Int. J. Pure Appl. Sci. 7(3):371-382 (2021)

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI: 10.29132/ijpas.972885

Third-Party Logistics (3PL) Provider Selection Using Hybrid Model of SWARA and WASPAS

Muhammet Enes Akpınar

Manisa Celal Bayar University, Faculty of Engineering, Department of Industrial Engineering, Manisa, Turkey
enes.akpinar@cbu.edu.tr
Received date:18.07.2021, Accepted date:12.09.2021

Abstract

Increasing competition as a result of globalization forces companies to focus on the core activities they are specialized in and to use outsourcing in areas other than these core activities. Companies seek to outsource their logistics functions partially or completely since this is not in their main field of activity. Thus, companies are faced with the problem of choosing a Third Party Logistics (3PL) service provider that can contribute to their sustainable development and perfectly perform the logistics activities. In this study, the 3PL selection problem of a cable manufacturing company is discussed. The study aims to solve the business problem and to show the applicability of Multi-Criteria Decision-Making (MCDM) methods in the most appropriate 3PL selection problems. The 3PL selection was made in line with the criteria and alternatives determined by a team of decision-makers working in the relevant department of the company. First of all, the weight value of each criterion was determined by using the SWARA method based on the MCDM method. This method was chosen because it takes group decisions into account and is easy to implement. Afterward, calculations were made according to the criteria levels of each alternative service provider with the WASPAS method. In the study, 12 criteria were determined by the decision-makers. Besides, 5 different 3PL companies were taken into account. According to the results of the study, it was the third 3PL that met the criteria at the most appropriate level.

Keywords: Third-party logistics, multi-criteria decision making, SWARA method, WASPAS method

SWARA ve WASPAS Hibrit Yöntemlerini Kullanarak Üçüncü Parti Lojistik (3PL) Sağlayıcısı Seçimi

Öz

Küreselleşmenin bir sonucu olarak artan rekabet, işletmeleri uzman oldukları temel faaliyetlere odaklanmaya ve bu ana faaliyetler dışında dış kaynak kullanmaya zorlamaktadır. İşletmeler, ana faaliyet alanlarında bu olmadığı için lojistik fonksiyonlarını kısmen veya tamamen dış kaynak üzerinden yürütmek istemektedirler. Bu istekten dolayı işletmeler, sürdürülebilir gelişimlerine katkıda bulunabilecek ve lojistik faaliyetlerini kusursuz bir şekilde gerçekleştirebilecek bir Üçüncü Taraf Lojistik (3PL) hizmet sağlayıcı seçme sorunu ile karşı karşıya kalmaktadır. Bu çalışmada bir kablo üreticisi firmanın 3PL seçim problemi ele alınmıştır. Çalışmanın amacı, işletme problemini çözmek ve Çok Kriterli Karar Verme (ÇKKV) yöntemlerinin en uygun 3PL seçim problemlerinde uygulanabilirliğini göstermektir. 3PL seçimi, işletmenin ilgili bölümünde görev yapan karar vericilerden oluşan bir ekip tarafından belirlenen kriterler ve alternatifler doğrultusunda yapılmıştır. Öncelikle ÇKKV yöntemine dayalı SWARA yöntemi kullanılarak her bir kriterin ağırlık değeri belirlenmiştir. Bu yöntem, grup kararlarını dikkate aldığı ve uygulanması kolay olduğu için seçilmiştir. Daha sonra WASPAS yöntemi ile her bir alternatif hizmet sağlayıcının kriter seviyelerine göre hesaplamalar yapılmıştır. Çalışmada karar vericiler tarafından 12 kriter belirlenmiştir. Ayrıca 5 farklı 3PL firması dikkate alınmıştır. Çalışmanın sonuçlarına göre kriterleri en uygun düzeyde karşılayan alternatifin üçüncü hizmet sağlayıcısı olduğu görülmüştür.

Anahtar Kelimeler: Üçüncü parti lojistik, çok kriterli karar verme, SWARA yöntemi, WASPAS yöntemi

INTRODUCTION

Logistics is the undamaged delivery of needed resources such as products, services, and people, at the right time, at the right place, in the right quantity, at the right cost, and with the highest flexibility. In other words, logistics is the effective and efficient planning and implementation of the movement of all kinds of products, services (Miah et al. 2014).

ijpas@munzur.edu.tr
ISSN: 2149-0910
Research article/Araştırma makalesi
DOI: 10.29132/ijpas.972885

The transportation of the desired product or service to the desired place, at the desired time, at the most affordable price, and in the most effective way has led to the development of the concept of logistics. An increase is observed in transportation activities with minimizing the amount of stock, specializing in the field, and the ease of monitoring and tracking brought about by technological developments. Increasing competition environment and developing information technologies have increased the importance of transportation systems. For this reason, criteria such as quality, price, time, and environment are taken into account when receiving transportation services. A successful migration should have the following characteristics (Schniederjans et al. 2006):

• The product must have gone to the desired place at the desired time.

• The product must be delivered undamaged.

• Service quality should satisfy the customer.

• The transportation cost should be in the amount that the customer can accept.

• Damage to the environment should be minimal.

With outsourcing in the logistics sector, companies have the chance to focus on their core competencies, which is the primary factor of competitive advantage, by transferring their logistics functions to external resources specialized in their fields with technology, technical expertise, and advanced information systems. This reduces the time and investment the company spends on complex logistics activities and enables the transfer of fixed investments, material purchase and/or follow-up, necessary information technology costs, and expertise for these activities to an external provider. Thus, companies can concentrate on their main fields of activity and maintain their competitive advantages. Objectives of outsourcing are as follows (Chima, 2011):

• Reducing logistics investment and operation costs.

• Transferring the risks that may occur during activities such as transportation, handling, and stocking to the service provider.

• Being able to concentrate on main activities such as production and marketing.

• To provide a logistical advantage by accelerating material and product flow.

• To increase customer satisfaction with a good logistics performance at the points where the customer is encountered.

• Saving on costly investments such as transportation vehicles, handling equipment, stock area.

• To benefit from the capacity of the service providers that they can use from other companies.

• Reducing stock costs with logistics planning, fast and successful operation.

• Labor savings.

• To provide the company's access to worldwide technological solutions and opportunities.

This study makes a significant addition to the industry's understanding of 3PL selection strategies. It may assist field experts and top management in preparing a flexible short/long-term solution that will aid in the implementation of the 3PL selection phase. It is critical to use a structured approach to calculate the weights for criteria and then use these weights to select the best 3PL. The weight has been determined using the SWARA technique, which allows decision makers to set their own priorities and uses objective opinions rather than a mandatory scale in the ranking of the criteria. The WASPAS method was also utilized to analyze the alternatives, which is based on a mixture of the Weighted Product Model and the Weighted Total Model, with the goal of preserving information loss during the review phase of the alternatives.

The rest of the study is structured as follows: The studies considering the 3PL selection problems are provided in literature review section. Logistic service providers are explained later. After, third part logistics definition is detailed. The methodologies used in the study are explained later. Application of the methodologies in the 3PL selection is provided. Finally, the results and the future research directions are shared.

LITERATURE REVIEW

In the study, the 3PL selection was made for a cable manufacturer company. For this selection, SWARA and WASPAS methods, which are Multi-Criteria Decision-Making (MCDM) methods, were used. Among these methods, the SWARA method has

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI: 10.29132/ijpas.972885

been previously reported in the literature for evaluation of investment alternatives for the sustainability of energy systems (Hashemkhani et al. 2013), product design (Hashemkhani et al. 2013), location selection (Zolfani et al. 2020), thermal insulation selection (Ruzgys et al. 2014), investment selection (Hashemkhani and Bahrami 2014), personnel selection, light source selection (Nakhaei et al. 2016), packaging design (Stanujkic et al. 2015), material selection (Yazdani et al. 2016), ERP software selection (Shukla et al. 2016), evaluation of enterprises according to their corporate social responsibilities (Karabasevic et al. 2016) and risk assessment (Valipour et al. 2017) can be given as an example.

The WASPAS method has been previously reported in the literature for telecommunications (Malekpoor et al. 2018; Yin et al. 2017), contractor selection (Stanujkic et al. 2015), construction site selection (Ruzgys et al. 2014; Stojić et al. 2018), supplier selection (Keshavarz et al. 2017; Stojić et al. 2018), logistics (Keshavarz et al. 2017), garage location selection (Baušys and Juodagalvienė 2017), strategy evaluation (Mirzaee et al. 2020), manufacturing decision-making (Chakraborty and Zavadskas 2014; Jahan 2018), personnel selection (Karabasevic et al. 2016) and so on. Also, a systematic and comprehensive review of the application of the WASPAS method is given by Mardani et al. (2017).

Different MCDM techniques are proposed for 3PL selection problems in literature. For example, analytical network process (Liou and Chuang 2010; Raut et al. 2018; Vazifehdan and Darestani 2019), Analytical Hierarchy Process (AHP) (Hou and Su 2006; Senthil, Srirangacharyulu, and Ramesh 2014), VIKOR (Liou and Chuang 2010), data envelopment analysis (Davoudabadi, Mousavi, and Sharifi 2020; Deng et al. 2020; Rashidi and Cullinane 2019; Raut et al. 2018), TOPSIS (Igoulalene, Benyoucef, and Tiwari 2015; Kannan, Pokharel, and Kumar 2009; Rashidi and Cullinane 2019; Senthil et al. 2014), fuzzy SWARA and fuzzy COPRAS (Zarbakhshnia, Soleimani, and Ghaderi 2018), fuzzy AHP (Yadav, Garg, and Luthra 2020), fuzzy VIKOR (Wang et al. 2021), fuzzy TOPSIS (Singh, Gunasekaran, and Kumar 2018), fuzzy-rough approach (Roy, Pamučar, and Kar 2020), Z-MABAC method (Fan, Guan, and Wu 2020), intuitionistic and hesitant fuzzy set (Liu et al. 2020), choquet integral (Qian et al. 2021) and mathematical programming (Alnahhal, Tabash, and Ahrens 2021). For more studies about 3PL selection problems, Minashkina and Happonen (2020) is provided in the literature.

Following a review of the literature, there is no study in which only SWARA and WASPAS methods are used together. Although there is a study in which these methods are considered with rough set theory, there is no study in the literature in which net values are used. Besides, many of the studies given in the literature have been applied in different industries (such as the automobile and airline industry). Therefore, the use of integrated SWARA and WASPAS methods together in the literature and their use in a different sector by considering case study, show that the study is important in terms of its contribution to the literature. Moreover, the developed integrated model can help decision-makers gain a better understanding of the entire 3PL assessment and selection processes.

LOGISTICS SERVICE PROVIDERS

Logistics service providers are companies that undertake the organization of all or most of the logistics services of a company, select logistics service providers within this framework, evaluate their performance, and provide coordination between them (Govindan et al. 2015).

The steps taken to gain a competitive advantage have significantly increased the share of logistics costs in total costs. For this reason, businesses have turned to outsource to reduce their logistics costs. These third-party activities may cover all activities in the processes, as well as often selected specific activities. To better understand the concept of "the third party" in the definition, if we need to explain the concepts of first and second parties (Coyle et al. 2012);

First Party: Supplier business.

Second Party: Business that is a direct customer of the first party.

Third-Party: Logistics intermediaries; freight forwarder service provider (companies that transport goods from one point to another, using a road, rail, airway or a combination of them, carrying out operations such as storage, customs clearance, packaging, distribution of cargo, and organizing these), carrier, warehouse (Under secretariat of

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI: 10.29132/ijpas.972885

Customs). They are warehouse operators, which are operated under a customs administration in line with the permission given by the Ministry of Health, whose owner is obliged to be a legal entity or institution, where only non-nationalized imported goods and goods for export can be placed.

Fourth Party: Freedom of existence and its basic function; It is said to be the management of own and third parties' resources, capabilities, and technologies to provide a comprehensive supply chain solution.

THIRD-PARTY LOGISTICS (3PL)

For outsourcing in logistics, all logistics services don't need to be performed by a company. The important thing is that at least three services that touch each other (consecutive) are fulfilled or controlled by the same organization in such a way as to achieve an optimization. The organization that provides or controls this service is referred to as the 3PL organization. 1st party is the producer, 2nd party is the consumer, and 3rd party logistics is the organization that manages the service between these two points (Willcocks 2010).

The realization and management of logistics services within the company can be so efficient that another company cannot provide them at a lower cost. Logistics services that satisfy the customer and provide a competitive advantage must be realized, directed, and developed within the company. Companies that will receive outsourcing logistics services must first analyze their structures very well, make a situation plan, determine their goals, determine how much of them they can do and what will be demanded from the outside (Wisner et al. 2015).

SWARA METHOD

Kersuliene published the first paper on the Step-Wise Weight Assessment Ratio Analysis (SWARA) methodology. The factors that should be employed in the evaluation of alternatives are evaluated using this procedure, starting with the most important weight ratio and decreasing in importance. The experts in the field then vote on each criterion, and the insignificant ones are eliminated (Keršulienė et al. 2010).

Step 1: Each decision-maker ranks the model's criteria in order of importance, from most important to least essential, based on their expertise. The most important criterion is given a score of 1 by the expert, and then the decision-making expert re-evaluates this evaluation between 0 and 1 in multiples of 0.05.

$$p_j^k;\ j=1,\dots,k=1,\dots,l;0\le p_j^k\le 1 \tag{1}$$

Step 2: The relative mean importance score is calculated for all criteria. When the number of decision-makers is shown as l, the average of the relative importance scores assigned to the criteria by the decision-makers is determined with the help of Equation (2).

$$S_j=\frac{\sum_{k=1}^{l} p_j^k}{l};\ j=1,\dots,n \tag{2}$$

Step 3: All criteria are ranked according to their relative average importance scores. As a result of the comparison, the comparative significance level of the average values of the criteria is calculated. The values are obtained by paired comparison by determining the significance ratio according to the j+1 criterion.

Step 4: The coefficient value C_j for all criteria is obtained by using Equation (3) below. The coefficient of the criterion with the largest Sj value is = 1; It is determined as = 1,..., n.

$$C_j=S_j+1;\ j=1,\dots,n \tag{3}$$

Step 5: S_j' value must be calculated for all criteria using Equation (4). The relative weight of the first-ranked criterion is accepted as $S_j'=1$ and the ranking made according to S_j is taken into account when calculating S_j'.

$$S_j'=\frac{S_{j-1}'}{c_j};S_{j-1}>S_j \tag{4}$$

Step 6: The final weights for all criteria are calculated using Equation (5). With this calculation, the values of Sj' are normalized and weights are obtained by wj; j = 1,…, n. Finally, the weights are listed.

$$W_j=\frac{S_j'}{\sum_{j=1}^{n} S_j'};\ j=1,\dots,n \tag{5}$$

Int. J. Pure Appl. Sci. 7(3):371-382 (2021)
ijpas@munzur.edu.tr
ISSN: 2149-0910
Research article/Araştırma makalesi
DOI: 10.29132/ijpas.972885

WASPAS METHOD

The WASPAS method determines the most appropriate choice in the multi-criteria data set by integrating the Weighted Sum Model (WSM) and Weighted Product Model (WPM) models, which are basic multi-criteria decision-making models, with a coefficient. The WASPAS method is used to evaluate and rank the alternatives. It was developed by Zavadskas in 2012. The WASPAS method aims at high accuracy in the estimation by optimizing the weighted aggregate function (Zavadskas et al. 2012).

In the problem handled with the method, m alternatives A_i($i = 1, 2,...,m$) and n criteria are specified as C_j($j = 1,2,...,n$).

Step 7: Creating the decision matrix (X) that shows us the performance of the alternatives in the problem based on the criteria in the problem.

$$X = [X_{ij}]_{mxn} = \begin{bmatrix} x_{11} & x_{12} & x_{13} \cdots & x_{1m} \\ x_{21} & x_{22} & x_{23} & x_{2m} \\ \vdots & & \ddots & \vdots \\ x_{m1} & x_{m2} & x_{m3} \cdots & x_{mn} \end{bmatrix} \quad (6)$$

Step 8: The decision matrix is normalized ($\overline{xij}$). Equation (7) is used if the evaluation criteria are in the maximization class or Equation (8) if they are in the minimization situation.

$$\overline{x_{ij}} = \frac{x_{ij}}{\max_i(X_{ij})} \quad i = 1, 2, ..., m \text{ and } j = 1,2,..,n \quad (7)$$

$$\overline{x_{ij}} = \frac{\min_i(X_{ij})}{x_{ij}} \quad i = 1, 2,...,m \text{ and } j = 1, 2,...,n \quad (8)$$

Step 9: The total relative importance of the i^{th} alternative is calculated separately according to the WSM and the WPM. The total relative importance of an alternative relative to the Weighted Sum ($Q_i^{(1)}$) and the total relative importance of an alternative to the Weighted Product ($Q_i^{(2)}$) is calculated using Equation (9) and Equation (10), respectively.

$$Q_i^{(1)} = \sum_{j=1}^{n} \overline{x_{ij}} w_j \quad (9)$$

$$Q_i^{(2)} = \prod_{j=1}^{n} \overline{x_{ij}}^{w_j} \quad (10)$$

Step 10: The total relative importance of the alternatives are combined into a single formula and indicated by Equation (11).

$$Q_i = \lambda\, Q_i^{(1)} + (1-\lambda)\, Q_i^{(2)} = \lambda \sum_{j=1}^{n} (X_{ij})\, w_j + (1-\lambda) \prod_{j=1}^{n} (X_{ij})^{w_j} \quad (11)$$

where Q_i is i^{th} represents the overall relative importance score of the alternative according to the WASPAS method, λ is a parameter used in the WASPAS method that can take values between 0 and 1. WASPAS method turns into the WPM method if we take the value of λ=0. When λ=1, it turns into the WSM method. Here, the choice of λ value depends on the decision-maker. Regarding how much λ should be, Zavadskas (2012) recommends calculating the optimum λ value. Qi values are based on the ranking of the alternatives according to the WASPAS method. Among the alternatives, the alternative with the highest Q_i value is the best alternative.

3PL SELECTION USING SWARA AND WASPAS

The manufacturing company discussed in the study produces cable assemblies, sheet metal parts, tubular manufacturing, and molds. The fact that there is a lot of production diversity in the production area and delivery to different customers in the city and outside the city causes business complexity in the logistics processes. The company outsources its logistics processes. The size of the company's production volume, product variety, and the fact that it has a large number of employees limit specialization in every field. Therefore, it is very important to select and evaluate the 3PL and examine its effects on costs in order not to lose control over business activities, not to increase costs, not to cause customer dissatisfaction, and not to take the risks of processes such as transportation and storage completely. The flowchart of the problem is provided in Figure 1.

Int. J. Pure Appl. Sci. 7(3):371-382 (2021)

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI: 10.29132/ijpas.972885

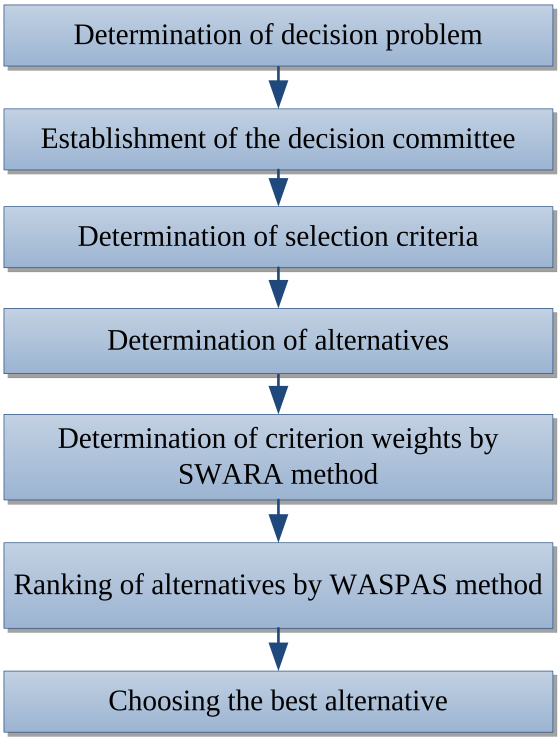

Figure 1. The flowchart of the 3PL selection procedure

Within the scope of the study, 3PL service provider selection criteria in terms of outsourcing and in terms of the production site of the company were determined by a joint decision made by a five-person committee formed by the supply chain department and production supervisors. The criteria set by these persons (Decision Makers (DM)); Price (K_1), Speed (K_2), Service diversity (K_3), Flexibility (K_4), Environmental sensitivity (K_5), Reliability (K_6), Information and communication technologies (K_7), Logistics equipment (K_8), Financial strength (K_9), Closeness to the facility (K_{10}), Logistics experience (K_{11}) and Reputation in the market (K_{12}).

Since the decision-makers evaluated the criteria, a new ranking was created by using the geometric mean of the criteria ordered in descending order (see Table 1). Afterward, the relative importance levels of the criteria were determined according to each DM (see Table 2 - Table 3). For this, taking the second criterion as the starting point, each criterion is compared with the previous criterion and the comparative importance of the criteria (s_j) is determined. Then, k_j, q_j, and w_j weight values were calculated for each decision-maker. The final criteria weights are given in Table 4.

Table 1. Determining the importance levels of the criteria based on decision-makers

Criteria	DM_1	DM_2	DM_3	DM_4	DM_5	Mean	Ranking
K_1	3	1	4	6	3	2,93	1
K_2	4	7	9	5	5	5,75	6
K_3	6	3	1	8	4	3,57	3
K_4	11	8	10	1	11	6,27	9
K_5	2	4	12	11	6	5,76	7
K_6	12	6	11	2	9	6,77	10
K_7	9	2	3	10	12	5,79	8
K_8	10	11	7	3	2	5,41	4

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI: 10.29132/ijpas.972885

K_9	1	5	2	4	7	3,09	2
K_{10}	7	12	8	7	8	8,22	12
K_{11}	8	9	6	12	1	5,53	5
K_{12}	5	10	5	9	10	7,42	11

Table 2. Weights of criteria according to DM_1 and DM_2

Ranking	**Criteria**	***DM₁***				***DM₂***			
		s_j	k_j	w_j	q_j	s_j	k_j	w_j	q_j
1	K_1		1	1	0,212		1	1	0,212
2	K_9	0.3	1,3	0,769	0,163	0.3	1,3	0,769	0,163
3	K_3	0.2	1,2	0,641	0,136	0.2	1,2	0,641	0,136
4	K_8	0.3	1,3	0,493	0,104	0.3	1,3	0,493	0,104
5	K_{11}	0.2	1,2	0,411	0,087	0.2	1,2	0,411	0,087
6	K_2	0.1	1,1	0,374	0,079	0.1	1,1	0,374	0,079
7	K_5	0.2	1,2	0,311	0,066	0.2	1,2	0,311	0,066
8	K_7	0.1	1,1	0,283	0,060	0.1	1,1	0,283	0,060
9	K_4	0.4	1,4	0,202	0,042	0.4	1,4	0,202	0,042
10	K_6	0.7	1,7	0,119	0,025	0.7	1,7	0,119	0,025
11	K_{12}	0.6	1,6	0,074	0,015	0.6	1,6	0,074	0,015
12	K_{10}	0.5	1,5	0,049	0,010	0.5	1,5	0,049	0,010

As seen in Table 4, the most important criterion was seen as Price (K_1) with a value of 0.266. The second most important criterion is the Speed (K_2) criterion with a value of 0.199. Significance levels for each criterion can be seen using Table 4. The determination of the criterion weights was done with the SWARA method. In the next stage, using these weights, the most suitable one among the alternative 3PL companies was selected with the help of the WASPAS method. For this selection process, the decision-makers determined five different 3PL alternatives. The values of the alternatives were obtained by the decision-makers giving the alternatives values between 1 and 5 (1 = Worst, 5 = Best). In this way, decision matrices that show the success status under the criteria of each alternative were created.

The results of the evaluations were determined by using the arithmetic mean of the scores given by the five decision-makers and are given in Table 5. Then, the obtained decision matrix was normalized based on maximization and minimization type criteria and the values are given in Table 6. According to the WSM, the total relative importance of an alternative is calculated as the weighted sum of the criteria values. The total relative importance ($Q_i^{(1)}$) of the alternatives were calculated according to the WSM. According to the WPM, it is calculated as the product of the power of the performance value of an alternative based on the criterion, equal to the criterion weight. According to the WPM, the total relative importance of the alternatives ($Q_i^{(2)}$) was calculate

Table 3. Weights of criteria according to DM_3, DM_4, and DM_5

Ranking	**Criteria**	***DM₃***				***DM₄***				***DM₅***			
		s_j	k_j	w_j	q_j	s_j	k_j	w_j	q_j	s_j	k_j	w_j	q_j
1	K_1		1	1	0,284		1	1	0,270		1	1	0,255
2	K_9	0.3	1,3	0,769	0,219	0.5	1,5	0,667	0,180	0.2	1,2	0,833	0,213
3	K_3	0.4	1,4	0,549	0,156	0.5	1,5	0,445	0,120	0.4	1,4	0,596	0,152
4	K_8	0.6	1,6	0,343	0,097	0.2	1,2	0,370	0,100	0.5	1,5	0,397	0,101
5	K_{11}	0.5	1,5	0,229	0,065	0.3	1,3	0,285	0,077	0.2	1,2	0,331	0,084

Int. J. Pure Appl. Sci. 7(3):371-382 (2021)

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI: 10.29132/ijpas.972885

6	K_2	0.3	1,3	0,176	0,050	0.2	1,2	0,237	0,064	0.3	1,3	0,254	0,065
7	K_5	0.4	1,4	0,126	0,036	0.4	1,4	0,170	0,046	0.7	1,7	0,150	0,038
8	K_7	0.2	1,2	0,104	0,030	0.5	1,5	0,113	0,030	0.4	1,4	0,107	0,027
9	K_4	0.4	1,4	0,075	0,021	0.6	1,6	0,071	0,019	0.1	1,1	0,097	0,025
10	K_6	0.1	1,1	0,068	0,019	0.5	1,5	0,047	0,013	0.4	1,4	0,069	0,018
11	K_{12}	0.5	1,5	0,045	0,013	0.8	1,8	0,026	0,007	0.3	1,3	0,053	0,014
12	K_{10}	0.3	1,3	0,035	0,010	0.3	1,3	0,020	0,005	0.6	1,6	0,033	0,008

Table 4. Final criterion weights

Criteria	***DM₁***	***DM₂***	***DM₃***	***DM₄***	***DM₅***	**Criteria Weights**
K_1	0,212	0,305	0,284	0,270	0,255	0,266
K_2	0,163	0,218	0,219	0,180	0,213	0,199
K_3	0,136	0,145	0,156	0,120	0,152	0,143
K_4	0,104	0,112	0,097	0,100	0,101	0,104
K_5	0,087	0,070	0,065	0,077	0,084	0,078
K_6	0,079	0,059	0,050	0,064	0,065	0,064
K_7	0,066	0,036	0,036	0,046	0,038	0,046
K_8	0,060	0,022	0,030	0,030	0,027	0,035
K_9	0,042	0,012	0,021	0,019	0,025	0,026
K_{10}	0,025	0,008	0,019	0,013	0,018	0,018
K_{11}	0,015	0,006	0,013	0,007	0,014	0,013
K_{12}	0,010	0,004	0,010	0,005	0,008	0,008

The total importance (Qi) of the alternatives calculated according to the WSM and WPM methods can be generalized with the integration formula. The λ value used below is a parameter used in the WASPAS method and takes a value between 0 and 1. When λ=0 and λ=1, the WASPAS method turns into WSM and WPM methods, respectively. As can be seen in Table 7, changing the λ value does not change the order of 3PL-3>3PL-5>3PL-4>3PL-1>3PL-2. Therefore, the selection of λ value does not affect the result, and the study is completed by choosing λ=0.4. In other words, it has been found that the most suitable 3PL supplier for the enterprise is 3PL-3.

Table 5. Decision matrix obtained by the evaluation of decision makers

Criteria	***Criteria Class***	***Criteria Weights***	***3PL-1***	***3PL-2***	***3PL-3***	***3PL-4***	***3PL-5***
K_1	Min	0,266	3,8	3,4	4,2	3,4	3,6
K_2	Max	0,199	3,2	4	2,6	2,8	3,4
K_3	Max	0,143	3	2,8	3,6	4	3,8
K_4	Max	0,104	2,6	3,2	3,6	3,8	3,2
K_5	Max	0,078	3,8	3,4	3,8	3,4	4
K_6	Max	0,064	2,8	3	2,6	3,2	3
K_7	Max	0,046	2,2	3,2	4	3,6	3,8
K_8	Max	0,035	3,6	3,6	2,8	4	3,2
K_9	Max	0,026	3,2	3	3,4	3,8	3,4
K_{10}	Max	0,018	4,2	3,6	3,6	3	3,2
K_{11}	Max	0,013	3,8	3,4	4,2	4,4	3,4
K_{12}	Max	0,008	3,6	3,2	3,6	3	4

,

Table 6. Decision matrix after normalization process

Criteria	***3PL-1***	***3PL-2***	***3PL-3***	***3PL-4***	***3PL-5***	***W_j***
K_1	0,90	0,81	1	0,81	0,86	4,2
K_2	0,80	1	0,65	0,70	0,85	4
K_3	0,75	0,70	0,90	1	0,95	4

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910
Research article/Araştırma makalesi
DOI: 10.29132/ijpas.972885

K_4	0,68	0,84	0,95	1	0,84	3,8
K_5	0,95	0,85	0,95	0,85	1	4
K_6	0,88	0,94	0,81	1	0,94	3,2
K_7	0,55	0,80	1	0,90	0,95	4
K_8	0,90	0,90	0,70	1	0,80	4
K_9	0,94	1	0,88	0,79	0,88	3
K_{10}	1	0,86	0,86	0,71	0,76	4,2
K_{11}	0,86	0,77	0,96	1	0,77	4,4
K_{12}	0,90	0,80	0,90	0,75	1	4

Table 7. Relative and total significance of alternatives

Q values	*λ values*	*3PL-1*	*3PL-2*	*3PL-3*	*3PL-4*	*3PL-5*
$Q_i^{(1)}$		0,849	0,843	0,884	0,860	0,861
$Q_i^{(2)}$		0,858	0,852	0,890	0,869	0,874
$Q_{0,1}$	0,1	0,8571	0,8511	0,8894	0,8681	0,8727
$Q_{0,2}$	0,2	0,8562	0,8502	0,8888	0,8672	0,8714
$Q_{0,3}$	0,3	0,8553	0,8493	0,8882	0,8663	0,8701
$Q_{0,4}$	**0,4**	**0,8544**	**0,8484**	**0,8876**	**0,8654**	**0,8688**
$Q_{0,5}$	0,5	0,8535	0,8475	0,887	0,8645	0,8675
$Q_{0,6}$	0,6	0,8526	0,8466	0,8864	0,8636	0,8662
$Q_{0,7}$	0,7	0,8517	0,8457	0,8858	0,8627	0,8649
$Q_{0,8}$	0,8	0,8508	0,8448	0,8852	0,8618	0,8636
$Q_{0,9}$	0,9	0,8499	0,8439	0,8846	0,8609	0,8626
$Q_{1,0}$	1	0,849	0,843	0,884	0,860	0,861

CONCLUSION

Companies have complex business processes in terms of product diversity and sending semi-finished and finished products both domestically and abroad. Today, with the effect of globalization, the removal of borders between countries, the formation of a competitive environment, and the importance of customer demands, logistics processes gain importance. Reducing costs by investing in logistics processes, transferring risks in activities such as transportation and stocking are important decisions for the company to focus on its core business. With these decisions, businesses can concentrate on production, increase customer satisfaction, save on costs such as vehicles, equipment, and stock levels, and access technological opportunities more easily. In short, many of the reasons mentioned have caused businesses to procure transportation services from logistics service providers. This concept is referred to as the concept of 3PL and it significantly alleviates the burden of businesses in terms of focusing on their professionalism.

In this study, the evaluation process of 3PL alternatives for a cable manufacturing company is discussed. The decision-makers in the study first determined the criteria for the service provider they needed. The SWARA method was used for the weight values of the determining criteria. Each decision-maker evaluated all criteria with this method. After the criteria weights were determined, each alternative service provider was evaluated. At this stage, the WASPAS method was used. Five different service providers determined by the decision-makers were evaluated by considering the steps of the method. It has been seen that the provider that meets the criteria at the most appropriate level among five different service providers is the third service provider. This work has limitations, which can be viewed as opportunities for further research. First and foremost, the scope of this research is restricted to the electrical cable manufacturing industry. Every industry has its own set of roadblocks to overcome. As a result, the answer differs depending on the

ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI: 10.29132/ijpas.972885

industry. This research can be applied to a variety of companies using a similar or different set of factors.

CONFLICT OF INTEREST

The authors report no conflict of interest relevant to this article.

RESEARCH AND PUBLICATION ETHICS STATEMENT

The authors declare that this study complies with research and publication ethics.

REFERENCES

Alnahhal, Mohammed, Mosab I. Tabash, and Diane Ahrens. 2021. "Optimal Selection of Third-Party Logistics Providers Using Integer Programming: A Case Study of a Furniture Company Storage and Distribution." *Annals of Operations Research*.

Baušys, Romualdas, and Birutė Juodagalvienė. 2017. "Garage Location Selection for Residential House by WASPAS-SVNS Method." *Journal of Civil Engineering and Management*.

Chakraborty, Shankar, and Edmundas Kazimieras Zavadskas. 2014. "Applications of WASPAS Method in Manufacturing Decision Making." *Informatica (Netherlands)*.

Chima, Christopher M. 2011. "Supply-Chain Management Issues In The Oil And Gas Industry." *Journal of Business & Economics Research (JBER)*.

Coyle, J. J., C. J. Langley, R. A. Novack, and B. Gibson. 2012. "Supply Chain Network Analysis and Design." in *Supply Chain Management: A Logistics Perspective*.

Davoudabadi, Reza, S. Meysam Mousavi, and Ebrahim Sharifi. 2020. "An Integrated Weighting and Ranking Model Based on Entropy, DEA and PCA Considering Two Aggregation Approaches for Resilient Supplier Selection Problem." *Journal of Computational Science*.

Deng, Fumin, Lin Xu, Yuan Fang, Qunxi Gong, and Zhi Li. 2020. "PCA-DEA-Tobit Regression Assessment with Carbon Emission Constraints of China's Logistics Industry." *Journal of Cleaner Production*.

Fan, Jianping, Runan Guan, and Meiqin Wu. 2020. "Z-MABAC Method for the Selection of Third-Party Logistics Suppliers in Fuzzy Environment." *IEEE Access*.

Govindan, Kannan, Hamed Soleimani, and Devika Kannan. 2015. "Reverse Logistics and Closed-Loop Supply Chain: A Comprehensive Review to Explore the Future." *European Journal of Operational Research*.

Hashemkhani Zolfani, Sarfaraz, Mohammad Hasan Aghdaie, Arman Derakhti, Edmundas Kazimieras Zavadskas, and Mohammad Hossein Morshed Varzandeh. 2013. "Decision Making on Business Issues with Foresight Perspective; An Application of New Hybrid MCDM Model in Shopping Mall Locating." *Expert Systems with Applications*.

Hashemkhani Zolfani, Sarfaraz, and Mohsen Bahrami. 2014. "Investment Prioritizing in High Tech Industries Based on SWARA-COPRAS Approach." *Technological and Economic Development of Economy*.

Hashemkhani Zolfani, Sarfaraz, Edmundas Kazimieras Zavadskas, and Zenonas Turskis. 2013. "Design of Products with Both International and Local Perspectives Based on Yin-Yang Balance Theory and SWARA Method." *Ekonomska Istrazivanja*.

Hou, Jiachen, and Daizhong Su. 2006. "Integration of Web Services Technology with Business Models within the Total Product Design Process for Supplier Selection." *Computers in Industry*.

Igoulalene, Idris, Lyes Benyoucef, and Manoj Kumar Tiwari. 2015. "Novel Fuzzy Hybrid Multi-Criteria Group Decision Making Approaches for the Strategic Supplier Selection Problem." *Expert Systems with Applications*.

Jahan, Ali. 2018. "Developing Waspas-RTB Method for Range Target-Based Criteria: Toward Selection for Robust Design." *Technological and Economic Development of Economy*.

Kannan, Govindan, Shaligram Pokharel, and P. S. Kumar. 2009. "A Hybrid Approach Using ISM and Fuzzy TOPSIS for the Selection of Reverse Logistics Provider." *Resources, Conservation and Recycling*.

Karabasevic, Darjan, Jane Paunkovic, and Dragisa Stanujkic. 2016. "Ranking of Companies According to the Indicators of Corporate Social Responsibility Based on SWARA and ARAS Methods." *Serbian Journal of Management*.

Karabasevic, Darjan, Dragisa Stanujkic, Snezana Urosevic, and Mladjan Maksimovic. 2016. "An Approach to Personnel Selection Based on Swara and Waspas Methods." *Bizinfo Blace*.

Keršulienė, Violeta, Edmundas Kazimieras Zavadskas, and Zenonas Turskis. 2010. "Selectıon Of Ratıonal Dıspute Resolutıon Method By Applyıng New Step-Wıse Weıght Assessment Ratıo Analysis (SWARA)." *Journal of Business Economics and Management*.

Keshavarz Ghorabaee, Mehdi, Maghsoud Amiri, Edmundas Kazimieras Zavadskas, and Jurgita Antuchevičienė. 2017. "Assessment of Third-Party Logistics Providers Using a CRITIC–WASPAS Approach with Interval Type-2 Fuzzy

Int. J. Pure Appl. Sci. 7(3):371-382 (2021)

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI: 10.29132/ijpas.972885

Sets." *Transport*.

Liou, James J. H., and Yu Tai Chuang. 2010. "Developing a Hybrid Multi-Criteria Model for Selection of Outsourcing Providers." *Expert Systems with Applications*.

Liu, Yumin, Peng Zhou, Liyuan Li, and Feng Zhu. 2020. "An Interactive Decision-Making Method for Third-Party Logistics Provider Selection under Hybrid Multi-Criteria." *Symmetry*.

Malekpoor, Hanif, Konstantinos Chalvatzis, Nishikant Mishra, Mukesh Kumar Mehlawat, Dimitrios Zafirakis, and Malin Song. 2018. "Integrated Grey Relational Analysis and Multi Objective Grey Linear Programming for Sustainable Electricity Generation Planning." *Annals of Operations Research*.

Mardani, Abbas, Mehrbakhsh Nilashi, Norhayati Zakuan, Nanthakumar Loganathan, Somayeh Soheilirad, Muhamad Zameri Mat Saman, and Othman Ibrahim. 2017. "A Systematic Review and Meta-Analysis of SWARA and WASPAS Methods: Theory and Applications with Recent Fuzzy Developments." *Applied Soft Computing*.

Miah, Shah Jahan, Kamrul Ahsan, and Kabossa A. B. Msimangira. 2014. "An Approach of Purchasing Decision Support in Healthcare Supply Chain Management." *Operations and Supply Chain Management: An International Journal*.

Minashkina, Daria, and Ari Happonen. 2020. "Systematic Literature Review and Research Gap Issues on Third Party Logistics Operators Selecting WMS for Efficient Operations for Customers." *International Journal of Supply Chain and Inventory Management*.

Mirzaee, Seyed Moslem Seyed, Seyed Heydar Mirfakhredini, Alireza Nasser Sadrabadi, and Ali Morovati Sharifabadi. 2020. "Compiling the Strategies of Alfa Mining Company and Prioritizing Them by Waspas Method." *Logforum*.

Nakhaei, Jalal, Shahin Lale Arefi, Mahdi Bitarafan, and Simona Kildienė. 2016. "Evaluation of Light Supply in the Public Underground Safe Spaces by Using of COPRAS-SWARA Methods." *International Journal of Strategic Property Management*.

Qian, Xiaohu, Shu Cherng Fang, Mingqiang Yin, Min Huang, and Xin Li. 2021. "Selecting Green Third Party Logistics Providers for a Loss-Averse Fourth Party Logistics Provider in a Multiattribute Reverse Auction." *Information Sciences*.

Rashidi, Kamran, and Kevin Cullinane. 2019. "A Comparison of Fuzzy DEA and Fuzzy TOPSIS in Sustainable Supplier Selection: Implications for Sourcing Strategy." *Expert Systems with Applications*.

Raut, Rakesh, Manoj Kharat, Sheetal Kamble, and Chandra Shekhar Kumar. 2018. "Sustainable Evaluation and Selection of Potential Third-Party Logistics (3PL) Providers: An Integrated MCDM Approach." *Benchmarking*.

Roy, Jagannath, Dragan Pamučar, and Samarjit Kar. 2020. "Evaluation and Selection of Third Party Logistics Provider under Sustainability Perspectives: An Interval Valued Fuzzy-Rough Approach." *Annals of Operations Research*.

Ruzgys, Audrius, Robertas Volvačiovas, Česlovas Ignatavičius, and Zenonas Turskis. 2014. "Integrated Evaluation of External Wall Insulation in Residential Buildings Using SWARA-TODIM MCDM Method." *Journal of Civil Engineering and Management*.

Schniederjans, Marc J., Ashlyn M. Schniederjans, and Dara G. Schniederjans. 2006. *Outsourcing Management Information Systems*.

Senthil, S., B. Srirangacharyulu, and A. Ramesh. 2014. "A Robust Hybrid Multi-Criteria Decision Making Methodology for Contractor Evaluation and Selection in Third-Party Reverse Logistics." *Expert Systems with Applications*.

Shukla, Sandarbh, P. K. Mishra, Rajeev Jain, and H. C. Yadav. 2016. "An Integrated Decision Making Approach for ERP System Selection Using SWARA and PROMETHEE Method." *International Journal of Intelligent Enterprise*.

Singh, Rajesh Kr, Angappa Gunasekaran, and Pravin Kumar. 2018. "Third Party Logistics (3PL) Selection for Cold Chain Management: A Fuzzy AHP and Fuzzy TOPSIS Approach." *Annals of Operations Research*.

Stanujkic, Dragisa, Darjan Karabasevic, and Edmundas Kazimieras Zavadskas. 2015. "A Framework for the Selection of a Packaging Design Based on the SWARA Method." *Engineering Economics*.

Stojić, Gordan, Željko Stević, Jurgita Antuchevičiene, Dragan Pamučar, and Marko Vasiljević. 2018. "A Novel Rough WASPAS Approach for Supplier Selection in a Company Manufacturing PVC Carpentry Products." *Information (Switzerland)*.

Valipour, Alireza, Nordin Yahaya, Norhazilan Md Noor, Jurgita Antuchevičienė, and Jolanta Tamošaitienė. 2017. "Hybrid SWARA-COPRAS Method for Risk Assessment in Deep Foundation Excavation Project: An Iranian Case Study." *Journal of Civil Engineering and Management*.

Vazifehdan, Mona Najar, and Soroush Avakh Darestani. 2019. "Green Logistics Outsourcing Employing Multi Criteria Decision Making and Quality Function Deployment in the Petrochemical Industry." *Asian Journal of Shipping and Logistics*.

Wang, Chia Nan, Ngoc Ai Thy Nguyen, Thanh Tuan

Int. J. Pure Appl. Sci. 7(3):371-382 (2021)
ijpas@munzur.edu.tr
ISSN: 2149-0910
Research article/Araştırma makalesi
DOI: 10.29132/ijpas.972885

Dang, and Chen Ming Lu. 2021. "A Compromised Decision-Making Approach to Third-Party Logistics Selection in Sustainable Supply Chain Using Fuzzy Ahp and Fuzzy Vikor Methods." *Mathematics*.

Willcocks, Leslie. 2010. "The next Step for the CEO: Moving IT□enabled Services Outsourcing to the Strategic Agenda." *Strategic Outsourcing: An International Journal*.

Wisner, Joel D., Keah-Choon Tan, and G. Keong Leong. 2015. *Principles of Supply Chain Management: A Balanced Approach*.

Yadav, Sanjeev, Dixit Garg, and Sunil Luthra. 2020. "Selection of Third-Party Logistics Services for Internet of Things-Based Agriculture Supply Chain Management." *International Journal of Logistics Systems and Management*.

Yazdani, Morteza, Edmundas Kazimieras Zavadskas, Joshua Ignatius, and Manuel Doval Abad. 2016. "Sensitivity Analysis in MADM Methods: Application of Material Selection." *Engineering Economics*.

Yin, Peng Yeng, Tsai Hung Wu, and Ping Yi Hsu. 2017. "Simulation Based Risk Management for Multi-Objective Optimal Wind Turbine Placement Using MOEA/D." *Energy*.

Zarbakhshnia, Navid, Hamed Soleimani, and Hadi Ghaderi. 2018. "Sustainable Third-Party Reverse Logistics Provider Evaluation and Selection Using Fuzzy SWARA and Developed Fuzzy COPRAS in the Presence of Risk Criteria." *Applied Soft Computing*.

Zavadskas, E. K., Z. Turskis, J. Antucheviciene, and A. Zakarevicius. 2012. "Optimization of Weighted Aggregated Sum Product Assessment." *Elektronika Ir Elektrotechnika*.

Zolfani, Sarfaraz Hashemkhani, Morteza Yazdani, Ali Ebadi Torkayesh, and Arman Derakhti. 2020. "Application of a Gray-Based Decision Support Framework for Location Selection of a Temporary Hospital during COVID-19 Pandemic." *Symmetry*.