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EVALUATION AND SELECTION OF KPI IN TRANSPORT USING SWARA METHOD

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Abstract:
Key performance indicators represent parameters which have a great influence on business efficiency in companies. In everyday business life, it is available a large number of data, but it is necessary to select the most important indicators, perform their measurement and monitoring. In this way, it can significantly affect the overall efficiency of the company. In this paper are shown a total of 62 performance indicators in the field of transport, out of which 20 key performance indicators are selected. The research is carried out on territory Serbia and Bosnia and Herzegovina involving 19 decision makers from 13 different transportation companies. For determination relative weights of the criteria and subcriteria is used Step-Wise Weight Assessment Ratio Analysis Method (SWARA). Obtained results are shown that the most important indicators belong the groups: vehicle utilization, realized routes and tours, transport costs.

Key words:
Key performance indicators, transport, SWARA, criteria

INTRODUCTION

Road transport is the oldest and the most used mode of transport, respectively moving or transfer goods using appropriate transport resources. Its main goal is to satisfy transport needs and transport demands determined group of users. The main advantage of road transport is the possibility to transfer goods from source to destination and because of that he is also known as transport "from door to door". Taking in consideration daily mobility, the trend of increasing demands for flows of goods, which are related to transport of goods to main goal (destination) in the shortest period of time for the lowest price, is continuously growing in Europe. The increase of transport demands requires the constant need for rationalization and optimization of transport processes which, according to Stević et al. [1] can very much influence the competitive position of the company.

Taking in consideration the fact that road transport is often applied like a carrier of most logistic activities and that transport like subsystem of logistics causes the biggest costs it is

necessary to do a lot of activities and processes to make this subsystem rational. The company must constantly practice measuring and monitoring its performance so it would properly manage with performances in the subsystem of transport which affect on logistics performances in the whole company. Since time plays one of the main roles in managing of the supply chain it is necessary for the company to focus only on the most important activities and its indicators. Accordingly to that, it is very important to make evaluation and selection of key performance indicators (KPI) in each company which will create a possibility of proactive way of managing. In this kind of system, the business results will not be expected, they will be managed by experts. According to Stević [2] using the methods of multi-criteria analysis it is possible to make decisions which have the significant influence on companies' business.

The main goal of this paper is to determine the key performance indicators in transport which can have the significant influence on the efficiency of management of companies in Bosnia and Herzegovina and Serbia. The experts from the field of transport and logistics from 13 different companies did ranking of performance indicators based on their own experience in mentioned companies. Relying on the ranking of experts and use of SWARA method, it is possible to create scenarios which will affect on increasing of company's productivity and also on completely satisfying of transport demands of users their services.

This paper is, besides introduction, structured in couple sections and subsections. In the introduction, it is shown the significance of transport and its performances. The first section gives a brief literature review related to the application of the MCDM method in the selection of KPIs and an overview of the application of the SWARA method in different areas. The second section represents methodology and problem postulate which has two subsections (SWARA method and description of problem). In this section, the algorithm of SWARA method and model for evaluating performance indicators are presented in detail. In the third section, the results of the model as part of the calculation are presented. In the end, the conclusions show the contributions of this research, implications, and directions for future research.

1 LITERATURE REVIEW

Multiple-criteria decision-making is daily used in different field of research. Their use is especially important in the transport area, specifically for evaluation and selection of key performance indicators. The survey which is shown in [3] demonstrated that KPIs are necessary for improving internal organization, customer relationships, competitiveness and strategy planning on the example of tanker shipping companies in Greece. Nathnail et al. [4] are used Analytic Hierarchy Process (AHP) for estimation the significance of each criterion and KPI in the analysis of attributes and general performance of two terminals. Bentaleb et al. [5] are identified key performance indicators for Casablanca seaport dry port case and analyzed them using MACBETH tool. The methodology based on previous analysis will help managers in these kind of companies to make decisions and increase global performances. In [6] the method of multi-criteria analysis Decision Making Trial and the Evaluation Laboratory (DEMATEL) method is used for analyzing the importance and the relations among the criteria for evalutation of transportation with intermodal transport. There are many different methods which are applying for assessment and comparison of key performance indicators [7-11].

Advantages of SWARA method according to Zavadskas et al. [12] are primarily seen in a significantly smaller number of comparisons in relation to other criteria, and in the possibility to evaluate the opinions of experts on the significance of criteria in a process of determining their weights. Thanks to these characteristics, this method is applied in many different areas. In [13] it is applied for the determination of the weights of indicators corporate social responsibility, while it is in [14] used for estimation of the significance of elements

SWOT analysis in green chain supply. Determination weights of indicators which consist of resource indicator, environment indicator, economic indicator and social indicator and their sub-criteria are performed in [15]. Determination of weights of the criteria for supplier evaluation has been implemented in [16] in the stainless steel industry. For the same purpose in [17] is applied in the company for manufacturing automobile in Iran.

METHODS AND PROBLEM POSTULATE

2.1 SWARA method

SWARA (Step-wise Weight Assessment Ratio Analysis) method is one of the methods for determining weight values that play an important role in a decision-making process. The method was developed by Kersuliene et al. [18] and, according to them, its basic characteristic is the possibility of assessing the opinion of experts on the significance of criteria in the process of determining their weights. After defining and forming the list of criteria involved in a decision-making process, the SWARA method consists of the following steps.

Step 1: Criteria need to be sorted according to their significance. In this step, experts perform the ranking of defined criteria according to the significance they have, for example, the most significant is in the first place, the least significant is in the last place, while the criteria between have ranked significance.

Step 2: Determine s_j - comparative importance of average value. Starting from the secondly ranked criterion, it is necessary to determine their significance in the following way. It is determined how much the criterion c_j is more important than the criterion c_{j+1}.

Step 3: Calculate the coefficient k_j as follows:

$$k_j = \begin{cases} 1 & j = 1 \\ s_{j+1} & j > 1 \end{cases} \tag{1}$$

Step 4: Determine the recalculated weight q_j as follows:

$$q_j = \begin{cases} 1 & j = 1 \\ \dfrac{q_{j-1}}{k_j} & j > 1 \end{cases} \tag{2}$$

Step 5: Calculate the weight values of criteria with the sum that is equal to one:

$$w_j = \frac{q_j}{\sum_{k=1}^{m} q_j} \tag{3}$$

where w_j represents the relative weight value of criteria.

2.2 Description of problem

Through the research carried out in this paper, a total of 62 indicators in transport have been considered, based on which the transport companies measure the efficiency of its operations. The research was carried out on the territory of Bosnia and Herzegovina and Serbia, involving 19 decision makers from 13 different companies. There is a large number of data available to the managers in the transport subsystem, but there is an evident lack of quality data. Of the comprehensive data structure, only about 10% is used, which is one of the limitations in the strategic management of the company. If it is added that time plays one of the most important roles, the used data gets more important. In essence, it is necessary to measure and monitor those performance indicators that significantly affect the company's operations. Therefore, it is necessary to dedicate time to the most important indicators, to measure and monitor them. Figure 1 shows the hierarchical structure of performance indicators in transport.

It is necessary to determine the key performance indicators using the SWARA method. The explanation of most indicators can be found in [19].

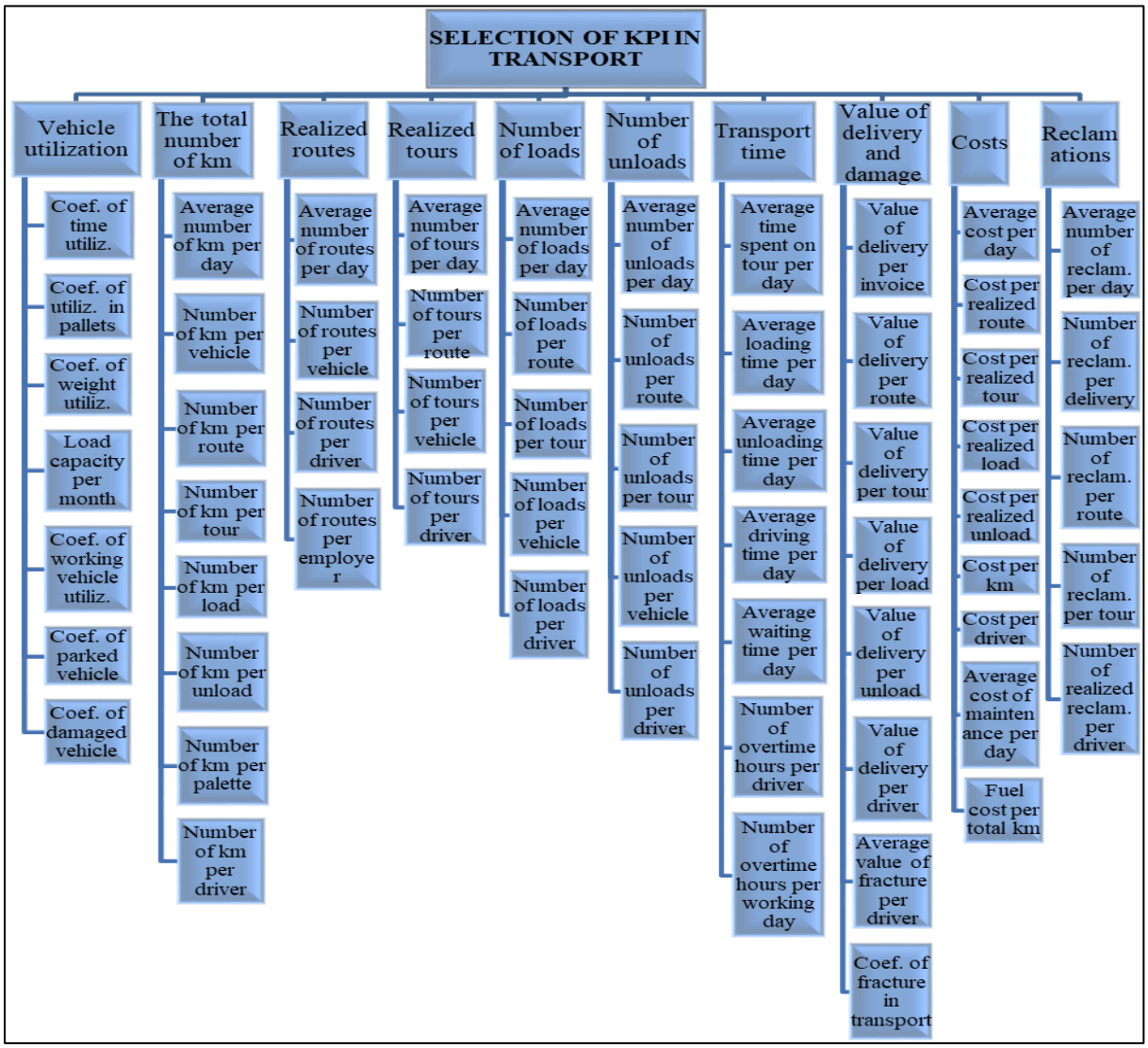

Fig.1 *Hierarchical structure of performance indicators in transport*

In figure 1 is shown that the main goal, which is for this paper selection key performance indicators, is on the top of the hierarchy. On the next level is presented 10 main criteria which are divided to sub-criteria at the next level of the hierarchy. The performance which is related to vehicle utilization has seven sub-criteria and the performance which is related to total number of kilometers has eight sub-criteria. For the realized routes and realized tours is defined four indicators. The performances of the groups of the number of loads and number of unloads consist of five indicators. When it comes to transport time it consists of seven sub-criteria. Next performance which is related to the value of delivery and value of damaged goods has eight indicators. Costs in transport are divided into nine sub-criteria. The last one is related to reclamations and consist of five sub-criteria. Through this formed hierarchical structure, the most common performances in transport companies and their indicators are defined.

After defining the hierarchical structure which is explained above, it is necessary to determine the significance of main criteria using SWARA method and comparing the influence between them. After that, it is required to define the significance of sub-criteria within their groups with the same methodology which represents their local rank. When the values from

local rank multiply with values of the main criteria that will create global rank. Based on this global rank the following step is to make the selection of key performance indicators.

3 RESULTS

By applying the SWARA method, first, it is necessary to perform the ranking of the criteria according to their significance according to the decision-makers. As already mentioned in the research, a total of 19 managers took part in the ranking of the criteria, as shown in Table 1.

After performed ranking, in second step it is necessary that decision-makers determine how much is the criterion c_j is more important than the criterion c_{j+1}. The first cell in the second column has a value of 1.00, while other cells has different values. For example second column denote that is criterion C_1 is for 0.145 more important in comparison with C_9, while C_9 in comparison with C_2 is more important for value 0.187 etc.

By applying the third step of SWARA method ie. equation (1) the values of the coefficient K_j in the third column are obtained. In the fourth step applying equation (2) the recalculated weights q_j are obtained.

For example q_9=1/1.145=0.873; q_2=0.873/1.187=0.736 etc.

In fifth step using equation (3) is need to calculate the weight values of criteria with the sum that is equal to one.

w_1=1/5.747=0.174; w_9=0.873/5.747=0.152; w_2=0.736/5.474=0.128 etc.

Tab 1. *Weights of the main criteria obtained using SWARA method*

	S_j	$K_j=S_j+1$	q_j	w_j
C_1	1.000	1.000	1.000	**0.174**
C_9	0.145	1.145	0.873	**0.152**
C_2	0.187	1.187	0.736	**0.128**
C_3	0.132	1.132	0.650	**0.113**
C_4	0.089	1.089	0.597	**0.104**
C_7	0.345	1.345	0.444	**0.077**
C_8	0.113	1.113	0.399	**0.069**
C_5	0.036	1.036	0.385	**0.067**
C_6	0.142	1.142	0.337	**0.059**
C_{10}	0.031	1.031	0.327	**0.057**
∑			5.747	

Based on Table 1 it can be concluded that the most important indicator is the first one which is related to vehicle utilization. The experts estimated that the second significant criterion is related to costs in transport, following by the total number of kilometers. It is significant that the realized routes are for 0.089 more important than realized tours, which implicates that managers of transport companies, who are monitoring performances which have influence on efficiency of management, in the most of cases are completely observing every trip, from start to moving till getting back to garage or to getting back on first loading place. The transport time took sixth place according to its weight in regards to rest of indicators and it is for 0.113 more significant from the value of delivery and value of damaged goods. The following are the number of loads and number of unloads. On the last place is an indicator which is related to reclamations.

After determination the importance of the main criteria, it is necessary to apply the same methodology for calculating the weights of all sub-criteria in order to select key performance indicators. Table 2 shows the weights of the sub-criteria of the vehicle utilization group.

w_j – denote weights of sub-criteria regarding vehicle utilization group.

w_j' – denote values of the criteria from an aspect of total number criteria which are obtained on following a way: $w_j'=w_j*w_1$ for example $w_1'=0.200*0.174=0.0348$; $w_5'=0.166*0.174=0.0289$ etc.

w_1 – denote value of first criterion ie vehicle utilization.

Tab 2. *Weights of the sub-criteria of group vehicle utilization*

	S_j	$K_j=S_j+1$	q_j	w_j	$w_j' = w_j * w_1$
C_1	1.000	1.000	1.000	**0.200**	0.03474
C_5	0.201	1.201	0.833	**0.166**	0.02893
C_3	0.103	1.103	0.755	**0.151**	0.02623
C_4	0.137	1.137	0.664	**0.133**	0.02307
C_2	0.075	1.075	0.618	**0.123**	0.02146
C_6	0.043	1.043	0.592	**0.118**	0.02057
C_7	0.082	1.082	0.547	**0.109**	0.01901
∑			5.008	**1.000**	0.17400

After application of SWARA method for all sub-criteria rank of all 62 criteria is obtained. In this research 20 key performance indicators are selected which are shown in Table 3.

Tab 3. *Selected KPI in transport using SWARA method*

Or. num.	Criteria	weight	Rank
1.	Coefficient of time utilization	0.03474	**1**
2.	Number of km per vehicle	0.03474	**1**
3.	Number of routes per vehicle	0.03187	**3**
4.	Number of routes per driver	0.03127	**4**
5.	Number of tours per vehicle	0.02966	**5**
6.	Coefficient of working vehicle utilization	0.02893	**6**
7.	Average number of routes per day	0.02835	**7**
8.	Number of tours per driver	0.02736	**8**
9.	Number of tours per route	0.02675	**9**
10.	Coefficient of weight utilization	0.02623	**10**
11.	Load capacity per month	0.02307	**11**
12.	Number of routes per employer	0.02161	**12**
13.	Coefficient of utilization in pallets	0.02146	**13**
14.	Costs per driver	0.02080	**14**
15.	Coefficient of parked vehicle	0.02057	**15**
16.	Average number of tours per day	0.02008	**16**
17.	Fuel cost per total km	0.02006	**17**
18.	Cost per realized route	0.01959	**18**
19.	Cost per km	0.01945	**19**
20.	Coefficient of damaged vehicle	0.01901	**20**

Coefficient of time utilization and number of km per vehicle have equal weight and they are determined like the most valuable indicators. The next indicators are number of routes per vehicle and number of routes per driver and they have almost equal weight, which means that they affect similarly on the efficiency of the company. After these two, on fifth place there is the number of tours per vehicle. Coefficient of working vehicle utilization and average number of routes per day also have similarly equal weight. The following are number of tours per driver,

number of tours per route and coefficient of weight utilization which have a similar influence on work of transport companies. Load capacity per month finished at eleventh place. After that, number of routes per employer and coefficient of utilization in pallets are coming with almost same significance. Then, there are four indicators which have approximately same value of weight. In the end, there is three criteria which are related to costs in transport and the coefficient of damaged vehicle.

4 CONCLUSION

After applied methodology of SWARA method, weight values of all criteria are obtained. First 20 criteria are representing key performance indicators in the transport area. Results in this paper are showing that all sub-criteria of group the vehicle utilization are recognized as key performance indicators. The same situation is with criteria that belong to groups realized tours and realized routes. Except that, some of the sub-criteria that belong to groups the costs in transport and the total number of kilometers are also recognized as key performance indicators in the transport area. It is important to note that these key performance indicators are observed with a viewpoint of transport companies. Therefore, the assessment is performed by managers who observed indicators with a viewpoint of the company whose they are employers and their influence on complete business. There were not observed others participants in transport process.

The contribution of this research presents the applied methodology, because authors didn't notice similar research in mentioned two countries. Except that, the contribution is also the possibility of the increase of the efficiency of transport companies using methodology that includes monitoring and measuring of key performance indicators.

When it comes to the limitation of this research they are primarily related to the hierarchical structure of indicators. In order to achieve more precise results, it is necessary to create a hierarchical structure which will consists of criteria with an equal number of sub-criteria. In this research that was not possible because of the diversity of represented criteria.

After defining key performance indicators it is necessary to practice their constant measuring and monitoring in order to influence on the increase of efficiency of companies. Nevertheless, the further research is possible to perform using multi-criteria model with alternatives. It is possible to accomplish the evaluation of different transport companies based on mentioned key performance indicators in order to determine their competitiveness on market.

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