

A FUZZY-AHP APPROACH TO EVALUATE THE CRITERIA OF THIRD-PARTY LOGISTICS (3PL) SERVICE PROVIDER

Stefan Jovčić ^{a,*}, Petr Průša ^a, Josef Samson ^a, Dragan Lazarević ^b

^a University of Pardubice, Faculty of Transport Engineering, Studentská 95, Pardubice 532 10, Czech Republic

^b University of Belgrade, Faculty of Transport and Traffic Engineering, Vojvode Stepe 305, Beograd 161904, Serbia

Abstract: *This paper deals with the criteria that should be taken into consideration when making a decision about Third-Party Logistics (3PL) service providers and their evaluation. Not all the criteria is equally important, so it is necessary to evaluate them in order to determine the priority and help the company to make a decision. The criteria for 3PL assessment were defined by consulting several experts in the field of logistics. It is very important to analyze and evaluate 3PL providers because there are a very large number of providers in the market and for the company it is very important to choose the right one, based on the relevant criteria. The methodology used for evaluation of the criteria is based on Fuzzy-AHP (Analytic Hierarchy Process) approach. This approach combines the Saaty's scale (which gives the value of most importance in the statements-criteria) and fuzzy logic (which deals with the linguistic statements). The main result of the paper is to rank the criteria by importance and direct it for the further research in the field of 3PL.*

Keywords: *Third-Party Logistics (3PL) Service Provider, Fuzzy-AHP approach, 3PL evaluation criteria*

1. INTRODUCTION

Third-Party logistics (3PL) providers have an important role in the logistics industry and represent a very important link between companies and customers. 3PL is a company organization dealing with the physical movement of a certain good between two points as well as a provision of additional value-added services such as warehousing, packaging, customs etc. More and more companies are moving from their own transport account to the accounts of external business partners (3PL). Nowadays, in the field of logistics, it is difficult to find the right external business partner, since the number of 3PL providers has increased significantly and continuous to grow. The other reason is that there is a huge amount of criteria that characterize 3PL and it is hard to make a decision about its

* stefan.jovcic93@gmail.com

evaluation and selection. It is especially important to pay attention to the criteria that characterize the external logistics partner. Not all criteria are equally important. Different companies are looking for providers through different criteria, all depending on their needs. The firm's competitiveness strategy and its external environment affect the selection criteria for 3PL, stated Menon et al. (2014). The criteria considered in this paper are determined by consulting several experts in the field of logistics.

According to Daugherty et al. (1996) the logistics service capabilities provided by a 3PL should include dedication to emergency assistance, ability to handle changes in environment, flexibility in meeting external needs, providing of emergency service, the ability to proposing solutions to potential problems, helping corporation in implementing cost reduction, analysis of problem solution, responding to unforeseen uncertain needs of operational situations, anticipating transportation problems, proposing counter measures when unable to provide service, and providing service or operational status report. All these possibilities should have a logistics provider to in order to be considered as a professional in the field of logistics. Önüt et al. (2009) emphasized that a company could greatly save costs, time and increase competitive advantage in the market by making the right decision about the logistics service provider. However, due to high competition in the market, it is a challenge when choosing an appropriate logistic provider, especially when bearing in mind that there are various criteria that characterize them. There are lots of factors affecting selection of the service provider according to Akman and Baynal (2014).

To evaluate 3PL service providers in better organizing their selection, a variety number of techniques is used in the literature. For example, Kannon et al. (2009) used the multi-criteria methods in Fuzzy environment to select the best 3PL reverse logistics service provider. In research mentioned, the authors combined the TOPSIS method and Fuzzy logic. Yang et al. (2010) were conducted the research based on LSP selection for AIR cargo by using the Analytic Network Process (ANP) method. As the main criteria involved are performance, features, reliability, conformance serviceability and perceived quality. Vijavargiya and Dey (2010) were used the AHP method for logistics service provider selection in India. They considered the criteria such as cost (inland transportation and ocean/air freight), delivery (schedule flexibility) and value-added services (clearing and forwarding and IT- Track and Trace). Kabir (2012) combined the Fuzzy-AHP approach with the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method for 3PL provider selection. The criteria, such as quality, cost and delivery time were taken into consideration.

The research paper discusses the importance of the criteria for selecting a third-party logistics provider and provides the methodology based on fuzzy-AHP approach. This methodology is very useful for determining the importance of the criteria. The rest of the paper is organized as follows: Section 2 gives a fuzzy-AHP methodology for solving the evaluation problem. In Section 3, the evaluation criteria for 3PL providers is done by using previously described methodology and the final rank of the criteria is obtained. After this section, there are some concluding remarks.

2. A FUZZY-AHP METHODOLOGY

In this paper, fuzzy-AHP methodology is used to evaluate the criteria for 3PL service provider. This methodology combines fuzzy logic, which is based on linguistic terms and

statements and well-known AHP methodology developed by Saaty. The authors of this paper decided to use exact this method because of its simplicity. It may be emphasized that for experts it is much easier to state the importance of the criteria by linguistic statements than by numerical values. Linguistic variables in Fuzzy logic are represented by triangular numbers (Kilincici and Onal, 2011). Ayhan (2013) conducted the case study in a gear-motor company. In that study, he used a fuzzy-AHP methodology which includes 7 steps.

Step 1. Formulation a Fuzzy-AHP Saaty's Scale with linguistic terms (table 1).

Table 1. Fuzzy-AHP triangular scale

Classic Saaty's Scale	Linguistic terms	Fuzzy Scale (triangular scale)
1	Equally important	(1,1,1)
3	Weakly important	(2,3,4)
5	Fairly important	(4,5,6)
7	Strongly important	(6,7,8)
9	Absolutely important	(9,9,9)
2	Values designed for evaluation of so-called interphase	(1,2,3)
4		(3,4,5)
6		(5,6,7)
8		(7,8,9)

According to the appropriate linguistic terms, the decision maker uses the given fuzzy number on the right side of the scale. For example, if the decision maker states "Criterion 1 is strongly important than Criterion 2" then it takes the fuzzy triangular scale as (6,7,8). On the contrary, in the pairwise comparison matrix of the criteria, comparison of Criterion 2 to Criterion 1 will take the fuzzy triangular scale as (1/8, 1/7, 1/6). The pairwise comparison of the criteria presented in the form of matrix is given in equation 1.

$$\tilde{P}_k = [\tilde{z}_{11}^k \tilde{z}_{12}^k \dots \tilde{z}_{1n}^k \tilde{z}_{21}^k \tilde{z}_{22}^k \dots \tilde{z}_{2n}^k \dots \dots \tilde{z}_{ij}^k \dots \tilde{z}_{n1}^k \tilde{z}_{n2}^k \dots \tilde{z}_{nn}^k] \quad (1)$$

where: \tilde{z}_{ij}^k indicates the k -th decision maker's preference of i -th criterion over j -th criterion, via fuzzy triangular numbers. Here, the sign "˜" indicates the triangular number demonstration.

For example, \tilde{z}_{12}^2 represents the second decision maker's preference of first criterion over second criterion and equals to $\tilde{z}_{12}^2 = (6,7,8)$. If there is more than one decision maker, preferences of each decision maker (\tilde{z}_{ij}^k) are averaged and \tilde{z}_{ij} is calculated on the following way, given in equation 2.

$$\tilde{z}_{ij} = \sum_{k=1}^k \frac{\tilde{z}_{ij}^k}{k} \quad (2)$$

Step 2. According to averaged preferences, pairwise contribution matrix is updated as it shown in equation 3.

$$\tilde{P} = [\tilde{z}_{11} \tilde{z}_{12} \dots \tilde{z}_{1n} \tilde{z}_{21} \tilde{z}_{22} \dots \tilde{z}_{2n} \dots \dots \tilde{z}_{ij} \dots \tilde{z}_{n1} \tilde{z}_{n2} \dots \tilde{z}_{nn}] \quad (3)$$

where: \tilde{P} represents pairwise contribution matrix.

Step 3. Geometric mean of fuzzy comparison values. It is done according to Buckley (1985) in equation 4.

$$\tilde{\tau}_i = (\prod_{j=1}^n \tilde{Z}_{ij})^{1/n}; \quad i=1,2,\dots,n; \quad (4)$$

where: $\tilde{\tau}_i$ represents geometric mean of fuzzy comparison values, $\prod_{j=1}^n \tilde{Z}_{ij}$ is multiplied of each fuzzy value from pairwise comparison matrix.

Step 4. The fuzzy weights of each criterion

It is shown in equation 5 including the following three sub-steps:

Step 4.1 Find the vector summation of each $\tilde{\tau}_i$

Step 4.2 Find the (-1) power of summation vector. Replace the fuzzy triangular number to make it in an increasing order.

Step 4.3 To find the fuzzy weight of criterion i (\tilde{W}_i), it's necessary to multiply each $\tilde{\tau}_i$ with this reverse vector.

$$\tilde{W}_i = \tilde{\tau}_i (\tilde{\tau}_1 \oplus \tilde{\tau}_2 \dots \tilde{\tau}_n)^{-1} = \{eW_i, fW_i, gW_i\} \quad (5)$$

where: eW_i, fW_i and gW_i are obtained fuzzy triangular numbers

Step 5. Since \tilde{W}_i are still fuzzy triangular numbers, they need to be de-fuzzified by Center of Area method. This method is proposed by Chou and Chang (2008), via applying the equation 6.

$$M_i = \frac{e\tilde{W}_i + f\tilde{W}_i + g\tilde{W}_i}{3} \quad (6)$$

where M_i represents a non-fuzzy number.

Step 6: Now, M_i , calculated beyond in equation 6 is a non-fuzzy number, but it needs to be normalized by following equation 7.

$$N_i = \frac{M_i}{\sum_{i=1}^n M_i} \quad (7)$$

where: N_i represents the final weights after normalization.

These 6 steps are performed to find the normalized weights of both criteria and the sub-criteria. Then by multiplying each sub-criteria weight with related criteria, the scores for each sub-criteria is calculated. According to these results, the sub-criteria with the highest score is suggested to the decision maker.

3. APPLICATION OF THE PROPOSED METHODOLOGY TO EVALUATE THE IMPORTANCE OF CRITERIA FOR 3PL PROVIDER SELECTION

In this paper, the previously described methodology is used to evaluate the importance of criteria that should be taken into consideration when the company makes a decision about 3PL provider selection. Several experts in the field of logistics and supply chain management were consulted and based on their opinion, the authors have given the weights for all criteria. Other words, not all criteria are equally important. In the

continuation of the paper, the criteria that should be of huge importance is going to be described and evaluated. The authors distinguished the following criteria.

Criterion 1. Total cost of logistics outsourcing - this criterion is one of the most important for a logistics company according to the authors' opinion. In the context of the total logistic cost of outsourcing the authors included transport cost, low cost distribution, cost reduction, cost of warehousing, expected leasing cost and cost savings.

Criterion 2. Delivery - this criterion may be represented by attributes such as delivery speed, on-time delivery rate, accuracy of transit/delivery time, on-time performance, on-time shipment and delivery etc.

Criterion 3. Reliability – this criterion means the ability to perform the promised service dependably and accurately. It should be of huge importance for the company for whom the 3PL service provider provides services.

Criterion 4. Flexibility – this is related to ability to adapt to changing customers' requirements. Keeping flexibility in mind, it will include the ability to meet future requirements, the capacity to accommodate and grow the client's business, the capability to handle specific business requirements, time response capability etc.

Criterion 5. Professionalism – from the authors' point of view, this is also one of the most important criteria when make a decision about exact 3PL provider. If the 3PL provider is an expert in providing logistics services, a company will be more confident and easier to cooperate with. This criterion is characterized by attributes such as expertise, competence, and experience. Also, 3PL provider have to show to exhibit sound knowledge of services in the industry, display punctuality and courtesy towards their customers in the way they interact and present to the customers.

Criterion 6. Connection with other transport modes – it is very important to emphasize this criterion. The 3PL provider will be more respectable from the company if it does not use only one transport mode. The 3PL provider will be more respectable for the company if it does not use only one transport mode. The flow of goods can be even faster and logistics services can be made even cheaper.

Criterion 7. Social responsibility – is an important criterion in every field of business and should not be neglected. According to Yu (2016) social responsibility means to enterprise behavior that conforms to the existing social regulations, values and expectations. The same author also emphasized that businesses, nowadays, want to increase efficiency and reduce costs, while also bearing in mind that “green logistics” is a key theme for the future regarding to social responsibility.

Criterion 8. Reputation – This criterion is more relevant in the initial screening of Third-Party Logistics providers. The opinion of the customers about how good are 3PL providers is in satisfying their needs is one important factor when the company evaluate and select them.

Criterion 9. Information and equipment system – This criterion is of huge importance for each 3PL provider. This corresponds to physical equipment and IT system that has a 3PL in order to facilitate communication and logistics operations of its customers. It is related to Electronic Data Interchange (EDI), track & trace technology capabilities, information accessibility, materials handling equipment, security of information system etc.

Criterion 10. Quality – According to experts, this criterion can not be omitted because it encompasses many aspects such as quality of service, commitment to continuous improvement, standard environment issues, risk management etc.

After describing the criteria, the authors approach to their assessment using a well-explained fuzzy-AHP method in Section 2. First, we do the assessment criteria by using the fuzzy-AHP triangular scale. It is given in table 2.

Table 2. Criteria for an assessment by using fuzzy-AHP triangular scale

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	(1,1,1)	(2,3,4)	(3,4,5)	(4,5,6)	(2,3,4)	(4,5,6)	(4,5,6)	(6,7,8)	(2,3,4)	(1,2,3)
C2	(0.25,0.33,0.5)	(1,1,1)	(0.16,0.2,0.25)	(1,2,3)	(2,3,4)	(4,5,6)	(4,5,6)	(6,7,8)	(1,2,3)	(3,4,5)
C3	(0.16,0.2,0.25)	(4,5,6)	(1,1,1)	(6,7,8)	(4,5,6)	(2,3,4)	(6,7,8)	(8,9,10)	(4,5,6)	(2,3,4)
C4	(0.16,0.2,0.25)	(0.33,0.5,1)	(0.13,0.14,0.16)	(1,1,1)	(1,2,3)	(2,3,4)	(4,5,6)	(6,7,8)	(3,4,5)	(5,6,7)
C5	(0.25,0.33,0.5)	(0.25,0.33,0.5)	(0.16,0.2,0.25)	(0.33,0.5,1)	(1,1,1)	(0.25,0.33,0.5)	(2,3,4)	(8,9,10)	(3,4,5)	(5,6,7)
C6	(0.16,0.2,0.25)	(0.16,0.2,0.25)	(0.25,0.33,0.5)	(0.25,0.33,0.5)	(2,3,4)	(1,1,1)	(4,5,6)	(6,7,8)	(1,2,3)	(0.16,0.2,0.25)
C7	(0.16,0.2,0.25)	(0.16,0.2,0.25)	(0.13,0.14,0.16)	(0.16,0.2,0.25)	(0.25,0.33,0.5)	(0.16,0.2,0.25)	(1,1,1)	(2,3,4)	(2,3,4)	(0.13,0.14,0.16)
C8	(0.13,0.14,0.16)	(0.13,0.14,0.16)	(0.1,0.11,0.13)	(0.13,0.14,0.16)	(0.1,0.11,0.13)	(0.33,0.5,1)	(0.25,0.33,0.5)	(1,1,1)	(0.16,0.2,0.25)	(8,9,10)
C9	(0.25,0.33,0.5)	(0.33,0.5,1)	(0.16,0.2,0.25)	(0.20,0.25,0.33)	(0.2,0.25,0.33)	(0.33,0.5,1)	(0.25,0.33,0.5)	(4,5,6)	(1,1,1)	(6,7,8)
C10	(0.1,0.11,0.13)	(0.16,0.2,0.25)	(0.25,0.33,0.5)	(0.14,0.16,0.2)	(0.14,0.16,0.2)	(4,5,6)	(6,7,8)	(0.1,0.11,0.13)	(0.13,0.14,0.16)	(1,1,1)

The next step proposed by the methodology is to find a fuzzy geometric mean of given values. This is calculated according to equation 4 and it is proposed in Table 3.

Table 3. A Fuzzy Geometric mean value for each criterion

Criterion	\tilde{t}_i	Values
C1	i=1	(2.26, 3.37, 4.18)
C2	i=2	(1.37, 1.88, 2.40)
C3	i=3	(2.55, 3.15, 3.75)
C4	i=4	(1.17, 1.53, 1.95)
C5	i=5	(0.85, 1.08, 1.46)
C6	i=6	(0.64, 0.84, 1.08)
C7	i=7	(0.34, 0.39, 0.49)
C8	i=8	(0.28, 0.32, 0.39)
C9	i=9	(0.50, 0.64, 0.89)
C10	i=10	(0.39, 0.46, 0.59)

Following the sub-steps of the step 4, we obtained fuzzy-weights and it is represented in Table 4.

Table 4. Obtained fuzzy weights

$\widetilde{Wf1}$	(0.14, 0.24, 0.38)
$\widetilde{Wf2}$	(0.08, 0.13, 0.22)
$\widetilde{Wf3}$	(0.15, 0.22, 0.34)
$\widetilde{Wf4}$	(0.07, 0.11, 0.18)
$\widetilde{Wf5}$	(0.06, 0.08, 0.13)
$\widetilde{Wf6}$	(0.04, 0.06, 0.10)
$\widetilde{Wf7}$	(0.02, 0.02, 0.04)
$\widetilde{Wf8}$	(0.02, 0.02, 0.04)
$\widetilde{Wf9}$	(0.03, 0.04, 0.08)
$\widetilde{Wf10}$	(0.02, 0.03, 0.05)

In Table 4, obtained \widetilde{W}_i are still fuzzy-triangular numbers, they need to be de-fuzzified by the center of area method. This is done by using the equation 6 and the following table represents a non-fuzzy numbers.

Table 5. De-fuzzification by using the Center of Area

Criterion	Center of Area
C1	0.25
C2	0.14
C3	0.23
C4	0.12
C5	0.09
C6	0.20
C7	0.02
C8	0.02
C9	0.05
C10	0.03
	1.16

After this procedure, by using non-fuzzy M_i 's, the normalized weights and the rank of each criterion are calculated and given in Table 6.

Table 6. Obtained criteria weights and the final rank

	Criterion	Weights	Rank
C1	Total cost of logistics outsourcing	0.22	1.
C2	Delivery	0.12	4.
C3	Reliability	0.20	2.
C4	Flexibility	0.10	5.
C5	Professionalism	0.08	6.
C6	Connection with other transport modes	0.17	3.
C7	Social responsibility	0.02	10.
C8	Reputation	0.02	9.
C9	Information and equipment system	0.04	7.
C10	Quality	0.03	8.

4. CONCLUSION

Third-Party Logistics (3PL) service providers represent a very important part of the logistics and supply chain. Nowadays, more and more companies outsource their own activities to 3PL. However, the process of selection of 3PL is affected by a numerous criteria that each company should take into consideration. Depending on the business the company is dealing with, various types of criteria should be distinguished by the logistics provider that is needed by the company. However, there are some criteria such as cost, delivery, quality etc. that are always significant and considered by the companies which selects the provider. In addition, there are many other criteria for the selection and evaluation of 3PL. Not all criteria are equally important. Companies should consider some criteria in more detail in order to keep business efficiently.

The main objective of this paper is to evaluate the criteria that characterize 3PL service providers. For this reason, the Fuzzy-AHP methodology is used to evaluate the criteria by importance. This methodology is particularly suitable, because it combines Saaty's scale with Fuzzy logic, which deals with the linguistic terms and statements.

For the evaluation process, 10 criteria are taken into consideration and the authors of this paper came to the following conclusion (given in Table 6): the highest importance while selecting 3PL provider is attributed to the total cost of logistics outsourcing with value of 0.22. The second and third place are devoted to reliability and connection with other transport modes, respectively. The criterion of delivery with participation of 0.12 is at the fourth place. The criterion related to the flexibility is also of huge importance and participates with the weight of 0.10. The last five criteria related to the professionalism, Information and equipment system, quality, reputation and social responsibility respectively, should not be neglected, but in this paper, there are lesser values attached to them.

This paper gives an insight into the evaluation criteria problem for 3PL selection. Future research should be done to select the best 3PL service provider for outsourcing activities. A direction for future research may be a further adjustment of the methodology. The selection of the 3PL, based on our research, should be done by using some of the multi-criteria analysis methods such as TOPSIS, ELECTRE, Promethee etc.

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