TRANSPORT & *LOGISTICS:*
the International Journal

Article history:
Received 02 February 2017
Accepted 18 March 2017
Available online 07 April 2017

ISSN 2406-1069

Article citation info: Stević, Ž., Modeling performance of logistics subsystems using fuzzy approach. Transport & Logistics: the International Journal, 2017; Volume 17, Issue 42, April 2017, ISSN 2406-1069

MODELING PERFORMANCE OF LOGISTICS SUBSYSTEMS USING FUZZY APPROACH

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Abstract:
The supply chain causes significant costs on daily basis, which presents the burden to companies in their business actions. Therefore, it is expected to rationalize these costs in all subsystems of supply chains in order to insure safe and effective flow of goods in it. The aim of this paper is use of combined approach of multi-criteria analysis in subsystem of supply which means the selection of material supplier for providing the production process. Combined approach means using the AHP (Analytic Hierarchy Process) method for determining the weight values of criteria, while the ranking of suppliers is done by using the Fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method. It is six criteria which mean combination of qualitative and quantitative criteria and their comparison is based on estimates of expert team, which has also done comparison of suppliers in accordance with criteria based on linguistic scale.

Key words:
Multicriteria decision making, AHP, fuzzy TOPSIS, procurement, supplier, logistics.

INTRODUCTION

Logistics according to [21] exists since the famous Greek phylosopher and mathematician Pitagora from Samos. With such similar characteristics it still exists with the appearance of strict requirements and needs to be fulfilled. Today, procurement logistics plays a very important role in the supply chain, so its optimization enables a significant effect on the entire logistics system [19]. Logistics gives an answer to question how to rationalize something, therefore, the aim of this paper is improvement of the supply process throughout ranking and selection of optimal supplier.

By using the methods of multi-criteria analysis it is possible to make decisions which have significant influence on companies' business. Therefore, large number of methods that belong to this field, are used for solving different problems. Most used methods are AHP and Topsis method, especially when it comes to the field of suppliers selection. The major reason for the AHP method application would be its ability to equally handle quantitative and qualitative criteria. Due to its simple concept, TOPSIS method has become very popular and is applied in many areas of decision-making procedure. But, in spite of that, this method is often criticized because there is no possibility for adequate uncertainty's handling and imprecision in the moment when the decision-maker wants accurate results. On the other hand, the fuzzy TOPSIS method presents one of the fuzzy methods of multi-criteria deciding, in which the theory of fuzzy sets is used due to improving the TOPSIS method in making decision when insufficiently precise data are taken in consideration.

AHP is often used in combination with other methods, as evidenced by [5] where the authors are using AHP in their work to assess the difficulty of criteria, and PROMETHEE method for obtaining the final ranking of alternatives, combination AHP and fuzzy TOPSIS [1; 13; 25; 10; 17], fuzzy AHP and TOPSIS method [3; 12], or combination fuzzy AHP and fuzzy TOPSIS [20; 27; 18; 6].

During the recent years a lot of the approaches are proposed to extend the crisp MCDM methods into fuzzy environment in order to deal with uncertain information [4]. For the purpose of suppliers' evaluation, this paper uses the combination of methods of mulitcriteria analysis. Analitical hierarchy proccess (AHP) had been used for determination of significance of criteria, which compares criteria based on Saty's scales for comparison, while fuzzy TOPSIS method was used for alternatives' ranking.

1 AHP AND TOPSIS METHOD

1.1 AHP method

The Analytic Hierarchy Process (AHP) developed by Saaty [14] and, AHP is a theory of measurement by pairwise comparisons and relies on the opinion of experts to derive priority scales. [15] defined the axioms which the AHP is based on: the reciprocity axiom. If the element A is n times more significant than the element B, then element B is 1/n times more significant than the element A; Homogeneity axiom. The comparison makes sense only if the elements are comparable, e.g. weight of a mosquito and an elephant may not be compared; Dependency axiom. The comparison is granted among a group of elements of one level in relation to an element of a higher level, i.e. comparisons at a lower level depend on the elements of a higher level; Expectation axiom. Any change in the structure of the hierarchy requires re-computation of priorities in the new hierarchy.

Some of the key and basic steps in the AHP methodology according to [22] are as follows: to define the problem, expand the problem taking into account all the actors, the objective and the outcome, identification of criteria that influence the outcome, to structure the problem previously explained hierarchy, to compare each element among them at the appropriate level, where the total of nx(n-1)/2 comparisons is necessary, to calculate the maximum value of own vector, the consistency index and the degree of consistency.

Let $\{A_1, A_2, ..., A_n\}$ be n alternatives, and $\{w_1, w_2,...,w_n\}$ be their current weights. The pairwise comparison is conducted by usage the Saaty's scale (1–9).

A pairwise comparison matrix that is defined as follows:

$$W=\left[\frac{w_i}{w_j}\right]=\begin{bmatrix}\frac{w_1}{w_1} & \frac{w_1}{w_2} & \dots & \frac{w_1}{w_n}\\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \dots & \frac{w_2}{w_n}\\ \dots & \dots & \dots & \dots\\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \dots & \frac{w_n}{w_n}\end{bmatrix} \quad (1)$$

This matrix A=[aij] represents the value of the expert's preference among individual pairs of alternatives (Ai versus Aj for all i, j = 1,2,...,n).

After this, the decision-maker compares pairs of alternatives for all the possible pairs. Based on that, the comparison matrix A is obtained, where the element aij shows the preference weight of Ai obtained by comparison with Aj.

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \dots & 1 \end{bmatrix} \tag{2}$$

The aij elements estimate the ratios wi/wj, where w is the vector of current weights of the alternative.

The matrix has reciprocal properties, which are aji=1/aij.

The matrices are formed after all pairwise comparison and the vector of weights w= [w_1,w_2, . . . ,w_n] is computed on the basis of Satty's eigenvector procedure in two steps. First, the pair-wise comparison matrix, A = $[aij]_{nxn}$, is normalized, and then the weights are computed.

Normalization:

$$a_{ij}^* = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{3}$$

for all j = 1,2,..., n.

Weight calculation:

$$w_i = (\frac{1}{n}) \sum_{i=1}^{n} a_{ij}^* \tag{4}$$

for all j = 1,2,..., n.

The consistency of the pairwise matrix (*CI*) is checked for a valid comparison.

$$CI = \frac{\lambda_{max} - n}{n-1} \tag{5}$$

where λmax is an important validating parameter in AHP and is used as a reference index to screen information by calculating the Consistency Ratio (CR) of the estimated vector. CR is calculated by using the following equation:

$$CR = \frac{CI}{RI} \tag{6}$$

where RI is the random consistency index obtained from a randomly generated pairwise comparison matrix. This coefficient is recommended depending on the size of the matrix, so we may find in the papers [11; 2;] that the maximum allowed level of consistency for the matrices 3x3 is 0.05, 0.08 for matrices 4x4 and 0.1 for the larger matrices. If the calculated CR is not of the satisfactory value, it is necessary to repeat the comparison to have it within the target range [16].

1.2 Fuzzy Sets

Fuzzy sets are sets whose elements have degrees of membership. The theory of fuzzy sets was first introduced by Zadeh [26], whose application enables decision makers to effectively deal with the uncertainties. In classical set theory, the membership of elements in a set is assessed in binary terms according to a bivalent condition – an element either belongs or does not belong to the set. Fuzzy sets used generally triangular (TFN), trapezoidal and Gaussian fuzzy numbers, which convert uncertain fuzzy numbers.

A fuzzy number $\tilde{A}$ on R to be a TFN if its membership function $\mu_{\tilde{A}}(x)$: R→[0,1] is equal to following Equation (7):

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{x-l}{m-l}, & l \leq x \leq m \\ \frac{u-x}{u-m}, & m \leq x \leq u \\ 0, & otherwise \end{cases} \tag{7}$$

From Equation (7), l and u mean the lower and upper bounds of the fuzzy number $\tilde{A}$, and m is the modal value for $\tilde{A}$. The TFN can be denoted by $\tilde{A} = (l,\ m,\ u)$.

The operational laws of TFN $\check{A}_1 = (l_1,\ m_1,\ u_1)$ and $\check{A}_2 = (l_2,\ m_2,\ u_2)$ are displayed as following equations.

Addition of the fuzzy number:

$$\check{A}_1 + \check{A}_2 = (l_1, m_1, u_1) + (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \tag{8}$$

Multiplication of the fuzzy number:

$$\check{A}_1 \times \check{A}_2 = (l_1, m_1, u_1)x(l_2, m_2, u_2) = (l_1 l_2, m_1 m_2, u_1 u_2) \text{ for } l_1 l_2 > 0;\ m_1 m_2 > 0;\ u_1 u_2 > 0 \tag{9}$$

Subtraction of the fuzzy number:

$$\check{A}_1 - \check{A}_2 = (l_1, m_1, u_1) - (l_2, m_2, u_2) = (l_1 - u_2, m_1 - m_2, u_{1-} l_2) \tag{10}$$

Division of the fuzzy number:

$$\frac{\check{A}_1}{\check{A}_2} = \frac{(l_1, m_1, u_1)}{(l_2, m_2, u_2)} = \left(\frac{l_1}{u_2}, \frac{m_1}{m_2}, \frac{u_1}{l_2}\right) \text{ for } l_1 l_2 > 0;\ m_1 m_2 > 0;\ u_1 u_2 > 0 \tag{11}$$

Reciprocal of the fuzzy number:

$$\check{A}^{-1} = (l_1,\ m_1,\ u_1)^{-1} = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right) \text{for } l_1 l_2 > 0;\ m_1 m_2 > 0;\ u_1 u_2 > 0 \tag{12}$$

1.3. Fuzzy TOPSIS method

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was first proposed by Hwang and Yoon [9] and a fuzzy TOPSIS method was later introduced by Chen and Hwang [8]. The basic idea for this method is to choose the alternative, which is as close to the positive ideal solution as possible and as far from the negative ideal solution as possible. The positive ideal solution is a solution with maximized benefit criteria and minimized cost criteria. The negative ideal solution is a solution, where the cost criteria are maximized and benefit criteria are minimized.

The algorithm of the fuzzy TOPSIS method can be described as follows: [7]

Step 1: Form a committee of decision-makers, then identify the evaluation criteria.

Step 2: Choose the appropriate linguistic variables for the importance weight of the criteria and the linguistic ratings for alternatives with respect to criteria.

Step 3: Aggregate the weight of criteria to get the aggregated fuzzy weight $\tilde{w}_j$ of criterion C_j , and pool the decision maker's opinions to get the aggregated fuzzy rating $\tilde{x}_{ij}$ of alternative A_i under criterion C_j.

$\tilde{R}_k = (a_k, b_k, c_k), k = 1,2,3, \dots K$, then the aggregated Fuzzy rating can be determined as $R = (a, b, c), k = 1,2,3, \dots K$. Here, $a = min_k(a_k), b = \frac{1}{K}\sum_{k=1}^{K} b_k$, $c = max_k(c_k)$.

Step 4: Construct the fuzzy decision matrix and the normalized fuzzy decision matrix.

$$\tilde{R}_k = \left[r_{ij}\right]_{mxn}\ i = 1,2,3, \dots, m;\ \ j = 1,2,3, \dots, n\ 0 \tag{13}$$

where B and C are the set of benefit criteria and cost criteria, respectively, and

$$r_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), \qquad j \in B$$

$$r_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{c_{ij}}{a_{ij}}\right), \qquad j \in C$$

$c_j^* = \max_i c_{ij}$ if $j \in B$
$a_j^- = \min_i a_{ij}$ if $j \in C$

Step 5: Construct the weighted normalized fuzzy decision matrix. Considering the different importance of each criterion, we can construct the weighted normalized fuzzy decision matrix as:

$$\tilde{V} = [\tilde{v}_{ij}]_{mxn} \; i = 1,2,,\dots,m; \; j = 1,2,,\dots,n \tag{14}$$

$\tilde{v}_{ij} = r_{ij}W$ where W is the weighted vector of evaluating criteria.

Step 6: Determine the Fuzzy positive ideal solution (FPIS) and Fuzzy negative ideal solution (FNIS):
$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \dots, \tilde{v}_n^*)$,
$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \dots, \tilde{v}_n^-)$,
where $\tilde{v}_j^* = (1, 1, 1)$ and $\tilde{v}_j^- = (0, 0, 0)$, $j = 1,2, \dots n$.

Step 7: Calculate the distance of each alternative from FPIS and FNIS, respectively. The distance of each alternative from A^* and A^- can be currently calculated as:

$$d_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^*), \quad i = 1,2, \dots . m, \tag{15}$$

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-), \quad i = 1,2, \dots . m, \tag{16}$$

where d(. ; .) is the distance measurement between two fuzzy numbers.

Step 8: Calculate the closeness coefficient of each alternative.

A closeness coefficient is defined to determine the ranking order of all alternatives once the d_i^* and d_i^- of each alternative A_i (i=1; 2; : : : ; m) has been calculated. The closeness coefficient of each alternative is calculated as:

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}, \; i = 1,2, \dots, m \tag{17}$$

Step 9: According to the closeness coefficient, the ranking order of all alternatives can be determined.

2. NUMERICAL EXAMPLE

Criteria applied in this study are: price of materials, reliability, delivery time, payment method, mode of delivery and quality of materials which are marked with C_1-C_6 respectively. Therefore, there are two criteria, quantitatively expressed and four criteria which are qualitative. The company which is the subject of research deals with the furniture production.

Prices of materials, and delivery time are the quantitative criteria that are easily expressed as they represent stabil measures, ie. specific values. Price of materials indicates the money value of goods established by the supplier based on investment in the form of materials, energy, labor, etc. Delivery time is the time interval between the moment of getting the order and the time of availability of goods to the customer. It is most commonly expressed in days, but can be in other time units as well.

In contrast to the above, the remaining criteria are qualitative, they represent soft masurers and are not so easy to express, so they should be presented by a descriptive mark.

Reliability is probability of the established time for delivery. Any failure to comply with previously agreed terms of delivery may cause some confusion to the customer for example: disruption of production due to lack of materials, cost increase, etc. It can be described as satisfactory, good and excellent.

Payment represent compensation in money for delivered goods as determined between the contract parties. During research, it was established that payment can be done as advance, postponed with bank guarantee, or percentage of total amount as advance, and the rest is paid postponed, what can be shown in following way: bad, acceptable, good and excellent.

Mode of delivery represents a qualitative criteria that can be expressed as good, average and bad, depending of the fact whether the transport is calculated in the price of material – is it free of charge, or delivery of goods is to be done by vehicles of examined company. If it is the second option distances of suppliers must be taken into consideration, as well as expences caused by that.

The quality of materials is the level of fulfilling the requirements of regulations and standards, on the one hand and the level of fulfilling customer's expectations on the other side. It can be described as good, very good, excellent and outstanding.

After defining criteria that is the basis of performing modelling in the supply chain, the comparison of criteria has been done based on the expert evaluation, in fact three decision makers determine the importance of criteria. Comparison of criteria according to Saaty's scale is shown in the table 1.

Tab. 1 *Pairwise comparison matrix for criteria*

	C_1	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
C_1	1	0.33	0.25	1.00	2.00	0.25
C_2	3.00	1	0.50	3.00	4.00	0.50
C_3	4.00	2.00	1	4.00	5.00	1.00
C_4	1.00	0.33	0.25	1	2.00	0.25
C_5	0.50	0.25	0.20	0.50	1	0.20
C_6	4.00	2.00	1.00	4.00	5.00	1

By using previously described methodology related to Analytical Hierarchical Process we get the following values of criteria shown in figure 1. Calculated level of consistency is 0,01, which means that subjectivity that is present while making decision is reduced to a minimum.

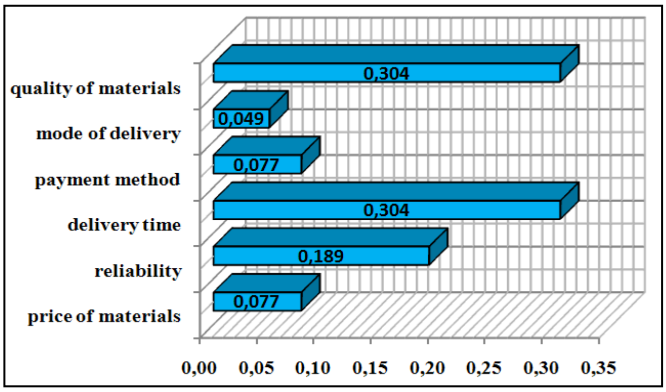

Fig. 1 *Results obtained from AHP computations*

It can be concluded from the previous figure that the third and sixth criteria, in fact the time of delivery and quality had the biggest influence on decision. The importance of these two criteria is confirmed by [23; 24], where they play the most important role in making decisions on suppliers selection. Beside these two criteria also the price can play important role according to mentioned authors.

After determining the importance of criteria, an expert team, which has three members, has compared alternatives on the basis of linguistic variables that was shown in the table 3. The comparison was done on the basis of linguistic variables shown in the table 2.

***Tab. 2** Linguistic variables for ratings*

Very good (VG)	(9, 10, 10)
Good (G)	(7, 9, 10)
Medium good (MG)	(5, 7, 9)
Fair (F)	(3, 5, 7)
Medium poor (MP)	(1, 3, 5)
Poor (P)	(0, 1, 3)
Very poor (VP)	(0, 0, 1)

***Tab. 3** Rating of the suppliers in linguistic terms*

Expert rating	**Suppliers**	**Criterion**					
		C_1	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
	S_1	VG	VG	VG	F	MG	VG
	S_2	G	VG	VG	VG	MG	VG
E_1	S_3	G	G	G	G	VG	MG
	S_4	MG	G	G	F	VG	MG
	S_5	MG	MG	MP	VG	G	G
	S_1	VG	G	VG	MG	F	VG
	S_2	G	G	VG	VG	F	VG
E_2	S_3	G	MG	MG	G	VG	G
	S_4	MG	F	G	MG	VG	G
	S_5	F	MG	MP	VG	MG	G
	S_1	G	VG	VG	F	MG	VG
	S_2	G	VG	VG	VG	MG	G
E_3	S_3	G	F	G	G	VG	MG
	S_4	MG	G	G	F	VG	MG
	S_5	MG	VG	MP	G	MG	G

After comparing the alternatives according to each criteria separately by three members of expert team on the basis of linguistic variables, the next step is turning linguistic variables into the fuzzy triangular numbers which is shown in the table 4.

***Tab. 4** Rating of partners in triangular Fuzzy numbers*

Exp. rating	**Supp liers**	**Criterion**					
		C_1	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
	S_1	(9,10,10)	(9,10,10)	(9,10,10)	(3,5,7)	(5,7,9)	(9,10,10)
	S_2	(7,9,10)	(9,10,10)	(9,10,10)	(9,10,10)	(5,7,9)	(9,10,10)
E_1	S_3	(7,9,10)	(7,9,10)	(7,9,10)	(7,9,10)	(9,10,10)	(5,7,9)
	S_4	(5,7,9)	(7,9,10)	(7,9,10)	(3,5,7)	(9,10,10)	(5,7,9)
	S_5	(5,7,9)	(5,7,9)	(1,3,5)	(9,10,10)	(7,9,10)	(7,9,10)
	S_1	(9,10,10)	(7,9,10)	(9,10,10)	(5,7,9)	(3,5,7)	(9,10,10)
	S_2	(7,9,10)	(7,9,10)	(9,10,10)	(9,10,10)	(3,5,7)	(9,10,10)
E_2	S_3	(7,9,10)	(5,7,9)	(5,7,9)	(7,9,10)	(9,10,10)	(7,9,10)
	S_4	(5,7,9)	(3,5,7)	(7,9,10)	(5,7,9)	(9,10,10)	(7,9,10)
	S_5	(3,5,7)	(5,7,9)	(1,3,5)	(9,10,10)	(5,7,9)	(7,9,10)
	S_1	(7,9,10)	(9,10,10)	(9,10,10)	(3,5,7)	(5,7,9)	(9,10,10)
	S_2	(7,9,10)	(9,10,10)	(9,10,10)	(9,10,10)	(5,7,9)	(7,9,10)
E_3	S_3	(7,9,10)	(3,5,7)	(7,9,10)	(7,9,10)	(9,10,10)	(5,7,9)
	S_4	(5,7,9)	(7,9,10)	(7,9,10)	(3,5,7)	(9,10,10)	(5,7,9)
	S_5	(5,7,9)	(9,10,10)	(1,3,5)	(7,9,10)	(5,7,9)	(7,9,10)

By using the expressions defined in the step three, the fuzzy decision matrix shown in the table 5 is formed.

Tab. 5. *Fuzzy rating of criteria (Fuzzy decision matrix)*

	Criterion					
	C_1	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
S_1	(7,9.667,10)	(7,9.667,10)	(7,9.667,10)	(3,5.667,9)	(3,6.333,9)	(9,10,10)
S_2	(7,9.333,10)	(7,9.667,10)	(9,10,10)	(9,10,10)	(3,6.333,9)	(7,9.667,10)
S_3	(7,9,10)	(3,7,10)	(5,8.333,10)	(7,9,10)	(9,10,10)	(5,7.667,10)
S_4	(5,7,9)	(3,7.667,10)	(7,9,10)	(3,5.667,9)	(9,10,10)	(5,7.667,10)
S_5	(3,6.333,9)	(5,8,10)	(1,3,5)	(7,9.667,10)	(5,7.667,10)	(7,9,10)

By using the equation (13) the normalized fuzzy matrix is formed and using equation (14) the weighted normalized fuzzy decision matrix shown in the table 6 is formed. The first and third criteria belong to cost, while the rest of criteria belong to the benefit criteria.

Tab. 6 *Weighted Normalized Fuzzy decision matrix*

	C_1	**C_2**	**C_3**
S_1	(0.023,0.024,0.033)	(0.132,0.183,0.189)	(0.03,0.031,0.043)
S_2	(0.023,0.025,0.033)	(0.132,0.183,0.189)	(0.03,0.03,0.034)
S_3	(0.023,0.026,0.033)	(0.057,0.132,0.189)	(0.03,0.036,0.061)
S_4	(0.026,0.033,0.046)	(0.057,0.145,0.189)	(0.03,0.034,0.043)
S_5	(0.026,0.036,0.077)	(0.095,0.151,0.189)	(0.061,0.101,0.304)
	C_4	**C_5**	**C_6**
S_1	(0.023,0.044,0.069)	(0.015,0.031,0.044)	(0.274,0.304,0.304)
S_2	(0.069,0.077,0.077)	(0.015,0.031,0.044)	(0.213,0.294,0.304)
S_3	(0.054,0.069,0.077)	(0.044,0.049,0.049)	(0.152,0.233,0.304)
S_4	(0.023,0.044,0.069)	(0.044,0.049,0.049)	(0.152,0.233,0.304)
S_5	(0.054,0.074,0.077)	(0.025,0.038,0.049)	(0.213,0.274,0.304)

By using the equations shown in the step 6 we get the values shown in the table 7, in fact the values which indicate the distances from ideal and anti-ideal solution.

Tab. 7 *Distance between A_i and A^* and A^- with respect to each criterion*

	C_1	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**Σ**
d_1^*	0.0270	0.8323	0.0352	0.9548	0.9701	0.7061	3.5255
d_2^*	0.0273	0.8323	0.0314	0.9257	0.9701	0.7510	3.5378
d_3^*	0.0276	0.8757	0.0444	0.9334	0.9527	0.7728	3.6066
d_4^*	0.0360	0.8714	0.0361	0.9548	0.9527	0.7728	3.6238
d_5^*	0.0513	0.8559	0.1883	0.9317	0.9627	0.7373	3.7272
d_1^-	0.9733	0.1699	0.9657	0.0491	0.0323	0.2943	2.4846
d_2^-	0.9730	0.1699	0.9687	0.0744	0.0323	0.2734	2.4917
d_3^-	0.9727	0.1371	0.9578	0.0673	0.0474	0.2379	2.4202
d_4^-	0.9650	0.1414	0.9643	0.0491	0.0474	0.2379	2.4051
d_5^-	0.9539	0.1500	0.8513	0.0691	0.0386	0.2664	2.3293

Based on these values and equation (17) gives the final rankings akternativa shown in table 8.

Tab. 8 *Closeness coefficient of alternatives and their ranking*

	d_i^*	d_i^-	$d_i^*+d_i^-$	$CC_i=\frac{d_i^-}{d_i^*+d_i^-}$	Rank
S_1	3.5255	2.4846	6.0101	0.4134	1
S_2	3.5378	2.4917	6.0295	0.4132	2
S_3	3.6066	2.4202	6.0268	0.4016	3
S_4	3.6238	2.4051	6.0289	0.3990	4
S_5	3.7272	2.3293	6.0565	0.3846	5

After using the two-phase approach to paper, which means determining significant criteria with the AHP method and ranking the suppliers with using the fuzzy TOPSIS method, it can be concluded that optimal solution is the first supplier. However, the supplier number two is almost as good solution and if the fourth criteria payment method becomes more significant while comparing criteria with each other, it would certainly take the first place in the overall ranking. Therefore, at this moment two suppliers are the solutions which can meet the needs and requests for the company which is subject of research.

3 CONCLUSION

Improvement of the supply process can contribute to the efficiency of the total supply chain. One of the most important strategic issues in logistics procurement is correct and optimal supplier selection, who enables increase of competitiveness in market. Thanks to constant changes that market is exposed to and which has more and more strict requests, it is certainly a challenge to maintain a competitive position. This is possible to accomplish if adequate production is achieved, which means as lower price of product as possible, as better quality as possible, high accuracy of delivery to the end users, as well as cooperation that is realized with both, buyers and suppliers. With effective performance of activities related to supply, which also includes optimal supplier selection, we can have significant influence on forming the price of the final product, as well as its quality which largely dictates the market position. Proper supplier selection at start provides possibility for timely, continuous and qualitative production, which allows the realization of the previously described advantages and which is used for the production to become competitive.

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