THE QUALITY EVALUATION OF THE FREIGHT TRANSPORTATION COMPANY

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1 Introduction

Quality evaluation has been a widely discussed research topic recently. Several definitions of quality have been proposed. The ISO standards define quality as the *totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs* [2]. Those features and characteristics can be either quantitative or qualitative. Another definition, given by J.Juran, suggests that quality is a *fitness for use* meaning that the users of a product or service should be able to count on it for what they needed or wanted to do with it [1]. Many authors agree that quality can be described by a set of attributes. The subjectiveness of quality implies that different points of view have to be satisfied and specific personal expectations should be considered in the quality evaluation of a product or service. B.Roy [5] suggests that those expectations have a psychosensoric character and should be defined by a human being because the quality evaluation serves to him/her.

There are different methods of quality evaluation [3,4,7]. The paper considers the possibility of the application of Multicriteria Decision Analysis (MCDA) to the quality evaluation of the freight transportation company. The MCDA has been a dynamically developing research area that utilizes several evaluation criteria in choosing, sorting and ranking of different alternatives (actions, solutions). Based on the classification of multicriteria methods proposed by P.Vincke [6], this paper is focused on a specific stream of MCDA methods called outranking methods. The characteristics of the outranking methods are as follows: the application of the outranking relation and the concept of pseudo-criterion in the modeling of decision maker’s (DM) preferences, the acceptance of incomparability between alternatives and the introduction of the non-additivity rule of criteria [5,6].

One of the outranking methods called ELECTRE III [5] is applied in the paper.

2 MCDA methodology applied to the quality evaluation of the freight transportation company

2.1 The set of the evaluation criteria

In the last few years several ISO norms have been developed to define evaluation criteria and quality standards for different branches. However, the transportation sector is not privileged

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in that respect. There are not many proposals of the quality standards for the transportation service. The paper proposes the set of criteria that can be used to evaluate the quality of the freight transportation company.

The criterion is a function \( g \), defined on the set of the alternatives \( A \), taking its values in a totally ordered set, as representing the DM’s preference, according to some points of view [6]. The \( A \) is a globalized set of alternatives to be explored during the evaluation procedure. The set of seven criteria \( F = \{ g_1, g_2, \ldots, g_7 \} \) called a family of criteria is used to evaluate a group of freight transportation companies.

The family \( F \) is composed of two groups of criteria. The first one - (criteria 1-4) represents customer’s concern and the aspiration for high level of transportation service, while the other (criteria 5-7) represents the operator’s attitude to the improvement of the company’s competitive position. All criteria except the criterion \( g_6 \) are maximized. The considered family of criteria is presented in table 1.

**Table 1. The family of criteria used in the quality evaluation of the freight transportation companies**

<table>
<thead>
<tr>
<th>Name of criterion</th>
<th>Criterion description</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehensiveness of service ( g_1 )</td>
<td>Express delivery, Forwarding, Transportation, Warehousing</td>
<td>( g_1 = {1, 2, 3, 4} )</td>
</tr>
<tr>
<td>Type of cargo ( g_2 )</td>
<td>Customs Parcels, General cargo, Goods in bulk, Parcels, Special cargo</td>
<td>( g_2 = {1, 2, 3, 4, 5} )</td>
</tr>
<tr>
<td>Company availability ( g_3 )</td>
<td>Number of company divisions in Poland</td>
<td>( g_3 : g_3 \in \mathbb{N} ; g_3 \geq 1 )</td>
</tr>
<tr>
<td>Company credibility ( g_4 )</td>
<td>Civil Forwarder’s Liability, Civil Carrier’s Liability, ISO certificate, ISO certification in process</td>
<td>( g_4 = {0; 0.5; 1; 1.5; 2; 2.5; 3} )</td>
</tr>
<tr>
<td>Fixed-Asset Turnover ( g_5 )</td>
<td>The quotient of annual sales and net property, plant and equipment</td>
<td>( g_5 : g_5 \in \mathbb{R} \setminus \mathbb{R}_- )</td>
</tr>
<tr>
<td>Vehicle-kilometer cost ( g_6 )</td>
<td>The quotient of total operational cost and vehicle-kilometers covered by company in one year</td>
<td>( g_6 : g_6 \in \mathbb{R} \setminus \mathbb{R}_- )</td>
</tr>
<tr>
<td>Profitability growth trend ( g_7 )</td>
<td>The relationship between the profitability in a particular year to its equivalent in a previous one</td>
<td>( g_7 : g_7 \in \mathbb{R} \setminus \mathbb{R}_- ; g_7 &gt; 0 )</td>
</tr>
</tbody>
</table>

\( \mathbb{R} - \) the rational number, \( \mathbb{R}_- - \) the rational non-positive number

### 2.2 ELECTRE method

The decision problem consists in the quality evaluation of different freight transportation companies with the application of the above defined family of criteria. The ELECTRE III, applied in the computational experiment, is a method based on the concept of the outranking binary relation \( S \). The \( S \) is defined in \( A \) such that \( a S b \) if, given what is known about the DM’s preferences and given the quality of the valuation of the alternatives and the nature of the problem, there are enough arguments to decide that alternative \( a \) is at least as good as \( b \), while there is no essential reason to refute that statement [6].

The ELECTRE III lets us rank different alternatives (in our case – freight transportation companies) from the best to the worst. The computational procedure consists of the following steps: building the valued outranking relation and exploiting the relation.

In the first step it is necessary to calculate the concordance index \( c(a,b) \) for each ordered pair \( (a,b) \). The concordance index is computed in the following way:

\[
 c(a,b) = \frac{1}{P} \sum_{j=1}^{n} p_j c_j(a,b) \quad \text{where} \quad P = \sum_{j=1}^{n} p_j \quad \text{for} \quad j = 1, 2, \ldots, 7
\]  

(1)
and the $p_j$ is a weight associated with each criterion $g_j$. The value of $c_j(a, b)$ is calculated from the figure 1.

The discordance index $D_j(a, b)$ is also applied in the computational procedure. The definition of discordance index requires the introduction of a veto threshold $v_j(g_j(a))$ (see fig.1) for each criterion $j$ such that any credibility for the outranking of $b$ by $a$ is refused if:

$$g_j(b) \geq g_j(a) + v_j(g_j(a))$$

(2)

the latter even if all the other criteria are in favour of the outranking of $b$ by $a$ [6].

![Fig.1 The concept of four-state model of preference (indifference $I$, weak preference $Q$, strong preference $P$ and incomparability $J$, including thresholds, respectively: $q$, $p$, $v$. [6,7]](image)

The exploitation step of the procedure is based on the qualification algorithm that makes use of the outranking relation. The algorithm of ELECTRE III leads to two preorders obtained by a descending and ascending distillation. The descending distillation selects at first the best alternatives to end the process with the worst ones. The ascending distillation selects at first the worst alternatives to end the process with the best ones. At the end the final ranking is constructed as an intersection of the preorders [6].

### 2.3 Computational experiment

In the computational experiment six alternatives are considered. Each of them represents a separate road transportation company that operates in Poland. In the computational procedure the consistent family of seven criteria is used. Table 2 presents the criteria measures for each alternative. Based on the ELECTRE III methodology the thresholds parameters $q$, $p$ and $v$ [5,6] are estimated to construct the set of pseudo-criteria (see table 2). In the experiment the four-state model of preference is considered. For each criterion the weight $p_j$ is introduced. The results of ascending and descending distillations and the final ranking are presented in figure 2.

**Table 2. List of parameters used in quality evaluation of freight transportation companies**

<table>
<thead>
<tr>
<th>Criterion</th>
<th>$A_1$</th>
<th>$A_2$</th>
<th>$A_3$</th>
<th>$A_4$</th>
<th>$A_5$</th>
<th>$A_6$</th>
<th>$q$</th>
<th>$p$</th>
<th>$v$</th>
<th>$p_j$</th>
<th>Weight</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$g_1$</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>$\beta = 1$</td>
<td>$\beta = 2$</td>
<td>$\beta = 3$</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$g_2$</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>$\beta = 1$</td>
<td>$\beta = 2$</td>
<td>$\beta = 3$</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$g_3$</td>
<td>6</td>
<td>3</td>
<td>5</td>
<td>56</td>
<td>2</td>
<td>16</td>
<td>$\beta = 1$</td>
<td>$\beta = 6$</td>
<td>$\beta = 15$</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$g_4$</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2,5</td>
<td>2,5</td>
<td>1</td>
<td>$\beta = 0,6$</td>
<td>$\beta = 1$</td>
<td>$\beta = 1,5$</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$g_5$</td>
<td>15,1</td>
<td>32,1</td>
<td>4,2</td>
<td>9,4</td>
<td>9,3</td>
<td>88,3</td>
<td>$\beta = 0,5$</td>
<td>$\beta = 5$</td>
<td>$\beta = 15$</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$g_6$</td>
<td>1,79</td>
<td>2,47</td>
<td>1,96</td>
<td>7,18</td>
<td>1,98</td>
<td>1,57</td>
<td>$\beta = 0,1$</td>
<td>$\beta = 0,4$</td>
<td>$\beta = 0,8$</td>
<td>5</td>
<td>PLN</td>
<td>-</td>
</tr>
<tr>
<td>$g_7$</td>
<td>23</td>
<td>134</td>
<td>101</td>
<td>75</td>
<td>253</td>
<td>227</td>
<td>$\beta = 30$</td>
<td>$\beta = 50$</td>
<td>$\beta = 80$</td>
<td>1</td>
<td>%</td>
<td>-</td>
</tr>
</tbody>
</table>
3 Conclusions

The presented multicriteria methodology applied to the quality evaluation of the freight transportation company let us obtain the final ranking of companies (see figure 2). The alternative A₆ is suggested as the best among the considered freight transportation companies. In the final ranking the incomparability between alternative A₃ and A₄ is observed. The alternative A₁ showed up to be the worst one.

The major advantage of the application of MCDA to the quality evaluation of the freight transportation companies is the possibility to take into account the aspiration of different stakeholders. It has been possible to satisfy both customers’ and operator’s expectations, reaching the final compromise solution in alternative A₆. The computational experiment proves that the traditional methods based on the computation of the quality index [4] can be effectively replaced by the multiobjective approach.

References


Summary

The paper considers the possibility of the application of MCDA to the quality evaluation of the freight transportation companies. The paper proposes the set of criteria, that can be used to the quality evaluation of those companies. The considered family of criteria includes: comprehensiveness of service, type of cargo, company availability, company credibility, fixed-asset turnover, vehicle-kilometer cost, profitability growth trend. The ELECTRE III method is applied to rank the different alternatives from the best to the worst.