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Selection Input Output by Restriction Using DEA Models Based on a Fuzzy Delphi Approach and Expert Information

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Abstract. Stock evaluation has always been an interesting problem for investors. In this paper, a comparison regarding the efficiency stocks of listed companies in Bursa Malaysia were made through the application of estimation method of Data Envelopment Analysis (DEA). One of the interesting research subjects in DEA is the selection of appropriate input and output parameter. In this study, DEA was used to measure efficiency of stocks of listed companies in Bursa Malaysia in terms of the financial ratio to evaluate performance of stocks. Based on previous studies and Fuzzy Delphi Method (FDM), the most important financial ratio was selected. The results indicated that return on equity, return on assets, net profit margin, operating profit margin, earnings per share, price to earnings and debt to equity were the most important ratios. Using expert information, all the parameter were clarified as inputs and outputs. The main objectives were to identify most critical financial ratio, clarify them based on expert information and compute the relative efficiency scores of stocks as well as rank them in the construction industry and material completely. The methods of analysis using Alirezaee and Afsharian’s model were employed in this study, where the originality of Charnes, Cooper and Rhodes (CCR) with the assumption of Constant Return to Scale (CSR) still holds. This method of ranking relative efficiency of decision making units (DMUs) was value-added by the Balance Index. The interested data was made for year 2015 and the population of the research includes accepted companies in stock markets in the construction industry and material (63 companies). According to the ranking, the proposed model can rank completely for 63 companies using selected financial ratio.

1. Introduction
Stock selection to a portfolio has always been a major task and the investors have faced problem since the availability of the number of securities with multiple input and output data makes it more complex to determine the stocks. Therefore, the decision to evaluate and rank the stock can be determined using Data Envelopment Analysis (DEA). A variety of DEA models were formulated to rank the efficiency of Decision Making Units (DMUs). DEA is a mathematical decision making technique to measure the
relative efficiency DMUs with multiple inputs and outputs. This method was originated by Charnes et al. [1]. One of the drawbacks of DEA is the problem of lack of discrimination among efficient DMUs and hence, yielding a large number of DMUs as efficient ones. Therefore two new models for ranking efficient DMUs based on Norm 1 and using means of inputs-outputs weights were developed [2]. Cross efficiency evaluation method has been widely used for ranking the performance of DMUs in Data Envelopment Analysis. However, there were still several flaws in the cross efficiency evaluation method, such as non-uniqueness of cross efficiency scores, that may limit its usefulness [3].

Many methods have been proposed to enhance the discrimination power of DEA, one of which is the super-efficiency method proposed by Andersen and Petersen [4] to break the tie of efficient DMUs that occurs under the CCR model proposed by Charnes et al.[1]. However, super efficiency models have three drawbacks: first, the inability to rank non-extreme efficient DMUs; second, evaluating DMUs according to the different weight; and finally, efficiency models were infeasible in some cases [5]. Hosseinzadeh Lotfi et al. [6] proposed one DEA ranking method based on applying aggregate units. Selecting the best ranking method or the way of combining different ranking methods for ranking DMUs is an important point in ranking DMUs in DEA. Hence, they proposed methodology based on the TOPSIS method for ranking DMUs [7]. A different theories and methods will produce different ranking. Therefore, in this paper, we introduced a complete ranking of DMUs using restriction in DEA where the input and output are selected based on Fuzzy Delphi approach and previous studies. The model used for ranking is restriction method in DEA, proposed by Alirezaee and Afsharian [8]. This model is more precise and logical than other methods because it using initial data of DEA models and does not destroy competition between DMUs. Furthermore, it is easily employed and logical [8]. This model was modified by Dong Guo, Jie Wu [9] and Jie Wu [10]. Some traditional approaches to select attractive stocks by means of evaluating the overall corporate performance of the firm’s financial statement analysis are based on the computation of financial ratio. These ratios provide a dynamic analysis of the company’s financial situation and evaluate with precision the advantage and disadvantage of the company. Roslah et al. [11] adopted the model proposed by Alirezaee and Afsharian for ranking efficiency unit stocks performance in Bursa Malaysia where the inputs and outputs were selected based on the previous study.

Financial ratios were also used for the purpose of predicting future performance. However, using all the available financial ratios in stock evaluation is impractical as it will make the evaluation process computationally and analytically complicated. There were many methods which have been implemented to identify the most important ratios. In order to select and identify the most important financial ratio, Fuzzy Delphi Method (FDM) on expert judgement was proposed because the method is an analytical technique. The advantage of using FDM is that it requires only a small number of samples and the derived results are objective and reasonable. Therefore, it can save time and the cost of collecting expert opinion. More importantly, it takes into account the fuzziness that cannot be avoided during the survey process [12]. With application of Alirezaee and Afsharian’s model, the DEA method was used to find the efficiency score and ranking on the selected stocks listed companies in Bursa Malaysia. CCR output oriented proposed calculating the efficiency score in every stock. The efficiency score has a range score between 0 and 1. A stock is efficient when the score is 1 and inefficient when the score is less than 1. If the stocks have the same efficient score, a problem will occur when ranking the stocks. Thus, the purpose of this study is to select the appropriate inputs and outputs, rank the stocks using the original model by Alirezaee and Afsharian using the Balance Index.
In order to perform the evaluation, financial analysis based on the computation of financial ratios can be used as evaluation criteria. Since there are many ratios available, it is important to identify the most critical ratio to be considered in the evaluation. In this study, we choose FDM to select the most important financial ratios for stock evaluation by using restriction in DEA. In the literature, many studies have used DEA model to measure performance companies and industry activities in various sectors. A summary of the literature including the DEA studies conducted by several business companies shown in Table 1. Based on Table 1, it shows that price to earnings ratio is the most parameter used among researchers to evaluate companies’ performances. Therefore, in this research, we use the price to earnings ratio as one of the critical financial ratio to evaluate performance of companies.

Table 1. DEA studies for various business companies.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Business sector</th>
<th>Input variable</th>
<th>Output variable</th>
<th>DEA Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>[13] 10 largest industries in India</td>
<td>Price to earnings ratio (PER), Sigma (3 years), Beta</td>
<td>Earnings per share (EPS), 1 year return, 3 year return, 6 year return</td>
<td>SBM</td>
<td></td>
</tr>
<tr>
<td>[14] 28 cement’s companies in Tehran stock market</td>
<td>Ratio to price income, Sigma (5 years)</td>
<td>Average of 5 year return on investment (ROI), dividends of stock</td>
<td>CCR</td>
<td></td>
</tr>
<tr>
<td>[15] 185 largest market cap stocks</td>
<td>Price earnings ratio (PER), Beta, Sigma (5 years)</td>
<td>Earnings per share (EPS), 1 year return, 3 year return, 5 year return, 10 year return</td>
<td>CCR</td>
<td></td>
</tr>
<tr>
<td>[16] 22 quarters Brazilian stock market</td>
<td>Price earnings ratio (PER), Beta, Return volatility</td>
<td>Earnings per share (EPS), 1 year return, 3 year return, 5 year return</td>
<td>CCR</td>
<td></td>
</tr>
<tr>
<td>[17] 20 companies in Bursa Malaysia</td>
<td>Current ratio, Debt ratio, Debt to equity ratio</td>
<td>Return on investment (ROI), Return on equity (ROE), Earning per share (EPS)</td>
<td>BCC</td>
<td></td>
</tr>
</tbody>
</table>

2. Fuzzy Delphi Method and Expert Information

Delphi method is an interactive method used to survey and collect the most reliable consensus opinion of a group of experts on subject. To determine the most important financial ratios for stock evaluation, the ratios have been firstly identified from review of the existing literature. Twenty financial ratios were chosen based on their popularity and relevance to the assessment of stock performance. The selected financial ratios were categorized into five groups perspective namely liquidity, profitability, leverage, asset turnover ratios and growth ratios.

From the previous study, FDM was adopted to identify the critical financial ratios for evaluation of the stock performance. This method creates a better way of criteria selection. Seven linguistic terms expressed by triangular fuzzy numbers were used to indicate the level of importance of each ratio [12]. The seven linguistic terms were extremely unimportant (EU), unimportant (U), quite unimportant (QU), fair (F), quite important (QI), important (I) and extremely important (EI). In addition, their study had distributed 14 questionnaires to experts who work at investment companies, brokerage companies and
academicians to obtain their opinions about the importance of the criteria. Mazura et al. [12] have applied FDM and the process were explained as follows:

**Step 1: Collect opinions of expert group:** Each expert is asked through a questionnaire to determine the importance of the evaluation criteria.

**Step 2: Set up triangular fuzzy numbers:** Calculate the evaluation value of the triangular fuzzy number of each criterion given by the expert. The evaluation value of a criterion \( j \) of \( m \) criteria given by expert \( i \) of \( n \) experts is expressed as

\[
\tilde{w}_{ij} = \left( a_{ij}, b_{ij}, c_{ij} \right), \quad i = 1, 2, ..., n \quad \text{and} \quad j = 1, 2, ..., m.
\]

Then the overall fuzzy value \( \tilde{w}_j = \left( a_j, b_j, c_j \right) \) where

\[
a_j = \min \{ a_{ij} \}, \quad b_j = \frac{1}{n} \sum_{i=1}^{n} b_{ij}, \quad c_j = \max \{ c_{ij} \}
\]

**Step 3: Defuzzification:** Use the center of gravity method to defuzzify the fuzzy value \( \tilde{w}_j \) of each criterion to define value of \( S_j \) where

\[
S_j = \frac{a_j + b_j + c_j}{3}, \quad j = 1, 2, ..., m.
\]

**Step 4: Screen evaluation criteria:** To achieve the goal of screening, a threshold value \( \alpha \) must be defined subjectively according to the needs of the study. The principle screening is as follows:

If \( S_j \geq \alpha \), then the criterion is accepted.

If \( S_j < \alpha \), then the criterion is rejected.

The evaluation criteria with a threshold value below 0.6 were deleted and the evaluation criteria with threshold value above 0.6 were selected [12]. From the research, the result identified the most important criteria for stock evaluation which are return on equity, return on asset, and earnings price per share, operating profit margin, net profit margin and debt to equity ratio. Table 2 shows seven critical financial ratio and definition for stock evaluation based on previous study and Fuzzy Delphi Method (FDM).

<table>
<thead>
<tr>
<th>Ratios</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return on equity</td>
<td>Net income divided by shareholder’s equity</td>
</tr>
<tr>
<td>Return on assets</td>
<td>Net income divided by total assets</td>
</tr>
<tr>
<td>Earnings per share</td>
<td>Net income minus preferred dividends divided by common shares outstanding</td>
</tr>
<tr>
<td>Operating profit margin</td>
<td>Operating income divided by net sales</td>
</tr>
<tr>
<td>Net profit margin</td>
<td>Net income divided by net sales</td>
</tr>
<tr>
<td>Debt to equity ratio</td>
<td>Long-term debt divided by shareholders equity</td>
</tr>
<tr>
<td>Price to earnings ratio</td>
<td>Stock price divided by net income per share</td>
</tr>
</tbody>
</table>

Table 2. Financial ratio for stock evaluation.

Based on expert information, selection of inputs and outputs also will be clarified. Expert information (EI) on inputs and outputs selection in an industry may have been formed over many years of experiences of studying inputting and outputting. Researchers often refer to expert opinions in defining these variables. Normally, profitability and growth perspective are typically considered as outputs because revenue or income generation is a major objective criterion for a firm. On the other hand, asset utilization, liquidity and leverage perspectives are considered as inputs because they were concerned with planning and operational strategies of a firm. In contrast, valuation perspective was concerned with how well the equity markets perceived success of a firm and thus it is not concerned with a firm’s input
strategy [18]. Therefore, based on definition from expert information, we clarify the inputs and outputs. Table 3 shows classification of selected financial ratios as inputs and outputs. It is important to mention that, most of the selected ratios were under the profitability category. The results of this study can be used to observe the achievement of the companies in terms of financial performance. The financial ratios that has been identified were used as inputs and outputs to compute the efficiency score of stocks using the restriction in DEA model.

Table 3. Classification of financial ratio.

<table>
<thead>
<tr>
<th>Ratios</th>
<th>Perspective</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return on equity (ROE)</td>
<td>Profitability</td>
<td>Output</td>
</tr>
<tr>
<td>Return on assets (ROA)</td>
<td>Profitability</td>
<td>Output</td>
</tr>
<tr>
<td>Earnings per share (EPS)</td>
<td>Profitability</td>
<td>Output</td>
</tr>
<tr>
<td>Operating profit margin (OPM)</td>
<td>Profitability</td>
<td>Output</td>
</tr>
<tr>
<td>Net profit margin (NPM)</td>
<td>Profitability</td>
<td>Output</td>
</tr>
<tr>
<td>Debt to equity ratio (D/E Ratio)</td>
<td>Liquidity</td>
<td>Input</td>
</tr>
<tr>
<td>Price to earnings ratio (PER)</td>
<td>Valuation</td>
<td>Input</td>
</tr>
</tbody>
</table>

3. Model of Complete Ranking

The model proposed by Alirezaee and Afsharian’s is presented as follows [8]. Their model considered the \( n \) decision making units which consume varying amounts of \( m \) inputs in the productions outputs. Then, suppose \( x_{ij} \) denotes the amount consumed by the \( i \)th input and \( y_{rj} \) denotes the amount produced by the \( r \)th output measured for the \( j \)th decision making unit. In order to measure the efficiency unit, DEA does not require any price data.

Let us define:

\[
u_r : \text{weight assigned to output } r \ (r = 1, \ldots, s)\]

\[
u_i : \text{weight assigned to input } i \ (i = 1, \ldots, m)\]

This method does not require any price data. Therefore, it uses vectors of shadow prices of inputs and outputs. Consider \( u \) and \( v \) are shadow price vectors for output and input respectively using these prices, efficiency for DMU\(_p\) is:

\[
EFF_p = \frac{\sum_{r=1}^{s} u_r y_{rp}}{\sum_{i=1}^{m} v_i x_{ip}}
\]

(1)

There were two restrictions where the shadow prices must be non-negative and the shadow prices have to be such that when aggregated using these prices, no DMUs input-output bundle results in efficiency greater than unity. This also ensures that \( EFF_p \leq 1 \) for DMU\(_p\).

These restrictions can be formulated as follows:

\[
EFF_j = \frac{\sum_{r=1}^{s} u_r y_{ij}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 , \quad \forall j
\]

(2)

\[
u_r, v_i \geq 0 , \quad \forall r \forall i
\]
The second restriction to get a profit for \( j^{th} \) DMU is presented as follows:

\[
\sum_{r=1}^{n} u_{r} y_{rj} - \sum_{i=1}^{m} v_{ij} x_{ij} \leq 0 \quad j = 1, \ldots, n.
\]  

(3)

When the shadow price was derived from technology, the input profits of DMU were zero. This situation is called a balanced situation. Therefore, when the profit restriction by shadow price becomes zero, we say that the \( p^{th} \) DMU is efficient. The profit for other DMUs is equal to or less than zero, so the current DMU has overcome the others in this profit competition [8]. Otherwise, the DMU is inefficient because its profit restriction was not zero, thus, it was considered a loss. Next, Alirezaee and Afsharian have used the profit restriction and sum to describe a new index in addition to the efficiency score for each DMU. This situation is called Balance Index.

Normally, most of the sum was equal to or less than zero. Based on Dong Gua and Jie Wu [9], the less the sum is, the more greatly the profit of the evaluated DMU differs from the profits of the DMUs, and the higher the evaluated DMU should be ranked. Therefore, we can conclude that if the efficiency score unit of DMU\(_A\) and DMU\(_B\) is the same, and if DMU\(_A\) obtains more negative quantity values in Balance Index than DMU\(_B\), then DMU\(_A\) has a better rank than DMU\(_B\).

4. Methodology

This study has analysed 63 stocks in the construction and material industry on Bursa Malaysia. Table 4 shows the variable under consideration for each specific financial ratio. The Bursa Malaysia data for analysis was taken from Bloomberg and Datastream. Both Bloomberg and Datastream terminals were available at the Tun Abdul Razak Library (UiTM) Campus Tapah, Perak, Malaysia. The data on year 2015 were used to rank the performance of the selected companies.

All analysis were to determine the efficiency score. The software used for these analyses was R-programming software employing Benchmarking package. The efficiency scores of stocks were computed whereby the 2 input and 5 output data were considered. The method by Alirezaee and Afsharian [8] was applied in which the constant return to scale (CRS) was used. Once the values were obtained, the ranking were done using Balance Index.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value symbol</th>
<th>Weight symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating profit margin (OPM)</td>
<td>( y_1 )</td>
<td>( u_1 )</td>
</tr>
<tr>
<td>Earnings per share (EPS)</td>
<td>( y_2 )</td>
<td>( u_2 )</td>
</tr>
<tr>
<td>Net profit margin (NPM)</td>
<td>( y_3 )</td>
<td>( u_3 )</td>
</tr>
<tr>
<td>Return on equity (ROE)</td>
<td>( y_4 )</td>
<td>( u_4 )</td>
</tr>
<tr>
<td>Return on assets (ROA)</td>
<td>( y_5 )</td>
<td>( u_5 )</td>
</tr>
<tr>
<td>Debt to equity ratio (D/E Ratio)</td>
<td>( x_1 )</td>
<td>( v_1 )</td>
</tr>
<tr>
<td>Price to earnings ratio (PER)</td>
<td>( x_2 )</td>
<td>( v_2 )</td>
</tr>
</tbody>
</table>
The linear programming model for measuring the efficiency score the $p^{th}$ stock from 63 selected stocks were:

$$\text{Max } EFF_p = \sum_{i=1}^{5} u_i y_{ip}$$  \hspace{1cm} (4)$$

Subject to the following constraints:

$$\sum_{i=1}^{5} u_i y_{ij} - \sum_{i=1}^{2} v_i x_{ij} \leq 0, \hspace{1cm} \text{for each stock } j$$  \hspace{1cm} (5)$$

$$\sum_{i=1}^{2} v_i x_{ij} = 1, \hspace{1cm} \text{for each stock } j$$  \hspace{1cm} (6)$$

$$u_i, v_i \geq 0, \hspace{1cm} \forall r \forall j$$  \hspace{1cm} (6)

where $u_i$ and $v_i$ are the weights assigned to output and input respectively. Ranking the entire list of stocks completely, would be impossible if it were only based on the efficiency score. Therefore, we considered $\sum_{i=1}^{5} u_i y_{ij}$ as the total revenue and $\sum_{i=1}^{2} v_i x_{ij}$ as the total cost for 63 stocks which were calculated as an optimization problem.

$$\left[ \sum_{i=1}^{5} u_i y_{ij} - \sum_{i=1}^{2} v_i x_{ij} \right] \leq 0 \hspace{1cm} j = 1,2, \ldots, 63.$$

The Balance Index was computed for year 2015 as follows:

$$\text{Balance Index}_{2015} = \left[ 676.3 u_1 + 416.8 u_2 + 8.184 u_3 + 525.4 u_4 + 640.8 u_5 \right] - \left[ 53.4 v_1 + 1003.1 v_2 \right]  \hspace{1cm} (8)$$

Alirezaee and Afsharian [8] ranked all DMUs with two stage approach. Firstly, they ranked all DMUs with different DEA efficiency scores in accordance to the score, and secondly, they ranked the DMUs with the same DEA efficiency scores in accordance to the proposed Balance Index.

5. Result and Discussion

The CCR model and Balance Index in Alirezaee and Afsharian’s method were applied to rank 63 selected stocks in construction and material companies listed in Bursa Malaysia. Table 5 shows the efficiency scores for each of companies (DMU) in 2015. According to Table 5, we found that some companies with the same efficiency score. For example, five efficient companies with the efficiency score of 1 and some inefficient companies such as DMU23 (HOCK SENG LEE BERHAD) and DMU33 (MALAYSIAN RESOURCES) with 0.59 efficiency score, while DMU20 (HEVEABOARD BHD) and DMU8 (BREM HOLDING BERHAD) is 0.52 efficiency score. DMU63 (WOODLANDOR HOLDINGS), DMU51 (SEACERA TILES BHD), DMU24 (HUME INDUSTRIES BHD) and DMU22 (HOCK HENG STONE) were others companies which inefficient and have same efficiency score. Therefore, we cannot rank these DMUs using only the efficiency score. Hence, we calculate Balance Index for comparing the competitive profits and reset the ranking process. More negative values in Balance Index indicates that the stock shows good performance and high rank. The quantities of Balance Index for each DMU are shown in Table 6.
According to Table 6, they obtained different negative quantities in Balance Index such as DMU7 (BOILERMECH HOLD), DMU47 (PINTARAS JAYA BERHAD), DMU42 (MULTI-USAGE HOLDINGS), DMU35 (MENANG CORPORATION) and DMU21 (HO HUP CONSTRUCTION) whose the efficiency score are 1 which is efficient and the quantities Balance Index are -8398.9, -7770.8, -307.5, -211.6 and -146.9 respectively. Based on Table 7, we can see DMU7 (BOILERMECH HOLD) obtained the top rank and DMU21 (HO HUP CONSTRUCTION) was at the bottom rank among efficient companies.

While DMU59 (WTK HOLDINGS BHD), DMU43 (IJM CORPORATION BHD) and DMU58 (UNITED ULI CORP) are inefficient companies which they got the same efficiency score 0.14 and the quantities Balance Index are -54.4, -41.0 and -34.8 respectively. According to quantity of Balance Index, DMU59 (WTK HOLDINGS BHD) get more negative quantities, therefore DMU59 (WTK HOLDINGS BHD) obtained better rank as compare to DMU25 (IJM CORPORATION BHD) and DMU58 (UNITED ULI CORP).

<table>
<thead>
<tr>
<th>DMU</th>
<th>Efficiency score</th>
<th>DMU</th>
<th>Efficiency score</th>
<th>DMU</th>
<th>Efficiency score</th>
<th>DMU</th>
<th>Efficiency score</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1.00</td>
<td>40</td>
<td>0.41</td>
<td>12</td>
<td>0.23</td>
<td>60</td>
<td>0.09</td>
</tr>
<tr>
<td>47</td>
<td>1.00</td>
<td>30</td>
<td>0.41</td>
<td>36</td>
<td>0.23</td>
<td>16</td>
<td>0.09</td>
</tr>
<tr>
<td>42</td>
<td>1.00</td>
<td>13</td>
<td>0.40</td>
<td>45</td>
<td>0.22</td>
<td>46</td>
<td>0.08</td>
</tr>
<tr>
<td>35</td>
<td>1.00</td>
<td>18</td>
<td>0.40</td>
<td>10</td>
<td>0.21</td>
<td>26</td>
<td>0.08</td>
</tr>
<tr>
<td>21</td>
<td>1.00</td>
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<td>56</td>
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</tr>
<tr>
<td>54</td>
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<td>0.05</td>
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<tr>
<td>11</td>
<td>0.65</td>
<td>57</td>
<td>0.32</td>
<td>50</td>
<td>0.16</td>
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</tr>
<tr>
<td>23</td>
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</tr>
<tr>
<td>33</td>
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<td>62</td>
<td>0.29</td>
<td>59</td>
<td>0.14</td>
<td>24</td>
<td>0.03</td>
</tr>
<tr>
<td>20</td>
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<td>41</td>
<td>0.29</td>
<td>25</td>
<td>0.14</td>
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</tr>
<tr>
<td>8</td>
<td>0.52</td>
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<td>0.27</td>
<td>58</td>
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<td>6</td>
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</tr>
<tr>
<td>5</td>
<td>0.50</td>
<td>61</td>
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the same could be ranked using their Balance Index. Table 7 shows complete ranking of 63 companies. DMU17 (FAJARBARU BUILD) obtained the highest rank and DMU1 (BOILERMECH HOLD) was the least rank among all DMUs. According to Table 7, we can see ranking of the same efficiency score of DMUs, for example five efficient DMUs which were ranked using their Balance Index or many inefficient DMUs which their efficiency score unit were also the same could be ranked using their Balance Index.

Table 7. Complete ranking for 2015

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6. Conclusion

This paper also illustrated method of selection and clarify inputs and outputs based on a Fuzzy Delphi and Expert Information. It also shows the efficiency measurement using shadow prices and ranking of stock’s companies by using efficiency score. Moreover, this study also demonstrated an empirical problem in complete ranking that were due to some decision making units with the same efficiency score. Decision on the selection the inputs and outputs can affect the ranking of performance evaluation of companies. Consequently, we can rank all of companies to which is efficient or inefficient DMUs easily and completely. In conclusion, the ranking by this method was employed easily and with logical computation.

Appendix

Company’s listed in Bursa Malaysia (Construction and Material Industry)

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