Efficiency Measurement of Enterprises Using

the Financial Variables of Performance Assessment

and Data Envelopment Analysis

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Abstract

The performance measurement of companies has been the subject of numerous surveys during the last few years. In the present study, the Data Envelopment Analysis (DEA) technique as well as the financial-based variables such as Return On Investment (ROI), Residual Income (RI), Return On Sale (ROS), Earnings Per Share (EPS), Price to Earnings ratio (P/E), Return On Assets (ROA), and Operating Cash Flows to owners’ equity (OCF) have been applied to measure the performance and efficiency of companies belonging to the metal industries and accepted in Tehran Stock Exchange Corporation. To do so, a six-year data of 24 companies, totally 144 observations, has been collected and used. Moreover, the multivariate regression has been employed to study the relationship between the financial variables and DEA. The results of the test show that there are significant relationships between three variables (ROS, EPS, and OCF) and the efficiency results of DEA. So such variables can be considered as appropriate criteria and introduced as substitute variables to measure the performance and efficiency of enterprises.

Keywords: Financial variables, Performance measurement, Data envelopment analysis
1. Introduction

The managers of enterprises have been given the authority by investors to manage and utilize their assets. In this way, managers would be able to accumulate the assets of numerous people for carrying out different activities and for a more proper use of these assets, thus giving more advantages to owners. Since owners can get benefits from the managers’ activities results, it is necessary to evaluate the performance of managers.

To assess the performance, owners usually use the criteria that encourage managers to do their best to utilize the resources in a way that more wealth can be acquired. Indeed, the intention of owners is an optimal and suitable usage of rare resources that are in the hands of managers. Owners desire to invest their own limited resources in activities that can bring them the highest outcomes.

In fact, owners or investors have rare resources and numerous investment opportunities that by choosing one of these chances and investing in it, they would lose the possibility of investing in the other options. Moreover, investors’ goal is to earn more wealth and interests. So the option they choose is the one that brings them more interests and such interests should be the amounts that can cover the possible results of ignoring the other investment options. This is a decision and some rational investors should choose the option expected to have the highest outcomes. The question is that how the results of companies’ activities can be shown in a reasonable and reliable manner.

In large stock companies whose stocks are in the hands of numerous people, due to the potential contrast between the benefits of investors and managers, the goals of companies’ management are not normally the same as those of stockholders. So stockholders have weak control over companies’ management. In this way, managers authoritatively act in a way that seems to them the best. The bigger the company is and the more the stockholders are, the less the access to the information resources would be. Stockholders as the owners of their assets need to be aware of the performance of their representatives in order to compare and to decide whether they should continue or stop investing in such companies.

Managers issue the periodical financial reports to present their performance. By using such reports and information, stockholders are able to evaluate their investments. The criteria used in such assessments are important both form the view of investors and form the view of managers. Investors always pay attention to companies’ performance in order to identify suitable investment opportunities. What makes stockholders invest their savings in a company’s activities is the appropriate performance of that company, and this will, therefore, lead to the increased company’s value and stockholders’ wealth.

Managers pay attention to the mechanisms through which their performance is judged. They follow the information about the direct sensitivity of reward/punishment systems to the performance. If reward systems are not sensitive to the performance, the company will lose its managers and they will leave the company. Managerial labour market directly puts a lot of pressures on the company in order to rank managers based
on their performance and to determine their rewards. Imposing such pressures results from the inevitable fact that the company is seeking new managers in the competitive labour market (Famma, 1980, pp. 288-307). Managers themselves recognize that their performance and the extent to which they have managed to increase stockholders’ wealth are determining factors in the managerial labour market (Raffij, 1999, pp. 145).

Companies’ managers may struggle to enhance their performance. However, such efforts would not necessarily lead to the best and ideal performance since in this way, managers may even avoid undertaking acceptable risks and not step towards increasing stockholders’ benefits. But, Jenson and Mecklink have developed a theory in this regard. They believe stockholders can be sure that if managers are given necessary incentives, they will make sound decisions to maximize stockholders’ wealth (Jenson and Mecklink, pp. 26).

Finally, it is noteworthy that if stockholders choose suitable assessment criteria that are also used as a basis for determining managers’ rewards, they will not only be able to make better decisions on investing their assets, but also they can direct managers’ goals towards their own goals and reach the goals quicker.

Nowadays, one of the most important financial issues of companies is performance measurement. The methods of assessing companies’ performance help to find out the extent to which companies have tried to increase stockholders’ benefits, the criteria used by banks and other credit institutes to grant loans to companies, the factors considered by companies’ owners to determine managers’ rewards, and the relevant legal requirements regarded as important by governmental authorities (Basidor et al., 1997, pp. 12).

2. Agency Theory and performance assessment of enterprises

Performance assessment and the agency theory are consistently related. Mirrless Holmstrom developed the primary model of agency used by accounting researchers. Later, Biman and Demoski (1980), Dye (1986), Lambert (1985) studied the model and its shortcomings. Similarly, other researches regarding performance evaluation and the agency model were carried out by Banker and Datar (1989), Bushman (1989), Indjejikian (1993), Feltham and Xie (1994) and others (Chandra, 2001).

Performance assessment of companies has been the subject of numerous studies, and several discussions in accounting and management have focused on the matter that which of the performance assessment criteria is more valid. Some people believe that there is no ideal criterion to measure the performance, but, by contrast, there are several assessment methods and each method has some major shortcomings. If such methods are applied to measure the performance and to determine the companies’ value, they will not definitely be able to find out the real value of companies.

However, performance evaluation of companies is a necessity and it has to be done through using accepted criteria which consider different aspects of limitation on activities and the possibility of taking advantages of facilities (Healy, 1998, pp. 16).
Generally, the performance measurement criteria are divided into two groups: financial and non-financial criteria (Spigelman, 1994, pp. 32). Non-financial criteria induce production, marketing, administrative, and social criteria while financial proportions are the examples of techniques proposed as financial criteria. Some financial researchers suggest applying combined (financial and non-financial) criteria. However, using such criteria is quite complicated due to the difficulty of determining the type of the criteria, the kind of their correlation, and the weight of each of the criteria (Bacidor et.al, 1997, pp. 14).

According to another classification, the performance measurement criteria are divided into five different applied approaches as follows (chien-Taho, 1997, pp. 14):
1. Data Envelopment Analysis (D.E.A.)
2. Analytic Hierarchy Process (A.H.P.)
3. Grey Relation Analysis (G.R.A.)
4. Balanced Scorecard (B.S.C.)
5. Financial Statement Analysis (F.S.A.)

It is important to consider the approach and the purpose of performance assessment since different people and groups with different approaches and aims may assess companies’ performance and use the results in making their own decisions. Assets’ owners, managers, creditors, and public and governmental organizations are the examples of such groups. These people have different views both on the definition of performance assessment and on the performance results of profit units. For instance, managers notice the operation analysis, resources management, and making profits, assets’ owners pay attention to the information on the profitability of commercial units, return on stock, and market reactions, and credit institutes consider the information about the liquidity and financial leverage of commercial units.

The criteria considered by the above-mentioned groups are not possibly in accordance with one another. For example, profitability is one of crucial factors for companies’ survival. However, when social and political goals are involved, profitability may have less importance than such goals. To be more precise, a company whose performance is regarded as successful from managers’ and owners’ point of views may not be confirmed from the social approach.

In the present study, the performance assessment has been done considering the view of investors.

2.1 Problem statement

If stockholders choose appropriate assessment criteria that are also used as a basis for determining managers’ rewards, they will not only be able to make better decisions on investing their assets, but also they can direct managers’ goals towards their own goals and reach the goals quicker. Moreover, performance evaluation of companies is a necessity and it has to be done through using accepted criteria which consider different aspects of limitation on activities and the possibility of taking advantages of facilities (Healy, 1998, pp. 16).
Therefore, in order to assess and to analyse the accounting information, applying different methods and models of other sciences such as mathematics and statistics rather than classical accounting models, which have several shortcomings, is recommended. Researchers are now trying to use such models as DEA so as to introduce appropriate mathematically-based investment criteria.

In the present study, the DEA technique as well as financial variables have been applied to measure the performance and efficiency of companies belonging to the metal industries and accepted in Tehran Stock Exchange Corporation. Moreover, the relationship between the financial variables and DEA has been studied in order to reach the results that can encourage managers to apply such concepts and mathematically-based criteria for representing a real and precise view of enterprises’ performance.

2.2 Overview of previous studies

Several studies applying DEA for the efficiency measurement of enterprises have been carried out so far. However, investigating and analysing the relationship between the financial variables of performance assessment and DEA, i.e. measuring performance based on financial statements through using DEA, have not specifically been done to date.

Some of the most important international researches in this regard are as follows:

Phirooz et al. (2003) carried out a research on analysing the financial statements (1982-1992) of active companies in the oil and gas industry stock exchange using DEA approach. The results of the study confirmed the validity and reliability of applying DEA for the performance assessment of enterprises. Saranga and Phani (2007) evaluated the internal efficiency of 44 pharmaceutical companies using DEA. The findings showed there is a relationship between the existing variables. Kadoya et al. (2008) assessed paradox investment strategies by DEA. They also introduced the classical criteria of investment evaluation such as book value to market value, and concluded that such criteria along with DEA would be appropriate for performance assessment.

3. Methodology

In the present study, the DEA technique as well as the financial-based variables such as Return On Investment (ROI), Residual Income (RI), Return On Sale (ROS), Earnings Per Share (EPS), Price to Earnings ratio (P/E), Return On Assets (ROA), and Operating Cash Flows to owners’ equity (OCF) have been applied to measure the performance and efficiency of enterprises. Moreover, the multivariate regression has been used to study the relationship between the financial variables and DEA.

It is worth mentioning that the research method is survey-exploratory, and the case study includes companies belonging to the metal industries and accepted in Tehran Stock Exchange Corporation. A six-year data (2003-2008) of 24 companies, totally 144
observations, has been collected using records such as financial statements and reports of Stock Exchange archive.

3.1 Research hypothesis

It is assumed that there are significant relationships between the financial variables of performance assessment (ROI, RI, ROS, EPS, P/E, ROA, and OCF) and the efficiency results of DEA regarding the companies selected.

3.2 Data envelopment analysis (DEA)

DEA has been recognized as an excellent method for analyzing performance and modelling organizations. It measures the relative efficiency of peer units when multiple inputs and outputs are present and generates an efficiency score for each unit, relative to a reference technology based on the sample of efficient units (Charnes et al., 1978).

Consider a set of homogeneous decision-making units (DMUs) as DMU\(_j\), \(j = 1, 2, \ldots, n\). Each DMU consumes \(m\) inputs to produce \(s\) outputs. Suppose that \(X_j = (x_{1j}, x_{2j}, \ldots, x_{mj})\) and \(Y_j = (y_{1j}, y_{2j}, \ldots, y_{sj})\) are the vectors of inputs' and outputs' value of DMU\(_j\), respectively and \(X_j \geq 0, X_j \neq 0\) and \(Y_j \geq 0, Y_j \neq 0\).

The CCR (Charnes, Cooper and Rhodes) model for assessing the performance of DMU\(_p\) is as follows (model 1):

\[
\begin{align*}
\min & \quad \theta \\
\text{s.t.} \quad & \sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{ip}, \quad i = 1, \ldots, m \\
& \sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{rp}, \quad r = 1, \ldots, s \\
& \lambda_j \geq 0, \quad j = 1, \ldots, n 
\end{align*}
\]

The value of \(\lambda\) and \(\theta\) will be calculated by solving model (1). The value of \(\theta^*\), the optimal solution of model (1), is called the relative efficiency of DMU\(_p\).

Model (2) shows the multiplier form of model (1):

\[
\begin{align*}
E_p &= \max \sum_{r=1}^{s} u_r y_{rp} \\
\text{s.t.} \quad & \sum_{i=1}^{m} v_i x_{ip} = 1 \\
& \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, \quad j = 1, \ldots, n \\
& u_r \geq 0, \quad r = 1, \ldots, s \\
& v_i \geq 0, \quad i = 1, \ldots, m 
\end{align*}
\]

(2)
In this research, the multiplier form of the input-oriented CCR has been used. The objective of the input-oriented models is to minimize inputs while the same levels of outputs can still be produced.

4. Results analysis

In order to apply DEA for performance assessment, it is required to classify assessment criteria as inputs and outputs. So, in this study, operating expenses and owners’ equity are considered as inputs while net earnings and operating cash flows are regarded as outputs.

The results of solving CCR model for each of the selected companies are shown in Table 1. Companies whose relative efficiencies equal 1 are the efficient companies while those with the relative efficiency of less than 1 are inefficient.

As mentioned before, the multivariate regression has been used to study the relationship between the financial variables of performance assessment and the efficiency results of DEA. Table 2 presents the results of the test. It is noteworthy that the financial variables and the efficiency results of DEA are considered as the independent and dependent variables, respectively. As Table 2 shows the level of significance and F confirm that there should be a relationship between the financial variables and the efficiency results of DEA. However, it is still required to study and to analyse the regression coefficients (Table 3).

Table 1: Relative efficiency of selected companies

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According to the regression coefficients of Table 3, it is claimed that there are significant relationships between three variables (ROS, EPS, and OCF) and the efficiency results of DEA. However, the other independent variables (ROI, RI, P/E, and ROA) do not have any significant relationships with DEA results as a dependent variable.

In addition, the $\beta$ coefficients show positive relationships between the three variables and DEA results. In other words, due to the positive $\beta$ coefficient, if EPS increases one unit, the efficiency measured by DEA will increase by 0.001 unit. Also,
decrease of EPS will lead to the same decrease of the efficiency. Similarly, if ROS and OCF increase one unit, the efficiency calculated by DEA will increase by 0.297 and 0.006 units, respectively. Besides, their decrease will result in the same decrease of the efficiency.

Considering the regression coefficients resulted from the Forward Testing (Forward Coefficients), it is confirmed that there are significant relationships between three variables (ROS, EPS, and OCF) and the efficiency results of DEA. However, the other independent variables (ROI, RI, P/E, and ROA) do not have any significant relationships with DEA results as a dependent variable. So equation (3) is suggested based on the test:

\[
\text{The efficiency results of DEA} = 0.006 \times \text{OCF} + 0.323 \times \text{ROS} + 0.001 \times \text{EPS} + 0.335
\]

Moreover, considering the regression coefficients resulted from the Backward Testing (backward excluded variables), it is claimed that there are significant relationships between five independent variables (ROI, ROA, ROS, EPS, and OCF) and the efficiency results of DEA as a dependent variable. However, the other two variables (RI and P/E) do not have any significant relationships with DEA results.

5. Conclusion and suggestions

The first objective of the present study was to apply DEA and the financial variables of performance assessment (ROI, RI, ROS, EPS, P/E, ROA, and OCF) in order to measure the performance and efficiency of companies belonging to the metal industries and accepted in Tehran Stock Exchange Corporation. To do so, a six-year data of 24 companies, totally 144 observations, was collected and used. The efficient and inefficient companies were identified by DEA.

The second objective was to employ the multivariate regression in order to study the relationship between the financial variables and DEA. The results of the test showed significant relationships between three variables (ROS, EPS, and OCF) and the efficiency results of DEA. So such variables can be considered as appropriate criteria and introduced as substitute variables to measure the performance and efficiency of enterprises.

To conclude, it is suggested stockholders consider ROS, EPS, and OCF as appropriate criteria to assess the efficiency of enterprises and to make any economic decisions. However, the other financial variables (ROI, RI, P/E, and ROA) may not be suitable criteria for the above purposes.
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