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INTEGRATED MCDM MODEL FOR PROCESSES OPTIMIZATION IN THE SUPPLY CHAIN MANAGEMENT IN THE WOOD COMPANY

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Abstract. *Supply chain management (SCM) is a global strategy in nowadays business environment. It is a useful tool for managing a number of processes and activities on a daily basis in order to achieve a competitive advantage. Also, in order to achieve adequate bases for successful functioning, it is necessary to know their abilities and weaknesses; this knowledge, yet, requires decomposition of the overall system. In this paper the decomposition in a wood company and its supplier selection in the subsystem of procurement is performed. For determining criteria weights the Full Consistency Method (FUCOM) is applied while the ranking of suppliers is performed using the Weighted Aggregated Sum Product Assessment (WASPAS) method. The obtained results are checked through the sensitivity analysis that is formed with modeling of criteria weights. In the sensitivity analysis it was found that the changes in the significance of the criteria could influence the decision-making and ranking of suppliers.*

Key Words: *FUCOM, WASPAS, SCM, Evaluation of Suppliers, Decomposition*

1. Introduction

A system approach to management is the base of every company's success because optimization is directly related to cost reduction across the supply chain. The supply chain management, as a new field of research for economists, provides a lot of examples where it is almost impossible to reach precise evaluation of the variables affecting the decision-making (Kozarević and Puška, 2018). Modern production is increasingly complex with regard to the participation of technology or production processes or operations. In complex process manufacturing, logistics is particularly important because it combines all the processes from the procurement of materials to the distribution of finished or semi-finished products. For the production process to be efficient, it is necessary to optimize the procurement

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subsystem. In doing so, great coordination is needed of the preparation, storage, and, especially, production system.

In this paper, the decomposition of logistics systems was first performed, i.e. the division of the same into procurement of materials, drying of boards, production, packaging, and distribution. In the part of the materials' procurement, the supplier was evaluated according to the seven criteria, ranking from the best to the worst. The FUCOM methods for determining weight coefficients and the WASPAS methods for ranking suppliers were used. The selection of suppliers is the first step in the process of product realization, starting from the procurement of materials to the delivery of the product (Stević et al. 2017b; Puška et al. 2017). The aim of the paper is to integrate all the processes of the logistics system, starting from the procurement. i.e. selection of the best supplier, *via* the production processes to the distribution. In addition, the goal of the paper is to create an adequate basis for future actions that involve the segmentation of the key performance indicators based on the performed logistic system decomposition, and their measurement and monitoring. The research was carried out in the wood design company "Wood Design" Ltd. in Bosnia and Herzegovina. By using the FUCOM method for determining criteria weights and the WASPAS method for ranking alternatives we obtain that Supplier 1 represents the best solution.

After the introductory considerations, the second part presents the algorithm of the used methods. In the third part of the paper, a case study was presented with a detailed explanation of the calculation. The fourth part presents the sensitivity analysis and the discussion of the obtained results, while in the fifth section the final considerations are presented.

2. Methods

By applying multi-criteria decision-making methods, it is possible to make valid decisions in different areas. Some of these decisions are: selection of adequate strategies, rationalization of logistics processes, and the decision-making that has an impact on the operations of companies or their subsystems, as evidenced by the next research (Stević et al. 2015; Stević et al. 2016; Ranjan et al. 2016; Jusoh et al. 2018)

2.1 Full Consistency Method (FUCOM)

The FUCOM method represents a new method for determining criteria weights developed by Pamučar et al. (2018). So far it is applied in few studies: (Prentkovskis et al. 2018; Nunić, 2018; Pamučar et al. 2018; Zavadskas et al. 2018; Fazlolahtabar et al. 2019). It consists of the following three steps:

Step 1 In this step, the criteria from the predefined set of the evaluation criteria $C=\{C_1,C_2,...,C_n\}$ are ranked. The ranking is performed according to the significance of the criteria, i.e. starting from the criterion which is expected to have the highest weight coefficient to the criterion of the least significance:

$$C_{j(1)} > C_{j(2)} > ... > C_{j(k)} \quad (1)$$

Step 2 In this step, comparison of the ranked criteria is carried out and comparative priority $(\varphi_{k/(k+1)}) = \frac{C_k}{C_{k+1}}$, $k = 1, 2, ..., n$, with k representing the rank of the criteria) of the evaluation criteria, is determined.

$$\Phi = \left(\varphi_{1/2}, \varphi_{2/3}, ..., \varphi_{k/(k+1)}\right) \tag{2}$$

Step 3 In this step, the final values of the weight coefficients of evaluation criteria $(w_1, w_2, ..., w_n)^T$ are calculated. The final values of the weight coefficients should satisfy the following two conditions:

(a) The ratio of the weight coefficients is equal to the comparative priority among observed criteria $(\varphi_{k/(k+1)})$ defined in Step 2, i.e. the following condition is met:

$$\frac{w_k}{w_{k+1}} = \varphi_{k/(k+1)} \tag{3}$$

(b) In addition to condition (2), the final values of the weight coefficients should satisfy the condition of mathematical transitivity, i.e. t $\varphi_{k/(k+1)} \otimes \varphi_{(k+1)/(k+2)} = \varphi_{k/(k+2)}$.

Then $\varphi_{k/(k+1)} = \frac{w_k}{w_{k+1}}$ and $\varphi_{(k+1)/(k+2)} = \frac{w_{k+1}}{w_{k+2}}$ $\frac{w_k}{w_{k+1}} \otimes \frac{w_{k+1}}{w_{k+2}} = \frac{w_k}{w_{k+2}}$ are obtained.

Thus, another condition that the final values of the weight coefficients of the evaluation criteria should meet is obtained, namely:

$$\frac{w_k}{w_{k+2}} = \varphi_{k/(k+1)} \otimes \varphi_{(k+1)/(k+2)} \tag{4}$$

Based on the defined settings, the final model for determining the final values of the weight coefficients of the evaluation criteria can be defined.

$$\begin{aligned}
&\min \chi \\
&s.t. \\
&\left|\frac{w_{j(k)}}{w_{j(k+1)}} - \varphi_{k/(k+1)}\right| = \chi, \ \forall j \\
&\left|\frac{w_{j(k)}}{w_{j(k+2)}} - \varphi_{k/(k+1)} \otimes \varphi_{(k+1)/(k+2)}\right| = \chi, \ \forall j \\
&\sum_{j=1}^{n} w_j = 1, \ \forall j \\
&w_j \geq 0, \ \forall j
\end{aligned} \tag{5}$$

By solving model (5), we obtain the final values of evaluation criteria $\left(w_1, w_2, \ldots, w_n\right)^T$ and the degree of consistency (χ) of the results obtained.

2.2 WASPAS method

The Weighted aggregate sum product assessment method (WASPAS) (Zavadskas et al. 2012) is one of the best known and often applied multiple criteria decision-making methods for evaluating a number of alternatives in terms of a number given criteria. In general, suppose that a given MCDM problem is defined on *m* alternatives and *n* decision criteria. Next, suppose that w_j denotes the relative significance of the criterion and x_{ij} is the performance value of alternative *i* when it is evaluated in terms of criterion j.

WASPAS methods consist of the following steps:

Step 1 Formatting of initial decision matrix (X). The first step is to evaluate *m* alternatives by *n* criteria. Alternatives are shown to the vectors: $A_i = \left(x_{i1}, x_{i2}, \ldots, x_{in}\right)$ where x_{ij} is value of i-th alternatives according to j-th criterion $\left(i = 1, 2, 3, \ldots, m; \ j = 1, 2, 3, \ldots, n\right)$.

$$X = \begin{matrix} & C_1 & \ldots & C_n \\ A_1 & x_{11} & \cdots & x_{1n} \\ \ldots & \vdots & \ddots & \vdots \\ A_m & x_{m1} & \cdots & x_{mn} \end{matrix} \tag{6}$$

Step 2 In this step it is necessary to normalize the initial matrix using the following equations:

$$n_{ij} = \frac{x_{ij}}{\max_i x_{ij}} \tag{7}$$

for $C_{1,} C_2, \ldots, C_n \in B.$

$$n_{ij} = \frac{\min_i x_{ij}}{x_{ij}} \tag{8}$$

for $C_{1,} C_2, \ldots, C_n \in B.$

Step 3 Weighing of the normalized matrix is done in such a way that the previous (normalized) matrix is multiplied by the weight coefficients:

$$V_n = \left[v_{ij}\right]_{m \times n} \tag{9}$$

$$V_{ij} = w_j \times n_{ij}, i = 1, 2, \ldots, m, \ j \tag{10}$$

Step 4 Summarizing all obtained values of the alternatives (summation in rows):

$$Q_i = \left[q_{ij} \right]_{1 \times m} \quad (11)$$

$$q_{ij} = \sum_{j=1}^{n} v_{ij} \quad (12)$$

Step 5 Determination of the weighted product model by using the following equations:

$$P_i = \left[p_{ij} \right]_{1 \times m} \quad (13)$$

$$p_{ij} = \prod_{j=1}^{n} (v_{ij})^{wj} \quad (14)$$

Step 6 Determination of the relative values of alternative A_i:

$$A_i = \left[a_{ij} \right]_{1 \times m} \quad (15)$$

$$A_{ij} = \lambda \times Q_i + (1 - \lambda) \times P_i \quad (16)$$

Coefficient λ can be crisp value; it can be any value from 0, 0.1, 0.2, … , 1.0.

Step 7 Ranking of alternatives. The highest value of the alternative is the best ranked while the smallest value reflects the worst alternative.

3. Case study

3.1 Decomposition of the logistic systems

The decomposition of the logistics of the system implies the division of the system into several smaller subsystems. Concretely, in this case, the decomposition was performed on the following subsystems: procurement, boards' drying, production, packaging and, finally, distribution of finished or semi-finished products.

The process of the boards drying and its length depend on the type of wood, its moisture and dimensions. This process lasts from 15 to 100 days. When the drying process is completed, the acclimatization process of the board is performed where the board equals the outside temperature with the temperature in the chamber as well as moisture. This process takes 48 hours. When it is all over, the board is fully ready for use and technical processing. After that, the boards must be properly stored.

The production at the company "Wood Design" Ltd. Usora is performed in 6 stages in order to reach the desired product. The phases are:

1. Cutting the boards,
2. Machining of the board on a four-sided machine,
3. Pairing the board,
4. Pressing and gluing,
5. Cutting to a certain length, and,

6. Sanding the boards on both sides.

After finishing the sanding of the boards, the next and final operation before delivery is the packaging of the boards. In this company, the finished packages are wrapped with stretch foil. The boards are packed in the pallets which are 66 cm wide while their length depends on the required package of the customer. 25 panels are placed in one pallet. When packing furniture boards, 10 boards are placed in one pallet, and each plate is wrapped in nylon, unlike the plates. The other principle of packaging is the same.

As for the deadline for delivering of ready-made boards, it is usually two weeks after the date of the received order, or one week if the order is urgent. Of course, the semi-finished products can be ordered earlier if the customer is not a priority.

3.2 Supplier selection in the wood company

The criteria for the evaluation of the supplier are shown below: C1 - quality of material, C2 - price of materials, C3 - product certification, C4 - delivery time, C5 - reputation, C6 - additional discount on quantity, C7 - warranty period, C8 - reliability, C9 - payment method. These criteria have been used in the following studies (Puška et al. 2018; Stević et al. 2017b; Stojić et al. 2018). The research was carried out at the company "Wood Design" Ltd., and accordingly, a supplier evaluation table was given with six suppliers taken into consideration. It should be noted that the criteria C1, C3, C5, C6, and C8 qualitative indicators are evaluated according to the linguistic scale in (Stević et al. 2017): 1 – excellent, 3 – very good, 5 – good, 7 – medium, 9 – poor, in the case that the criterion should be minimized. In the case where the criteria should be maximized, the evaluation is entered in reverse order. The C2, C4, C7 and C9 quantitative indicators are shown as the cash units for the price of the material, that is, during the delivery days, the warranty period and the method of payment.

Table 1. Initial MCDM matrix

	C1	C2	C3	C4	C5	C6	C7
D1	9	1200	9	5	7	5	7
D2	7	1000	7	3	5	7	3
D3	9	1250	9	7	15	3	9
D4	9	1150	7	5	7	5	5
D5	5	750	9	5	3	9	3
D6	9	1200	9	5	15	7	1

According to criteria C5 and C6, all suppliers have an equal estimate of 5 of 9. In the next step, these criteria are eliminated because they have no influence on making the final decision. Also, it is important to note that the suppliers are evaluated according to the criterion “payment method” on the basis of the following facts:

1 - Advance 30% before delivery; 3 - Cash (payment upon download); 5 - delay up to 7 days after delivery; 7 - delay up to 15 days after delivery; 9 - delay up to 30 days after delivery.

3.2.1 Determining criteria weights using the FUCOM method

Step 1 Ranking the criteria:

$C_1 > C_2 > C_4 > C_7 > C_6 > C_5 > C_3$

Step 2 Comparison of the ranked criteria is carried out and the comparative priority of the evaluation criteria is determined. Comparative priority of the evaluation criteria is obtained by equation (3). Assessment of the criteria is shown in Table 2.

Table 2. Ranking and assessment of the criteria

Criteria	C1	C2	C4	C7	C6	C5	C3
$\omega_{j(k)}$	1	2	2.3	2.7	3	3.8	4

On the basis of the obtained significance of the criteria (Table 2) it is necessary to calculate comparative priority of the criteria:

$\varphi_{C_1/C_2} = 2/1 = 2$, $\varphi_{C_2/C_4} = 2.3/2 = 1.15$, $\varphi_{C_4/C_7} = 2.7/2.3 = 1.17$ $\varphi_{C_7/C_6} = 3/2.7 = 1.11$, $\varphi_{C_6/C_5} = 3.8/3 = 1.27$, $\varphi_{C_5/C_3} = 4/3.8 = 1.05$

Step 3 The final values of the weight coefficients should meet the following two conditions:

a) The final values of the weight coefficients should meet condition (3), i.e. that $\frac{w_1}{w_2} = 2$, $\frac{w_2}{w_4} = 1.15$, $\frac{w_4}{w_7} = 1.17$, $\frac{w_7}{w_6} = 1.11$, $\frac{w_6}{w_5} = 1.27$ and $\frac{w_5}{w_3} = 1.05$.

b) In addition to condition (3), the final values of the weight coefficients should meet the condition of mathematical transitivity, i.e. that

$\frac{w_1}{w_4} = 2 \times 1.15 = 2.3$, $\frac{w_2}{w_7} = 1.15 \times 1.17 = 1.35$, $\frac{w_4}{w_6} = 1.17 \times 1.11 = 1.30$, $\frac{w_7}{w_5} = 1.11 \times 1.27 = 1.41$ and $\frac{w_6}{w_3} = 1.27 \times 1.05 = 1.33$.

By applying expression (5), the final model for determining the weight coefficients can be defined as:

$$\min \chi$$

$$s.t. \begin{cases} \left|\frac{w_1}{w_2} - 2\right| \le \chi,\ \left|\frac{w_2}{w_4} - 1.15\right| \le \chi,\ \left|\frac{w_4}{w_7} - 1.17\right| \le \chi,\ \left|\frac{w_7}{w_6} - 1.11\right| \le \chi,\ \left|\frac{w_6}{w_5} - 1.27\right| \le \chi,\ \left|\frac{w_5}{w_3} - 1.05\right| \le \chi, \\ \left|\frac{w_1}{w_4} - 2.3\right| \le \chi,\ \left|\frac{w_2}{w_7} - 1.35\right| \le \chi,\ \left|\frac{w_4}{w_6} - 1.3\right| \le \chi,\ \left|\frac{w_7}{w_5} - 1.41\right| \le \chi,\ \left|\frac{w_6}{w_3} - 1.33\right| \le \chi, \\ \sum_{j=1}^{7} w_j = 1,\ w_j \ge 0, \forall j \end{cases}$$

By solving this model, the final values of the weight coefficients are:

Quality of material $w_1 = 0.317$, price of material $w_2 = 0.159$, product certification $w_3 = 0.080$, delivery time $w_4 = 0.138$, warranty period $w_5 = 0.083$, reliability $w_6 = 0.106$, payment method $w_7 = 0.118$ and DFC of results $\chi = 0.001$ are obtained.

After obtaining the results we can conclude that the first criterion quality of material is the most important one with value 0.317.

3.2.2 Supplier evaluation and selection using the WASPAS method

In Table 3 the multi-criteria decision-making model is shown as consisting of seven criteria and six alternatives, i.e. suppliers. This represents the first step of the WASPAS method.

Table 3. Initial decision-making matrix extended with criteria orientation

	C1	C2	C3	C4	C5	C6	C7
S1	9	1200	9	5	7	5	7
S2	7	1000	7	3	5	7	3
S3	9	1250	9	7	15	3	9
S4	9	1150	7	5	7	5	5
S5	5	750	9	5	3	9	3
S6	9	1200	9	5	15	7	1
	MAX	MIN	MAX	MIN	MAX	MAX	MAX
	9	750	9	3	15	9	9

Step 2 Normalization of initial matrix (Table 4) using the following equations:

$n_{ij} = \frac{x_{ij}}{\max_i x_{ij}}$ for criteria C1, C3, C5, C6 and C7,

i.e. $n_{ij} = \frac{\min_i x_{ij}}{x_{ij}}$ for criteria C2 andC4.

Table 4. Process of calculation for normalization of initial matrix

	C1	C2	C3	C4	C5	C6	C7
S1	9/9	750/1200	9/9	3/5	7/15	5/9	7/9
S2	7/9	750/1000	7/9	3/3	5/15	7/9	3/9
S3	9/9	750/1250	9/9	3/7	15/15	3/9	9/9
S4	9/9	750/1150	7/9	3/5	7/15	5/9	5/9
S5	5/9	750/750	9/9	3/5	3/15	9/9	3/9
S6	9/9	750/1200	9/9	3/5	15/15	7/9	1/9

Results obtained using normalization process are shown in Table 5.

Table 5. Normalized matrix

	C1	C2	C3	C4	C5	C6	C7
S1	1	0.625	1	0.6	0.467	0.556	0.778
S2	0.778	0.75	0.778	1	0.333	0.778	0.333
S3	1	0.6	1	0.429	1	0.333	1
S4	1	0.652	0.778	0.6	0.467	0.556	0.556
S5	0.556	1	1	0.6	0.2	1	0.333
S6	1	0.625	1	0.6	1	0.778	0.111

Step 3 Multiplication of the previously obtained matrix with criteria weights. Using the following equation:

$$V_{ij} = w_j \times n_{ij}, i = 1, 2, \ldots, m, j$$

In Table 6 the normalized matrix with criteria weights is shown.

Table 6. Normalized matrix with criteria weights

	C1	C2	C3	C4	C5	C6	C7
S1	1	0.625	1	0.6	0.467	0.556	0.778
S2	0.778	0.75	0.778	1	0.333	0.778	0.333
S3	1	0.6	1	0.429	1	0.333	1
S4	1	0.652	0.778	0.6	0.467	0.556	0.556
S5	0.556	1	1	0.6	0.2	1	0.333
S6	1	0.625	1	0.6	1	0.778	0.111
W	0.317	0.159	0.080	0.138	0.083	0.106	0.118

Example of calculation:

$$v_{11} = 0.317 \times 1.000 = 0.317$$

$$v_{12} = 0.159 \times 0.625 = 0.099$$

Weighted normalized matrix is shown in Table 7.

Table 7. Weighted normalized matrix

	C1	C2	C3	C4	C5	C6	C7
S1	0.317	0.099	0.080	0.083	0.039	0.059	0.092
S2	0.247	0.119	0.062	0.138	0.028	0.082	0.039
S3	0.317	0.095	0.080	0.059	0.083	0.035	0.018
S4	0.317	0.104	0.062	0.083	0.039	0.059	0.066
S5	0.176	0.159	0.080	0.083	0.017	0.106	0.039
S6	0.317	0.099	0.080	0.083	0.083	0.082	0.013

Step 4 Summarizing of all values per alternatives (Summarizing per rows, Table 8)

$$q_{ij} = \sum_{j=1}^{n} v_{ij}$$

Example:

$$Q_1 = 0.317 + 0.099 + 0.080 + 0.083 + 0.039 + 0.059 + 0.092 = 0.769$$

Table 8. Calculation of Qi

	C1	C2	C3	C4	C5	C6	C7	Qi
S1	0.317	0.099	0.080	0.083	0.039	0.059	0.092	0.769
S2	0.247	0.119	0.062	0.138	0.028	0.082	0.039	0.715
S3	0.317	0.095	0.080	0.059	0.083	0.035	0.018	0.687
S4	0.317	0.104	0.062	0.083	0.039	0.059	0.066	0.730
S5	0.176	0.159	0.080	0.083	0.017	0.106	0.039	0.660
S6	0.317	0.099	0.080	0.083	0.083	0.082	0.013	0.757

Step 5: Determining of the weighted product model using the following equation (Table 9): $p_{ij} = \prod_{j=1}^{n} (v_{ij})^{wj}$, Example:

$$P_1 = (1.000)^{0.317} \times (0.625)^{0.159} \times (1.000)^{0.080} \times (0.600)^{0.138} \times (0.467)^{0.083}$$
$$\times (0.056)^{0.106} \times (0.778)^{0.118} = 0.741$$

Table 9. Weighted product model

	C1	C2	C3	C4	C5	C6	C7	Pi
S1	1	0.625	1	0.6	0.467	0.556	0.778	0.741
S2	0.778	0.75	0.778	1	0.333	0.778	0.333	0.675
S3	1	0.6	1	0.429	1	0.333	1	0.730
S4	1	0.652	0.778	0.6	0.467	0.556	0.556	0.703
S5	0.556	1	1	0.6	0.2	1	0.333	0.594
S6	1	0.625	1	0.6	1	0.778	0.111	0.655
W	0.317	0.159	0.080	0.138	0.083	0.106	0.118	

Step 6 Determining of relative values alternatives *Ai*.

We have taken value λ=0.5.

$$A_1 = 0.5 \times 0.769 + (1 - 0.5) \times 0.741 = 0.755$$

Step 7 Ranking of the alternatives (Table 10). Alternative with the biggest value represents the best ranked while the smallest value denotes the worst alternative.

Table 10. Ranking of alternatives

	Qi	Pi	Ai
Supplier 1	***0.769***	***0.741***	***0.755***
Supplier 2	*0.715*	*0.675*	*0.695*
Supplier 3	*0.687*	*0.730*	*0.709*
Supplier 4	*0.730*	*0.703*	*0.717*
Supplier 5	*0.660*	*0.594*	*0.627*
Supplier 6	*0.757*	*0.655*	*0.706*

$$S_1 > S_4 > S_3 > S_6 > S_2 > S_5$$

Using the FUCOM method for determining criteria weights and the WASPAS method for ranking alternatives we obtain that Supplier 1 represents the best solution.

4. Sensitivity analysis and discussion

Sensitivity analysis is a component part of experimental simulation and can have influence on formulation model. Usually it is used for investigating behavior of the model. In this case, the sensitivity analysis is performed forming scenarios with changes of criteria weights (Fig. 1).

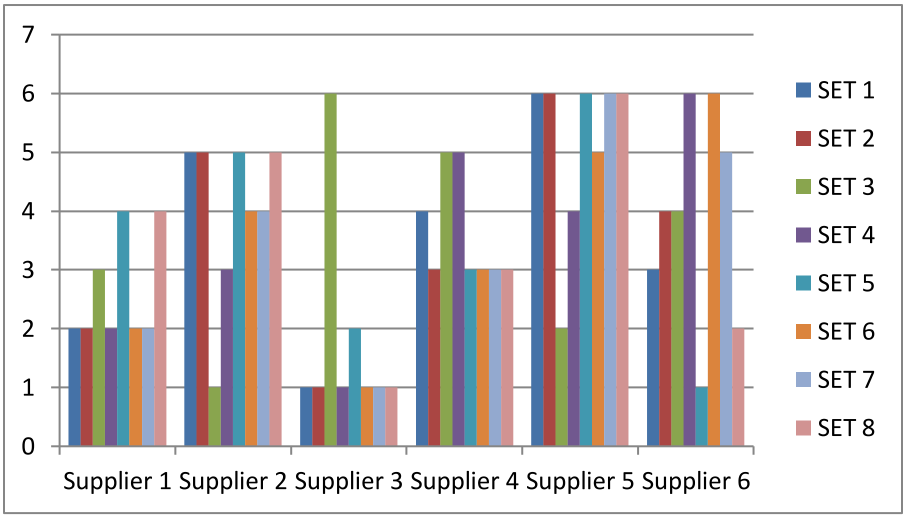

Figure 1. Formed scenarios in sensitivity analysis

In SET 1, weights of first two criteria w_1 and w_2 are decreased by 10%, while w_3, w_4, w_5, w_6 and w_7 are increased for 4%. In this set, with the decreasing significance of criteria quality and price as well as the increasing other criteria, the third supplier is getting higher values and represents the best solution. In the second place is the first supplier, in third Supplier 6, fourth Supplier 4, fifth Supplier 2 and in the last place is Supplier 5. In SET 2, weights of the last three criteria w_5, w_6 and w_7 are increased for 4%, while w_1, w_2, w_3 and w_4 are decreased per 3%. With the increasing significance of the criteria warranty period, reliability and payment method, and with the decreasing significance of the other criteria, Supplier 3 has higher values and represents the best solution. In this set, Supplier 1 is in the second place, Supplier 4 in the third, Supplier 2 in the fifth place and Supplier 5 in the last place. In SET 3, weight coefficients w_1, w_3, w_5 and w_7 are decreased per 6%, while other three w_2, w_4 and w_6 are increased per 8%. In SET 4, the first weight coefficient w_1 is decreased per 24%, while other w_2, w_3, w_4, w_5, w_6 and w_7 are increased per 4%. In this set with the decreasing significance of the criterion quality of material and the increasing of the other criteria, Supplier 3 gets higher values and represents the best alternative. In SET 5, the first five weight coefficients w_1, w_2, w_3, w_4 and w_5 are increased per 4%, while w_6 and w_7 are decreased per 10%. With increasing criteria quality, price, product certification, delivery time and warranty period, Supplier 3 obtains the highest value. In SET 6, only the last weight coefficient w_7 is increased per 30%, while other w_1, w_2, w_3, w_4, w_5 and w_6 are decreased per 5%. With the increasing of significance of the criterion payment method and the other six criteria decreasing, Supplier 3 is the best solution. In SET7, the first and last weight coefficients, i.e. w_1 and w_7 are increased per 15%, while w_2, w_3, w_4, w_5 and w_6 are decreased per 6%. The first ranked alternative in this set is also Supplier 3. In the last SET8, weight coefficients w_3 and w_5 are increased per 20%, while the other five criteria, i.e., w_1, w_2, w_4, w_6 and w_7 are decreased per 8%. Supplier 3 is the first ranked alternative.

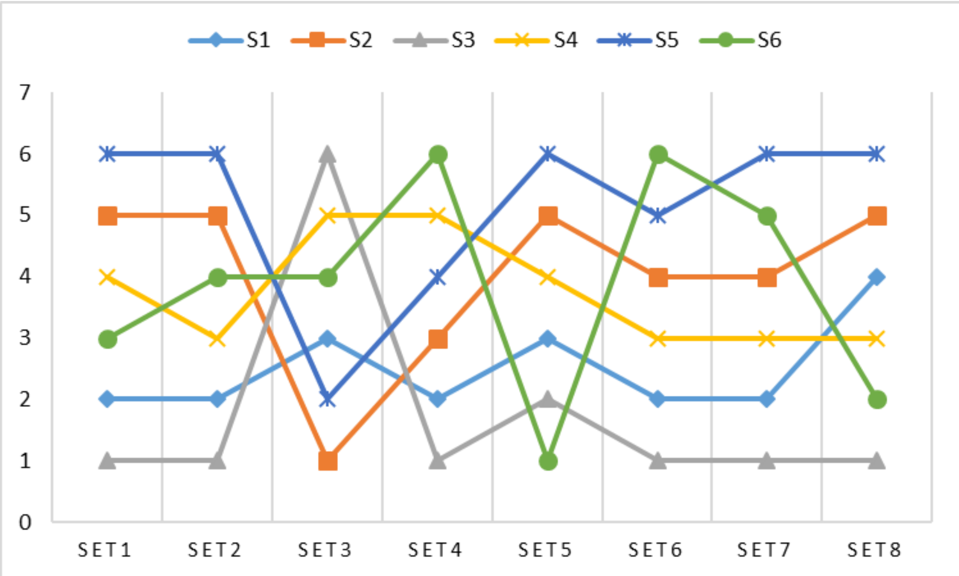

Figure 2. Ranking of suppliers in various scenarios

With decreasing of the significance of criteria quality of material, product certification and warranty period, and, on other hand, with increasing the other criteria, the best solution is Supplier 2. Of the eight SETs made, the best solution for them was Supplier 3 in six sets as can be seen in Fig. 2.

5. Conclusion

For each company, the main goal is to do successful business and achieve a competitive position in a very demanding market. In order to achieve long-term sustainability of the company in the business world, one needs to take into account all the business processes of one company. Each manufacturer should respond to the customers' requests to meet their needs. Yet, in order to meet these requirements, each manufacturer must dispose of his product at the required place, at the required time and in the required quantity. Fulfilling these requirements and achieving a successful business both require the constant disposal of required quantities and types of products.

In this paper, the decomposition of the logistic systems was carried out on the procurement of materials, drying of the boards, production, packaging, and distribution. The aim of the procurement is the quality and timely realization of material goods flows (Stojić et al., 2018, Stević et al., 2017a, Stević et al., 2019), and in this regard, most attention was devoted to the development of a model for evaluating suppliers. In this section, the FUCOM-WASPAS model was used to rank suppliers. We realized that Supplier 1 was the most suitable for further cooperation. After procurement of the material, the drying process of the board lasts from 15 to 100 days depending on the type and characteristics of the wood; in addition, this is very important for the process of production itself because artificial drying under controlled conditions provides material that is suitable for further processing. The production process takes place in six stages. All the phases are interconnected and each phase needs to be thoroughly done if the final product is to be of high quality. After the production process, the process of packaging follows. In the end, the distribution process in which the finished product is placed at the disposal of the customer is completed, that is, it follows the transport to the country from which the order came. Since this company produces boards or semi-finished products, its final product is completed in cooperation with other companies.

In addition, during the analysis and discussion of the solutions achieved, by changing the weight coefficients and by increasing or decreasing the value of certain criteria, the rank of the supplier also changed. It could be concluded that the changing of weight coefficients affected the final result. After setting eight SET with changing of weight coefficients, Supplier 3 had highest ranking results. Through this research, an adequate basis for future actions is created, which implies the separation of key performance indicators based on the executed decomposition of logistics systems, and their measurement and monitoring.

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