The paper is devoted to a possibility to measure the company financial performance. This aspect is one of the crucial points in the financial decision-making of the metallurgy company. Several methodologies are to be applied. Multi-criteria method to efficiency measure on input and output relation approach on Data envelopment analysis (DEA) is described and applied. DEA method for CCR and BCC alternatives is explained and described. Simplified example of performance efficiency for ROA, financial leverage and liquidity indices is applied for ten decision-making units (DMU). Results are discussed, graphically presented and show possibility to successfully apply DEA methods.

Keywords: financial performance, MCDM, efficiency, Data envelopment analysis (DEA), DMU, CCR, BCC

1. INTRODUCTION

Performance of company is one of the most important objectives of the financial decision-making and management. Metallurgical plants and units are characterised by the high investments and a longer innovation cycle. Company financial performance is in the metallurgy industry one of the crucial goal. Therefore a correct and credible performance evaluation is important aspect from There is several conception based on multi-criteria decision-making (MCDM), how to measure company financial performance. The traditional approaches are based on the multi-criteria utility function (weighted sum method (WSM), weighted product method (WPM), simple additive weighted method (SAWM), analytic hierarchy process (AHP), analytic network process (ANP)), distance and compromise measures (TOPSIS, VIKOR, compromise solution, goal programming) and outranking methods (fuzzy preference relations) (ORESTE, ELECTREE, PROMETHEE). Special group of the multi-criteria decision method is Data Envelopment Analysis (DEA). DEA method serves to evaluation of the efficiency and performance of the various production subjects (decision making units (DMU)) including production companies. Advantages of the method are possibility to characterise the performance by a vector of factors (parameters, criteria, aspects, indices).

The intention of the paper is an application and the verification of the DEA method in financial performance of companies evaluation. The output oriented and constant return to scale approach is investigated. Simplified example of ten companies and three financial indices is presented.

2. DEA METHOD DESCRIPTION

Data envelopment analysis (DEA) is a multi-criteria productivity analysis model for measuring the relative efficiencies of a homogenous set of decision making units (DMU). We can distinguish two basic approaches; output oriented and input oriented models. Due to functional dependence of outputs to inputs there exists a constant return to scale model (CRS) or a variable return to scale (VRS) one. The basic idea of the output oriented models is comparison of the output vector to input vector. Efficiency of the output and CRS model is following:
Efficiency of DMU(Q) = \frac{\text{weighted sum of outputs}}{\text{weighted sum of inputs}} = \frac{\sum_{j=1}^{S} v_j \cdot y_{j,Q}}{\sum_{i=1}^{R} u_i \cdot x_{i,Q}}, \quad (1)

where Q is DMU investigated, x_{i,k} is amount of i-th input of k-th DMU, y_{j,k} is amount of i-th output of k-th DMU, u_i is weight of i-th input, v_j is weight of of i-th output. The DEA model is formulated as fractional mathematical problem. Subsequently the model is transformed to the linear programming problem, primal or dual versions, which are used for computation.

2.1 DESCRIPTION OF THE CCR (Charnes, Cooper, Rhodes) MODEL

The model CCR designed by Charnes, A., Cooper, W. W., & Rhodes, E. (1978) is a constant return to scale (CRS) type.

Problem 1 Fractional programme

\[ \max z_Q = \frac{\sum_{j=1}^{S} v_j \cdot y_{j,Q}}{\sum_{i=1}^{R} u_i \cdot x_{i,Q}}, \]

Subject to the constraints:

\[ \sum_{j=1}^{S} v_j \cdot y_{j,k} \leq 1, \quad \text{for } k = 1, 2 \ldots T, \]

\[ \sum_{i=1}^{R} u_i \cdot x_{i,k} \]

\[ u_i \geq 0, \quad v_j \geq 0, \quad \text{for } i = 1, 2 \ldots R, j = 1, 2 \ldots S, \]

where \( z_Q \) is DMU efficiency, \( x_{i,k} \) is amount of i-th input of k-th DMU, \( y_{j,k} \) is amount of i-th output of k-th DMU, \( u_i \) is weight of of i-th input, \( v_j \) is weight of of i-th output.

Problem 2 PRIMAL Linear Charnes transformation of Problem 1

\[ \max z_Q = \sum_{j=1}^{S} v_j \cdot y_{j,Q}, \]

Subject to the constraints:

\[ \sum_{i=1}^{R} u_i \cdot x_{i,Q} = 1, \]

\[ \sum_{j=1}^{S} v_j \cdot y_{j,k} - \sum_{i=1}^{R} u_i \cdot x_{i,k} \leq 0, \quad \text{for } k = 1, 2 \ldots T \]

\[ u_i \geq 0, \quad v_j \geq 0, \quad \text{for } i = 1, 2 \ldots R, j = 1, 2 \ldots S, \]

Problem 3 Dual form of Problem 2

\[ \min \theta_Q, \]

Subject to the constraints:

\[ \sum_{k=1}^{T} \lambda_k \cdot x_{i,k} - \theta_Q \cdot x_{i,Q} \leq 0, \quad \text{for } i = 1, 2 \ldots R, \]
\[ \sum_{k \in T} \lambda_k \cdot y_{jk} - y_{j,0} \geq 0, \quad \text{for } j = 1, 2 \ldots S, \]
\[ \lambda_k \geq 0, \quad \theta_0 \in (-\infty; +\infty), \quad \text{for } k = 1, 2 \ldots T, \]
where \( \theta_0 \) is efficiency score, \( \lambda_k \) is dual variable.

**Problem 4 Dual form of Problem 2 in a matrix form**

\[
\min \theta_0,
\]
Subject to the constraints:
\[
X \cdot \lambda - \theta_0 \cdot x_\infty \leq 0, \quad ,
Y \cdot \lambda - y_\infty \geq 0, \quad ,
\lambda \geq 0, \quad \theta_0 \in (-\infty; +\infty),
\]
where \( \theta_0 \) is efficiency score \( \theta_0 \in [0; 1] \) dual variable vector, \( X \) input matrix, \( Y \) output matrix.

Very important and useful information is the efficient level of inputs and outputs of particular DMU (companies). Company get information about how to improve total efficiency correcting the factors (inputs, outputs) level.

**Efficient (optimal) values of inputs and outputs**

\[ x_\infty = X \cdot \lambda \]
\[ y_\infty = Y \cdot \lambda \]

where \( x_\infty \) is optimal value input vector of DMU \( Q \), \( y_\infty \) is optimal value output vector of DMU \( Q \), \( \lambda \) is optimal value dual variable vector.

### 2.2 DESCRIPTION OF THE BCR (BANKER, CHARNES, COOPER) MODEL

The model BCC designed by Banker, R. D., Charnes, A., & Cooper, W. W. (1984) is variable return to scale (VRS) model type.

**Problem 5 PRIMAL Linear Charnes transformation of Problem 1 with flexibility**

\[
\max z_\infty = \sum_{j=1}^{S} v_j \cdot y_{j,0} + v_o,
\]
Subject to the constraints:
\[
\sum_{i=1}^{R} u_i \cdot x_{i,0} = 1,
\]
\[
\sum_{j=1}^{S} v_j \cdot y_{j,k} - \sum_{i=1}^{R} u_i \cdot x_{i,k} + v_o \leq 0, \text{for } k = 1, 2 \ldots T,
\]
\[ u_i \geq 0, \quad v_j \geq 0, \quad v_o \in (-\infty; +\infty), \quad \text{for } i = 1, 2 \ldots R, \ j = 0, 1, 2 \ldots S. \]

**Problem 6 Dual form of Problem 5**

\[
\min \theta_0,
\]
Subject to the constraints:
\[ \sum_{k=1}^{T} \lambda_k \cdot x_{ik} - \theta_k \cdot x_{i0} \leq 0, \quad \text{for } i = 1, 2 \ldots R, \]
\[ \sum_{k=1}^{T} \lambda_k \cdot y_{jk} - y_{j0} \geq 0, \quad \text{for } j = 1, 2 \ldots S, \]
\[ \sum_{k=1}^{T} \lambda_k = 1, \]
\[ \lambda_k \geq 0, \quad \theta_k \in (-\infty, \infty), \quad \text{for } i = 1, 2 \ldots T, \]
where \( \theta_k \) is efficiency score, \( \lambda_k \) is dual variable.

3. **DEA MODEL OF COMPANY FINANCIAL PERFORMANCE**

There is in the chapter proposed, applied and verified the DEA method application of company financial performance.

3.1 **DEA PERFORMANCE MODEL DESCRIPTION**

The model will be of CCR and CRS type. For computation Problem 2 and Problem 3 is applied. Values of efficient inputs and outputs are calculated as follows, \( x_0 = X \cdot \lambda, \quad y_0 = Y \cdot \lambda \). We suppose furthermore, outputs consist of three indices: return on assets (ROA), financial leverage (F) and liquidity (L). And inputs consist of one dummy factor, unit vector. Ten companies are analysed.

3.2 **INPUT DATA AND RESULTS**

There are in Table 1 given outputs and inputs of particular companies.

<table>
<thead>
<tr>
<th>DMU Company</th>
<th>Outputs (X)</th>
<th>Inputs (Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ROA</td>
<td>A/E</td>
</tr>
<tr>
<td>%</td>
<td>CZK/CZK</td>
<td>CZK/CZK</td>
</tr>
<tr>
<td>A</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>D</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>6,5</td>
<td>2</td>
</tr>
<tr>
<td>F</td>
<td>2,5</td>
<td>2</td>
</tr>
<tr>
<td>G</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>H</td>
<td>7,5</td>
<td>2,5</td>
</tr>
<tr>
<td>I</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>J</td>
<td>5</td>
<td>1,5</td>
</tr>
</tbody>
</table>

Following Table 2, the optimal weights of every outputs and inputs, including efficiency are presented. Table 3 show required correction of the inputs and outputs so as particular companies would have reached efficiency. Comparing an efficiency of companies, see Table 2 and Fig. 1, there are three groups of companies concerning efficiency. The first group consist of four fully effective companies, B, E, G, and H. The second group include companies D, A, I, F and last one is of companies J, C.
Table 2 Optimal weights of outputs and inputs

<table>
<thead>
<tr>
<th>DMU</th>
<th>Outputs (v)</th>
<th>Inputs (w)</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ROA</td>
<td>A/E</td>
<td>CA/CL</td>
</tr>
<tr>
<td>A</td>
<td>0.0000</td>
<td>0.1923</td>
<td>0.1538</td>
</tr>
<tr>
<td>B</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.2500</td>
</tr>
<tr>
<td>C</td>
<td>0.1333</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>D</td>
<td>0.0667</td>
<td>0.0333</td>
<td>0.1667</td>
</tr>
<tr>
<td>E</td>
<td>0.0800</td>
<td>0.0000</td>
<td>0.1600</td>
</tr>
<tr>
<td>F</td>
<td>0.0000</td>
<td>0.1923</td>
<td>0.1538</td>
</tr>
<tr>
<td>G</td>
<td>0.0000</td>
<td>0.2500</td>
<td>0.0000</td>
</tr>
<tr>
<td>H</td>
<td>0.1333</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>I</td>
<td>0.0467</td>
<td>0.1133</td>
<td>0.1467</td>
</tr>
<tr>
<td>J</td>
<td>0.0800</td>
<td>0.0000</td>
<td>0.1600</td>
</tr>
</tbody>
</table>

Table 3 Optimal corrections of inputs and outputs

<table>
<thead>
<tr>
<th>DMU</th>
<th>OUTPUTS</th>
<th>INPUTS</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ROA</td>
<td>A/E</td>
<td>CA/CL</td>
</tr>
<tr>
<td>A</td>
<td>0.3846</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>B</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>C</td>
<td>0.0000</td>
<td>0.6667</td>
<td>0.1667</td>
</tr>
<tr>
<td>D</td>
<td>-1.0000</td>
<td>-0.3333</td>
<td>-0.8333</td>
</tr>
<tr>
<td>E</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>F</td>
<td>1.4231</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>G</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>H</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>I</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>J</td>
<td>0.0000</td>
<td>0.1000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>
4. CONCLUSION

There is in the paper a possibility of application of DEA methodology for company financial performance evaluation described, explained and applied. Firstly, principles and formulations of DEA models are introduced. Model on CCR and CRS basis is applied in a simplified example with three output indices, dummy input and ten companies. It is apparent that an application of the DEA method is one of the useful and fruitful approaches of financial performance evaluation. Advantageous aspect of procedure is multifactor of inputs and outputs and not necessity to state preferences (weights) of criteria (inputs, outputs). Results could serve to creating a cluster of efficient companies and clusters of similarly efficient companies. The financial performance of the companies is furthermore possible to assess applying BCR and VRS model. Comparison of companies ranking on DEA, utility function and distance (compromise) measure could be interesting.

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REFERENCES