Full Length Research Paper

Data envelopment analysis (DEA) based performance evaluation system for investment companies: Case study of Tehran Stock Exchange

Maryam Zohdi¹, Amir Babak Marjani²*, Ali Montazeri Najafabadi³, Jamalodin Alvani³, Mohammad Reza Dalvand⁴

¹Beiza Branch, Islamic Azad University, Beiza, Iran.
²Department of management, Central Tehran Branch, Islamic Azad University, Tehran, Iran.
³Bushehr Branch, Islamic Azad University, Bushehr, Iran.
⁴Zahedshahr Branch, Islamic Azad University, Zahedshahr, Iran.

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An investment company is a company that invests money on behalf of its shareholders who are participant in profits and losses. Therefore, appraisal of performance of such companies is most important for related investors. As we know, data envelopment analysis (DEA) is a nonparametric method that measures the relationship between produced outputs and consumed inputs and determines an efficiency score and has been widely applied in performance evaluation domain. This paper provides a DEA based system for evaluation of the performance of Iranian investment companies using financial statement analysis. Four different versions of DEA are applied for efficiency analysis and AP-DEA is applied for ranking of twelve considered companies. Ten different financial ratios are considered as inputs and outputs of each decision making unit. The results show that the BCC form of DEA is not able to distinguish between efficient and inefficient units and AP-DEA is an appropriate method to obtain full ranking of companies. Using this performance evaluation system, a new ranking of investment companies is obtained compared to the traditional ranking presented by Tehran stock exchange (TSE).

Key words: Performance evaluation, investment companies, data envelopment analysis (DEA).

INTRODUCTION

Based on the definition suggested by U.S. Securities and Exchange Commission, “an investment company is generally a company (corporation, business trust, partnership, or Limited Liability Company) that issues securities and is primarily engaged in the business of investing in securities”. An investment company invests the money received from investors on a specific investment plan, and each investor will be shared in the investment income and risks in proportion to the investor’s interest in the investment company.

There are three basic types of investment companies namely mutual funds or open-end companies, closed-end funds or close-end companies, and unit investment trusts (UITs). Each type has its own unique features. For example, mutual fund and UIT shares are redeemable but closed-end fund shares are not redeemable. It is notable that because of specific business rules of Iran only close-end and UITs investment companies exist in Iran and open-end investment companies not exist.

Generally, the performance of an investment company is based on the performance of the securities and other assets that the investment company owns. Assessing the performance of investment companies is most important for investors and financial managers. Hence, performance evaluation of investment companies has been widely studied in the literature. For instance, Quigley and Sinquefield (2000) examined the performance of all UK unit trusts through a three-factor model which takes into account their exposure to market, value and size risk. Mahmud and Mirza (2011) evaluate

*Corresponding author. E-mail: ab.marjani@yahoo.com.
the performance of investment companies of Pakistan which has an emerging economy like Iran. They analyzed the performance of this industry in the period of the birth of asset management companies and asset managers. Cuthbertson et al. (2010) reviewed the empirical findings on the performance of investment companies, especially mutual fund companies of US and UK. They found that the key drivers of relative performance are load fees, expenses and turnover. There are large numbers of methods for assessing the performance of the company. In traditional approaches of performance evaluation of investment companies, some indices such as Treynor index, the Sharpe index or the Jensen index have been used to evaluate the return of the company. Such approaches are not comprehensive enough to assess the performance in various aspects (Chen et al., 2011). Therefore, various methods have been developed for performance evaluation of investment companies. Ho (2007) demonstrated that combination of financial statement analysis and data envelopment analysis (DEA) is a powerful system for performance evaluation of different types of corporation and organization.

DEA has been considered in the literature as an appropriate tool for measuring and analyzing the efficiency and performance of investment companies. Parkan and Wu (1999) measured the performance of a particular type of investment corporation namely investment bank using the operational competitiveness rating (OCRA) procedure and validated obtained results using DEA and profit scores. Chen et al. (2005) used DEA to assess the performance of a special type of investment companies in China namely trust and investment company (TIC). They expressed that “TICs were set up by banks, large state-owned enterprises, provinces and ministries as a means to channel investment including foreign investment to projects that state banks would not traditionally fund”. Valderrama and Bautista (2005) estimated the performance of investment companies of Philippine focusing on mutual fund industries and using Beta estimates, Jensen’s alpha, and an extension of Sharpe ratio. In fact, they used DEA analysis to extend the traditional Sharpe ratio analysis by accounting for other costs incurred in the management of mutual funds. An application of integrated DEA and analytic hierarchy process model for evaluating and selecting flexible manufacturing system based on financial and non financial criteria can be found at Rezaie et al. (2009) and Rezaie et al. (2010)’s studies.

However, two main reasons increased the necessity of a DEA based performance evaluation system for Iranian investment companies 1) lack of previous DEA research on assessing performance of investment companies; 2) advantages of DEA in performance evaluation area. Using analysis of the DEA results, the principle causes of the poor performance of an investment company can emerged and it can help both fund managers and investors to analyze their funds. It also help fund managers to extract possible ways to control risk related to certain aspects of their companies.

RESEARCH METHODOLOGY

The research methodology will be discussed here. As stated previously, in this study DEA will be used for assessing performance of the Iranian investment companies. Therefore, a brief introduction to DEA, its inputs and outputs variables, and description of data source will be presented.

Data envelopment analysis (DEA)

Data envelopment analysis (DEA), initially introduced by Charnes et al. (1978), is a nonparametric method to evaluate the efficiency of decision making units (DMUs) which has not any assumption about functional form for the frontier and it evaluate the performance considering various inputs and outputs simultaneously. It also does not require prior assumptions of the relationship between inputs and outputs and they can have very different units. There are different versions of DEA model based on its features. Two well-known features of DEA model are structure of its returns to scale and orientations in efficiency analysis.

Based on the structure of returns to scale, there are two versions namely constant returns to scale (CRS) or CCR (Charnes et al. 1978) and variable returns to scale (VRS) or BCC (Banker et al., 1984). In the CRS version, it is assumed that an increase in the amount of inputs would lead to a proportional increase the amount of outputs. In the VRS version, the amount of outputs is deemed to increase more or less than proportionally than the increase in the inputs. The CRS version is more restrictive than the VRS and usually produces fewer numbers of efficient units and also lower efficiency scores among all DMUs. This is due to the fact that the CRS is a special case of the VRS model.

Based on the orientations in efficiency analysis there are two well-known orientations in efficiency analysis. Input-oriented models are models where DMUs are supposed to produce a given amount of outputs with the smallest possible amount of inputs. Output-oriented models are models where DMUs are supposed to produce with given amounts of inputs and the highest possible of outputs (Charnes, 1994).

Assuming n DMUs with m inputs and k outputs, the CCR and BCC model related to DMUj are as shown in Equations 1 and 2 respectively. Where, \( \theta_p \) indicates the efficiency score of \( DMU_p \), \( x_j \) indicates the \( i \)th input of the \( j \)th DMU, \( y_r \) indicates the \( r \)th output of the \( j \)th DMU, and \( \lambda_j \) indicates the weight of the \( j \)th DMU.

\[
\begin{align*}
\text{Min } \theta_p \\
\text{s.t.} \\
\sum_{j=1}^{n} \lambda_j x_{ij} & \leq \theta_p x_{ip} \\
\sum_{j=1}^{n} \lambda_j y_{rj} & \geq y_{rp} \\
\lambda_j & \geq 0, \ j = 1...n, \ i = 1...m, \ r = 1...k \\
\end{align*}
\]
Table 1. The top 12 companies of Tehran stock exchange (TSE) in year 2010.

<table>
<thead>
<tr>
<th>DMU</th>
<th>Company name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bahman</td>
</tr>
<tr>
<td>2</td>
<td>Booali</td>
</tr>
<tr>
<td>3</td>
<td>Melli-e Iran</td>
</tr>
<tr>
<td>4</td>
<td>Ghadir (Holding)</td>
</tr>
<tr>
<td>5</td>
<td>Tooka Foolad (Holding)</td>
</tr>
<tr>
<td>6</td>
<td>Petroshimi</td>
</tr>
<tr>
<td>7</td>
<td>Rena (Holding)</td>
</tr>
<tr>
<td>8</td>
<td>Sandoogh-e Bazneshastegi</td>
</tr>
<tr>
<td>9</td>
<td>Omid</td>
</tr>
<tr>
<td>10</td>
<td>Sakhteman-e Iran</td>
</tr>
<tr>
<td>11</td>
<td>Shahed</td>
</tr>
<tr>
<td>12</td>
<td>San'at-o Madan</td>
</tr>
</tbody>
</table>

Min $\theta_p$  

s.t.  

$$\sum_{j=1}^{n} \lambda_j \chi_{ij} \leq \theta_p \chi_{ip}$$  

$$\sum_{j=1}^{n} \lambda_j \gamma_{ij} \geq \gamma_{ip}$$  

$$\sum_{j=1}^{n} \lambda_j = 1$$  

$$\lambda_j \geq 0, \ j = 1...n, \ i = 1...m, \ r = 1...k$$  

(2)

Data sources and description

The sample data in the study are obtained from investment companies included in the brief list of the top-fifty companies of Tehran Stock Exchange (TSE) in last three months of year 2010. These twelve companies are shown in Table 1.

Input and output variables

The variables are selected based on the variables chosen in earlier DEA studies in the related literature (Powers and McMullen, 2000; Luo, 2003; Seiford and Zhu, 1999; Ho and Zhu, 2004; Shih-Fang and Wen-Min, 2006). The five inputs variables considered in this study are beta index or systematic risk, sigma index or unsystematic risk, price/earnings ratio (P/E), return on owners’ equity, and total assets. The five outputs variables also considered in this study are earnings per share (EPS), sales growth, current ratio, quick ratio, and net income.

EFFICIENCY SCORE ANALYSIS

In order to test the applicability of the different DEA models, four different models included both input-oriented and output-oriented of both CCR and BCC models were applied to a set of 12 investment companies. Table 2 shows the efficiency scores of the mentioned companies under specific conditions of four versions of DEA.

According to the obtained results from both input and output-oriented of CCR model, the DMU 3, 5, 6, and 10 are inefficient whereas the obtained results from both input and output-oriented of BCC model only identified DMU 6 as inefficient DMU. As seen in Table 2, in this case, the BCC models do not have enough discrimination ability to distinguish efficient units from inefficient units. The CCR models also identified only four inefficient units. Based on the results of the efficiency models we were not able to rank the DMUs.

Hence, in the next step, the Andersen and Petersen’s model (AP-DEA) will be applied to achieve full ranking of DMUs. The mathematical model of AP-DEA is stated in Equation 3. Table 3 shows the ranking of each DMU.

\[ \text{Min } \theta \]

s.t.  

$$\sum_{j=1}^{n} \lambda_j \chi_{ij} \leq \theta \chi_{ip}; \ i = 1, 2, ..., m$$

$$\sum_{j=1}^{n} \lambda_j \gamma_{ij} \geq \gamma_{ip}; \ r = 1, 2, ..., s$$

$$\lambda_j \geq 0; \ \forall j$$

\[ \theta \text{ is free} \]

(3)

As seen in Table 3, the DMU 6, 10, 5 and 3 which is identified as inefficient units in CCR models, take the four last ranks among all DMUs respectively. The DMU 2, 9 and 1 identified as efficient units in all models, also take the three first ranks. All these results are graphically observable in Figures 1 and 2.

Conclusion

DEA is a mathematical programming approach which can be used to evaluate the efficiency and identify relationship between inputs and outputs of any decision making unit. Considering these concepts, in this study, DEA has been presented as a useful method to evaluate the performance of investment companies. This study examined the performance of Iranian investment companies listed in top-fifty most active companies of TSE using financial ratios and DEA. The financial ratios are considered were beta index or systematic risk, sigma index or unsystematic risk, price/earnings ratio (P/E), return on owners’ equity, total assets as inputs, and earnings per share (EPS), sales growth, current ratio, quick ratio, and net income as outputs. The ranking of the
Table 2. Efficiency scores of DMUs.

<table>
<thead>
<tr>
<th>DMU</th>
<th>CCR</th>
<th>BCC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Input-oriented</td>
<td>Output-oriented</td>
</tr>
<tr>
<td>1</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>2</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>3</td>
<td>0.77</td>
<td>1.30</td>
</tr>
<tr>
<td>4</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>5</td>
<td>0.73</td>
<td>1.37</td>
</tr>
<tr>
<td>6</td>
<td>0.99</td>
<td>1.01</td>
</tr>
<tr>
<td>7</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>8</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>9</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>10</td>
<td>0.92</td>
<td>1.08</td>
</tr>
<tr>
<td>11</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>12</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 3. Ranking of DMUs.

<table>
<thead>
<tr>
<th>DMU</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rank</td>
<td>3</td>
<td>1</td>
<td>12</td>
<td>8</td>
<td>11</td>
<td>9</td>
<td>6</td>
<td>7</td>
<td>2</td>
<td>10</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 1. Efficiency chart.

mentioned companies is compared with the obtained ranking from the study in Table 4. The two ranking are very different because of difference in ranking systems. The top-fifty list is based on a hybrid index which represents the more active companies and it is not based on the performance whereas this study ranked the companies based on the performance. The obtained results demonstrated the ability of DEA to assess the
Table 4. Comparison of top-fifty ranking and ranking of this study.

<table>
<thead>
<tr>
<th>Ranking</th>
<th>DMU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top-fifty list</td>
<td>2  3  5  12  13  16  18  22  26  28  39  41</td>
</tr>
<tr>
<td>In investment companies (included in top-fifty list)</td>
<td>1  2  3  4  5  6  7  8  9  10  11  12</td>
</tr>
<tr>
<td>This study</td>
<td>3  1  12  8  11  9  6  7  2  10  4  5</td>
</tr>
</tbody>
</table>

performance of investment companies.

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REFERENCES