 years and into 4 isolated windows [(2000, 2001, 2002), (2001, 2002, 2003),…]. Each window was considered to be an independent unit. The research results showed that window data envelopment analysis is a useful and reliable tool to analyze financial statements because it makes decision making units' assessment possible during the time period.

Gumus & çelikkol (2011) studied the performance of firms in Istanbul during the years between 2005 and 2008. They studied the relationship between data envelopment analysis and financial ratios. The results of their research showed that the standard deviation of DEA efficiency has a meaningful relationship with fast ratios' standard deviation, net profit to sales, return of assets (ROA), and return of owners' equity (ROE) statistically and this approves that DEA and financial ratios complement each other in liquidation ratios and profitability.

Khajavi & et al. (2010) considered data envelopment analysis technique as a complement for traditional analyzing of financial ratios in their research. Thus, they analyzed the financial statements of 267 firms accepted in Tehran Stock Exchange between the years 2005 and 2007. The results showed that 32 firms of 267 firms had a relative efficiency and 235 firms were inefficient.

Yang & Chang (2009) studied the efficiency of telecommunication firms in Taiwan by using window data envelopment analysis. Their research results showed that the integration of firms results in increasing the efficiency and reducing the technical efficiency in short term and the strategic adjustments such as increasing the markets' share or improving financial portfolios and helps the firm to achieve a better scale.

Akbari & Dinmohammadi (2007) scaled the efficiency of milk production units by using data envelopment analysis approach. They used the window model as a subordinate model of data envelopment analysis to scale the efficiency of milk production firms (Feka, Malard, Golshahr, Goldasht) and then estimated the model in 4 scenarios. As a result, in first and second scenarios the efficiency ranks of the firms were as follows: Feka, Malard, Golshahr and Goldasht (Goldasht and Golshahr are in the same rank in this scenario). And in third scenario they are Feka, Malard, Golshahr and Goldasht, respectively. In fourth scenario Malard, Feka, Goldasht and Golshahr (Feka and Golshahr are in the same rank in this scenario) have had higher ranks, respectively.

Asmild & et al. (2004) combined window data envelopment analysis with malmquest criterion approach in a study of banking industry in Canada. They studied the efficiency degrees of Canadian banks during a 20 years time period and found out that the combination of these two methods will result in more efficiency.

Halkos & Salamouris (2004) used data envelopment analysis and financial ratios to assess the performance and identify the efficiency of banking industry in Greece. The research results showed that we can use data envelopment analysis method both as an alternate and as a complementary method of traditional financial ratios analysis to assess organizations.

Webb (2003) studied efficiency levels of big banks in England during the years between 1982 and 1995 by using DEA window analysis. The results showed that regarding all research sample, the average inefficiency has been less than the previous studies and the overall trend of efficiency average has been descending and all banks under investigation showed the reduction of efficiency compared with the sum of the investigation period.

Feroz & et al. (2003) analyzed financial statements by using data envelopment analysis. They wanted to prove: "Can data envelopment analysis model complement traditional accounting ratios in analyzing financial statements?". Their research results approved the hypothesis. In fact the researchers found out that data envelopment analysis method is more efficient than the traditional accounting ratios in analyzing financial statements.

2. Data Envelopment Analysis

Data envelopment analysis is a mathematical programming method to assess the efficiency of the decision making units which have several inputs and outputs. In 1957, Farell used a method like efficiency assessment in engineering discussions, to scale the efficiency of a manufacturing unit. The thing considered by Farell to scale efficiency, included an input ad an output. Charnes, Cooper and Rhodes developed Farell's viewpoint and presented a pattern which was able to scale efficiency with several inputs and outputs. This pattern was called data envelopment analysis and was first used in PhD dissertation of Edward Rhodes and under the supervision of Cooper entitled: "Assessing the study development of American National Schools' students" in the year 1976

in Karengi University. Since this pattern was presented by Charnes, Cooper and Rhodes, it was called CCR which abbreviated the names of those three persons. And it was presented in the year 1978 in a paper entitled: "Assessing the efficiency of decision making units (Tadris Hassani, 2011). But the disadvantage of this method is that every multiple of inputs will produce the same multiple of the outputs, which is technically called the fixed scale. Benker, Charnes and Cooper posed a model in 1984 based on the return to scale variable called BCC in which every multiple of the inputs can produce the same multiple from the outputs or less than it or more than it in outputs.

3. 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 (Mirhassani, 2010). Charnes & et al. (1985) suggested window data envelopment analysis based on changing average analysis in order to assess efficiency during the time period (Gu & Yue, 2011). In fact window analysis is a subordinate part of data envelopment analysis. This method doesn't have any limitations in inputs or outputs like other data envelopment analysis models (Fallah Delcheh & Mehreghan, 2010). By using this method the smallness problem of the size of sample in data envelopment analysis is removed (Gue & Yue, 2011). In this method, the integration of temporary and time series observations can remove the problem of shortage of observations in efficiency assessment and a more precise analysis is gained. In this case each unit for every time period is considered as an independent DMU. The performance of a unit in a certain period is compared with the same unit in other periods and the performances of other units in definite time period and this can increase the observation number (Fallah Delcheh & Mehreghan, 2010).

Based on the research carried out by Asmild & et al. (2004), consider the decision making unit which uses r input to produce s output is located in times $(t=_{1,...,T})T$. DMU_n^t shows n number of observations and the period t

is shown by the input vector of $X_n^t = \begin{bmatrix} x_n^{1t} \\ . \\ . \\ x_n^{rt} \end{bmatrix}$ and output vector of $Y_n^t = \begin{bmatrix} y_n^{1t} \\ . \\ . \\ y_n^{st} \end{bmatrix}$.

If the window starts in the time k ($1 \leq k \leq T$) with the width of w ($1 \leq w \leq T-K$), the matrix of inputs and outputs will be as follows:

$$X_{kw} = \begin{bmatrix} x_1^k & \cdots & x_N^k \\ \vdots & \ddots & \vdots \\ x_1^{k+w} & \cdots & x_N^{k+w} \end{bmatrix} \qquad Y_{KW} = \begin{bmatrix} y_1^k & \cdots & y_N^k \\ \vdots & \ddots & \vdots \\ y_1^{k+w} & \cdots & y_N^{k+w} \end{bmatrix}$$

The DEA window problem for DMU_n^t by supposing the changing return compared with the scale (BCC model) will be like the following (Gue & Yue, 2011):

Min θ

s.t.

$$\theta' X_t - \lambda' X_{kw} \geq 0$$

$$\lambda' Y_{kw} - Y_t \geq 0$$

$$\sum_{n=1}^{N} \lambda_n = 1$$

$\lambda_n \geq 0 \qquad$ (n=1,2, …,N×w).

4. RESEARCH METHODOLOGY

In this research, after study the related literature, Debt ratio, current liability ratio to Equity and long-term liability to Equity ratio as the input variables of the model and the ratio of net earning margin, return of assets ratio (ROA), return of owners' equity ratio (ROE), Acid-test ratio and total assets turnover ratio as the output variables of the model were selected. Then, the variables above were extracted from the sample firms and entered into EXCEL software to be categorized. Then they were entered into WINQSB software to calculate the efficiency degrees of the firms. After that each of these decision making units (sample firms) with the inputs and outputs mentioned were assessed again as independent windows and during the pass of time. In this research, each window had a range of 3 years (in a 6 years period). Of course, there were no certain reasons found to consider the 3 years period in theoretical fundamentals. But they were chosen because of the common use (by 3 years, we mean that every 3 years is considered as an independent window, for example, (2005, 2006, 2007) (2006, 2007, 2008), …). In this research the calculations related to data envelopment analysis was used by radial

model of variable return to scale or BCC model. Also the model discussed, was administered as output oriented for all observed decision making units. In an output-oriented model, we try to maintain maximum outputs by keeping the inputs fixed.

5. Population and Statistical Sample

First we used the systematic deletion method to choose from among firms accepted in Tehran Stock Exchange between the years 2005 and 2010 to have the following characteristics:

- They should have been active in Stock Exchange between the years 2005 and 2010 and should not have stopped for more than 6 months.
- They should not be from among investing and financial mediators, banks and insurance companies.
- Their fiscal year should end on 29th. Esfand (March 21st.).
- The information related to the research should be accessible.

Then randomly and by using the Kokran's formula, 100 firms were chosen as the final sample.

6. Research findings

After data collection and receiving the output of the research software, the final data were entered into EXCEL software as windows with 3 years period to be compared and calculate the averages. Then once the average of each window and once the averages of each year were calculated and finally the final average was calculated and entered into the table. Of course, due to the large volume of the output, only 10 firms were randomly chosen –one firm from among 10 firms is shown in the following table:

Table1: Results of WDEA

Year' No/firm	2005	2006	2007	2008	2009	2010	Window average	Rank
3	1.011	1.0055	1.0106				1.009	
		1.0231	1.033	1.0355			1.0305	
			1.0094	1.008	1.0086		1.0086	
				1.0115	1.0117	1.0122	1.0118	
Year average	**1.011**	**1.0143**	**1.0175**	**1.0182**	**1.0102**	**1.0122**	**1.0149**	**10**
18	1.0084	1.0072	1.0066				1.0074	
		1.0085	1.0087	1.0072			1.0081	
			1.0077	1.0075	1.0078		1.0076	
				1.0061	1.0064	1.0062	1.0063	
Year average	**1.0084**	**1.0078**	**1.0077**	**1.0069**	**1.0071**	**1.0062**	**1.0073**	**8**
25	1.0023	1.002	1.007				1.0038	
		1.0011	1.0034	1.0002			1.0016	
			1.0018	1	1.005		1.0023	
				1.0092	1.0104	1.0108	1.0101	
Year average	**1.0023**	**1.0016**	**1.0041**	**1.0031**	**1.0077**	**1.0108**	**1.0044**	**5**
36	1.0012	1.0007	1.0066				1.0028	
		1.0011	1.0052	1.0057			1.004	
			1.0051	1.0056	1.006		1.0056	
				1.0048	1.0051	1.0045	1.0048	
Year average	**1.0012**	**1.0009**	**1.0057**	**1.0054**	**1.0056**	**1.0045**	**1.0039**	**4**
44	1.01	1.0098	1.0108				1.0102	
		1.007	1.0091	1.009			1.0084	
			1.0078	1.0081	1.0083		1.008	
				1.0056	1.0058	1.0061	1.0059	
Year average	**1.01**	**1.0084**	**1.0092**	**1.0076**	**1.007**	**1.0061**	**1.0081**	**9**
50	1.0034	1	1				1.0011	
		1.0008	1.0016	1.0006			1.001	
			1.0018	1	1.0022		1.0013	
				1.0028	1.0051	1.0048	1.0043	
Year average	**1.0034**	**1.0004**	**1.0011**	**1.0011**	**1.0037**	**1.0048**	**1.0019**	**3**
68	1	1	1				1	
		1	1	1			1	
			1	1	1		1	
				1	1	1	1	
Year average	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
77	1.005	1.0055	1.0079				1.0061	
		1.0045	1.0063	1.0063			1.0057	
			1.006	1.006	1.0058		1.006	
				1.0049	1.0054	1.0048	1.0051	
Year average	**1.005**	**1.005**	**1.0067**	**1.0058**	**1.0056**	**1.0048**	**1.0057**	**6**
84	1.003	1.0028	1.007				1.0043	
		1.003	1.0076	1.0075			1.006	
			1.0094	1.0079	1.0083		1.0085	
				1.0083	1.0087	1.0093	1.0087	
Year average	**1.003**	**1.0029**	**1.008**	**1.0079**	**1.0085**	**1.0093**	**1.0069**	**7**
99	1	1.0012	1.0024				1.0012	
		1.0039	1.0048	1.0043			1.0044	
			1.0049	1.0052	1.0052		1.0051	
				1.0053	1.0054	1.0055	1.0054	
Year average	**1**	**1.0026**	**1.004**	**1.005**	**1.0053**	**1.0055**	**1.004**	**2**

7. **Conclusion& Suggestion**

The aim of this research was to analyze and rank the firms in Tehran Stock Exchange by using a new model called window data envelopment analysis (WDEA). To do so, a sample including 100 firms from among was chosen from among Tehran Stock Exchange firms during the time period between 2005 and 2010. The period under investigation was divided into 4 windows of 3 years and the performance of each of the firms in these windows were assessed separately and the performance of each year was compared with the performance of the same firms in other years and also with the performances of other firms in the same year. The research results showed that none of the companies had not a stable performance during the research period. It can be shown of large changes in management, lack of stability in the financial and operating policies of the company, lack of predetermined plans, Changes in economic and political policies, international factors and others.

Based on results, we suggest that the firms have a predetermined mid- term and long-term policies for the next 5 to 10 years and have more stability in the selection and replacement of their management.

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