Supplier Evaluation and Selection for Logistics Outsourcing: A Conceptual Framework

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Abstract

Outsourcing is hiring an external company to do one or more internal activities because these activities are either difficult to achieve, or costly to do in-house. This external hired company is known as Third Party Logistics (3PL). 3PL selection decision inherently is a multi-criterion problem, sometimes with strategic importance to companies. Management science techniques might be helpful tools for these kinds of decision-making problems. Multi-Criteria Decision-Making (MCDM) techniques are often used to solve 3PL problems. In this paper, different types of MCDM are overviewed, and then a framework for 3PL selection is proposed by using a hybrid two-phase Fuzzy Analytic Hierarchy Process (FAHP) to select the best 3PL company providing the most satisfaction for the criteria determined, and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to evaluate the performance of 3PLs. This integration provides a good methodology to rank 3PLs.

Keywords
Outsourcing, Third Party Logistic, Multi-Criteria Decision-Making, Fuzzy Analytic Hierarchy Process, Technique for Order Preference by Similarity to Ideal Solution

1. Introduction

Nowadays, the globalization of logistics has become immensely important, with an increasing focus on improving customer service quality and decreasing industry costs. Logistics is concerned with the integration between transportation, material handling, information, packaging operations, and storage (Akman and Baynal, 2014). For any company in the present competitive business world, it is almost impossible to work without close collaboration with exterior partners, or what is called 'outsourcing' (Akman and Baynal, 2014). Outsourcing is the delegation of one or more internal activities to an exterior organization because these activities are either difficult to achieve, or costly to do in-house (Perçin, 2009). The hired external organization, called 'Third Party Logistics' or 3PL, should have proven itself as a 'skilled and 'efficient' company that can provide the required outsourced good or service (Sitek and Wikarek, 2012). Outsourcing can reduce financial risks for the organization and make savings in capital investments and operational costs. The growing demand for logistics outsourcing and the increase in the number and type of Logistics Services Providers (LSPs) highlight the importance of the evaluation and selection processes for 3PL. Hence, it is necessary for organizations to use some approaches to analyze, evaluate and select their 3PL partners (Alkhatib et al., 2015). The 3PL selection decision is a complex task due to the high numbers and varying types of 3PL providers in the market. 3PL evaluation and selection problem is a Multi-Criteria Decision-Making (MCDM) problem that includes both qualitative and quantitative approaches (Sharma and Kumar, 2015). The 3PL sector is continuously evolving with the increasing trends of globalization, shortened delivery periods and customer-centered supply chains (Gürcan et al., 2016).
A first party is a company that provides services or products; a second party is the customer (or customers). A third-party, then, is a firm basically hired to do some functions which neither the first nor the second party desires to perform. A 3PL organization provides outsourced or "third party" logistics services to the companies for some portion or all of their supply chain management functions such as warehousing and transportation services. These

services can be scaled and customized according to customer needs, based on market conditions and the demand and delivery service. 3PL has evolved from a pre-dominantly transactional role to a one that is more strategic in nature. Selecting the right 3PL company is of vital importance to the company and depends on a variety of factors (Sahu et al., 2015).

According to Vasiliauskas and Jakubauskas (2007), the benefits for an organization to use 3PL include:

1. Enabling the organization to save time and to focus on its core competencies.
2. As 3PL companies are specialized, for example in logistics business, therefore even if the company has available resources, the 3PL company can do the job better.
3. Offering the opportunity to deliver the perfect order every time, share responsibility and keep customers and stores properly stocked.
4. Meeting global market demands and gaining a competitive merit.
5. 3PL does not need to own warehousing facilities, vehicles, or aircrafts to perform duties such as quoting, booking, routing, and auditing, these are often leased on terms equaling those of the 3PL contract minimizing liability to capital expenditure.

However, the main drawback of using 3PL is the difficulty to find reliable partners. According to Sahu et al. (2015), selection of 3PL providers is a complicated decision since various criteria must be considered throughout the decision-making process (Karrapan et al., 2017). While selecting the suitable 3PL providers, logistics managers may face several issues such as, how to decide the criteria for the selection of 3PL services providers? How to prioritize the criteria? How to develop hierarchical relationship among the selection criteria? How to exploit the knowledge of experts for maximum benefit? Hence, the selection process can be time consuming and generally expensive.

The logistics functions performed by the 3PL can encompass various spectrums of logistics activities such as: warehousing, transportation, logistics information, data access, system development, spare parts distribution, inventory management, freight bill payment and audit, and value-added services including packaging, repairs, and return management.

The 3PL sector is continuously evolving due to many factors including the increased demand and competition, the increasing trends of globalization, shortened delivery periods and customer-centered supply chains. 3PL includes all of the services regarding effective planning, storage and controlling of each kind of product, service and information flow from the start to the end of the supply chain (Gürcan et al., 2016).

According to Yang (2014), 3PLs are strategic for creating competitive advantage through increased service and flexibility and making the supply chain operation effective and efficient. 3PL activities have five main steps: (1) identifying the need to outsource logistics or not; (2) developing feasible alternatives; (3) evaluating candidates and selecting suppliers; (4) implementing service; and (5) continuous evaluation.

Due to the associated negative environmental impacts, green and sustainable supply chain management has attracted attention in recent years so that logistics services can play a significant role in it. Because of the huge costs involved and the opportunities to identify and eliminate inefficiencies and reduce the carbon footprint, sustainable strategies are implemented in supply chain operations (Raut et al., 2018).

This paper includes three sections besides introduction. Section 2 presents literature review on 3PL selection methods. In section 3, a framework is developed to show the different methods for 3PL selection. Finally, conclusions and recommendations are presented in section 4.

2. Literature review

This section provides a literature review on 3PL evaluation and selection studies during the period 2013-2018. The selection methods for 3PL can be grouped in five categories: MCDM techniques, statistical approaches, artificial intelligence, mathematical programming, and hybrid. The main MCDM methods used for 3PL selection are: Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Interpretive Structural Model (ISM) , multi-criteria optimization and compromise solution (VIKOR), Quality Function Deployment (QFD), Decision-Making Trial and Evaluation Laboratory (DEMATEL), Elimination and Choice Expressing Reality (ELECTRE), utility theory, and Fuzzy Sets Theory (FST) (Aguezzoul, 2014; Li et al., 2012).

AHP method is one of the most utilized MCDM methods that can be used to determine the best alternative. AHP allows decision makers to start from pairwise comparisons that are simple enough to work with and often are preferred by the decision. The method takes into consideration intangible criteria besides tangible ones (Gürcan et al., 2016).Weight, financial performance, reputation, and long-term relationships are the most important factors in

3PL company selection (Gürcan et al., 2016). For example, TEKER (2017) have used AHP method in pharmaceutical industry, they determined relative weights of four criteria and twelve sub-criteria to select the most important; they found that the most important criteria are experience, risk management, information technology, and relationship. AHP is flexible enough to incorporate both qualitative and quantitative factors. In the work by Hwang and Shen (2015), the AHP method was applied to rank high-tech manufacturers in Taiwan according to the importance of the selection criteria, the three criterion groups with the greatest influence on selection were found to be performance, cost, and service, relatively. Sensitivity analysis helps decision makers to see the impact of data changes and/or possible misjudgments in their pairwise comparisons. According to Bayazit and Karpak (2013), sensitivity analysis is “as important as finding the best solution”.

According to Lam and Dai (2015), ANP is a multi-criteria decision analysis technique that can capture inter-dependencies among the decision attributes. Factors for the evaluation of logistics service performance are interrelated. ANP is a series of pairwise comparisons in order to obtain the relative importance of these attributes.

TOPSIS, one of the classical MCDM methods, was proposed by Hwang and Yoon (1992). TOPSIS is based on the concept that the chosen alternative should have the shortest distance from the Positive Ideal Solution (PIS) and the farthest from the Negative ideal solution (NIS) for solving a MCDM problem (Celik et al., 2016).

In 1973, Warfield proposed ISM to analyze the complex socio-economic systems (Gorvett, 2006). ISM enables individuals or groups to develop a map of the complex relationships between the many elements involved in a complex situation (Gorane and Kant, 2013). For example, Gupta and Walton (2016) have used ISM in the evaluation and selection of 3PLs based on twelve criteria. The results indicated that the most dependence and least driving power was the cost, the most driving power and least dependence was financial stability.

VIKOR method was introduced in 1998, VIKOR is based on the particular measure of “closeness” to the “ideal” solution. VIKOR method is an efficient tool to find a compromise solution from a set of conflicting criteria (Liao and Xu, 2013). QFD is a technique that transforms customer needs or the voice of customers into technical requirements by using the House Of Quality (HOQ) matrix that summarizes the relation between customer attributes and product characteristics (Sharma and Kumar, 2015). The DEMATEL method can handle the importance and causal relationships among criteria; it has the ability to display the interrelationships between criteria and ranking them based on their relationships. However, DEMATEL cannot deal with lack of information, express ambiguous values, conflicted opinions, or uncertain situations (Govindan et al., 2016). ELECTRE was developed in 1968, it is an outranking method, which is suitable for problems resolution such as LSP selection because of their capacity to deal with both qualitative and quantitative criteria, manage compensatory effects, and understand relationships between criteria. ELECTRE method has been developed to determine a preference order among a discrete set of alternatives relative to a set of criteria (Aguezzoul and Paché, 2018). Some researchers addressed the integration between two methods like DEMATEL with TOPSIS, FUZZY AHP with FUZZY TOPSIS, and AHP with TOSIS. Table 1 shows some literature that used different methods for 3PL selection and evaluation.

Table 1. Different methods for 3PL selection and evaluation in literature

Method	**References**
AHP	Gürcan et al. (2016); Hwang and Shen (2015); Bayazit and Karpak (2013); TEKER (2017)
ANP	Lam and Dai (2015)
TOPSIS	Celik et al.(2016)
ISM	Gupta0 and Walton(2016)
VICOR	Liao and Xu (2013)
QFD	Sharma and Kumar (2015)
DEMATEL	Govindan et al. (2016)
ELECTRE	Aguezzoul and Paché (2018)

3. Conceptual framework

In this paper, a framework is proposed to solve the 3PL selection and evaluation problem. The proposed approach integrates two methods: FAHP and TOPSIS. FAHP is used to assign weight to decision elements for 3PL and TOPSIS is used to determine the order preference of 3PLs (ranking). Figure 1 shows the two phases of the framework.

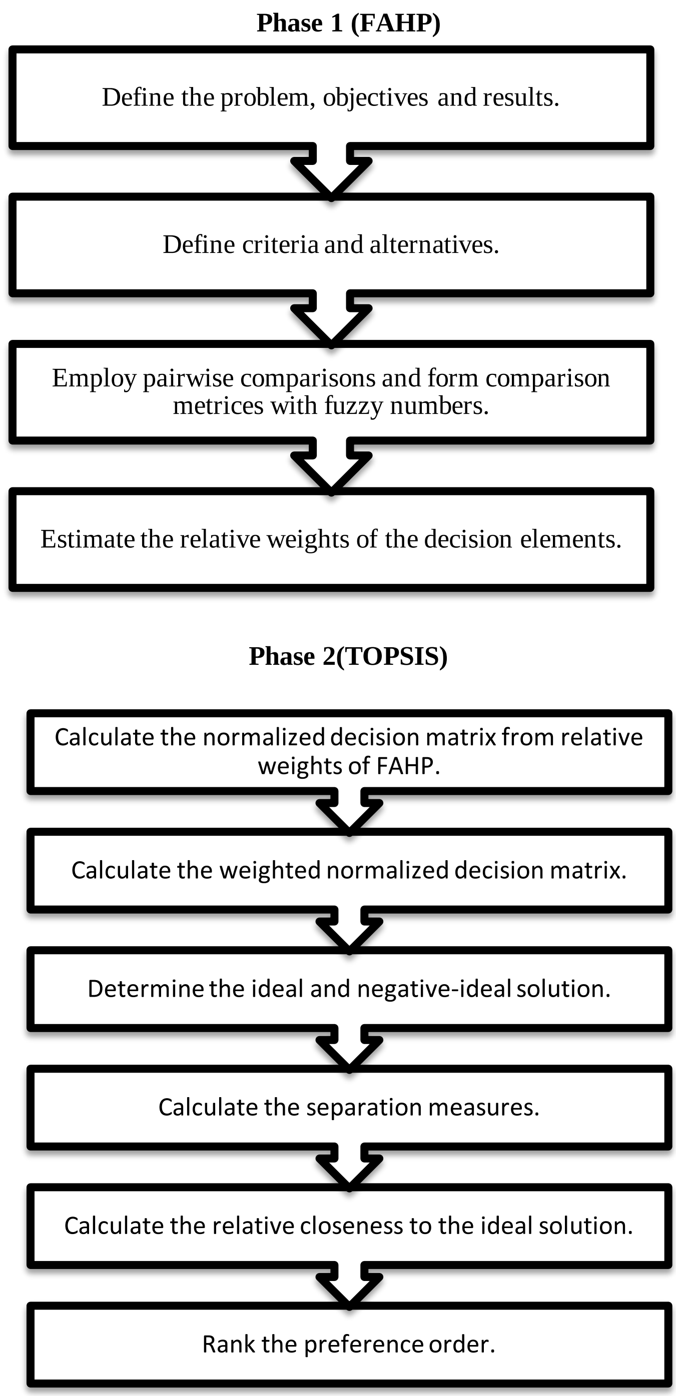

Figure 1. A conceptual framework for the integrated FAHP-TOPSIS approach

3.1 Phase 1 (FAHP)

Before explaining the phase of FAHP, a fuzzy set should be defined. A fuzzy set is a class of objects with a continuous sequence of grades of membership. Each object is assigned to a grade of membership ranging between zero and one (Kahraman et al., 2003). Triangular Fuzzy Numbers (TFNs) are three real numbers that can be expressed as a triple (l, m, u) where l ≤ m ≤ u for describing a fuzzy event used in the pairwise comparison (Srichetta and Thurachon, 2012). "Fuzzy AHP is a helping tool to convert qualitative inputs to quantitative inputs and to capture the linguistic vagueness in response of the respondents" (Kumar and Singh, 2012).

The extension of AHP is Fuzzy AHP or FAHP; it was developed to solve the hierarchical fuzzy problems. Fuzzy-AHP is the pairwise comparisons for fuzzy numbers that are modified by the designer's emphasis in the judgment matrix. TFNs are utilized to develop the scaling scheme in the judgments metrics, and the fuzzy Eigen vector is solved by interval arithmetic (Akman and and Baynal, 2014).

According to Ziaei and Hajizade (2011), there are four steps for FAHP:

Let X: is an object set; $X = \{x_1, x_2, \ldots\ldots, x_n\}$, G: is a goal set, $G = \{g_1, g_2, \ldots\ldots, g_m\}$.

An extent analysis value for each object can be obtained. TFNs can be expressed as $A_{gi}^1, A_{gi}^2, \ldots\ldots, A_{gi}^n$, $i = 1,2, \ldots., n$, where all A_{gi}^j, $j = 1,2, \ldots., m$.

Step 1. the value of fuzzy synthetic extent with respect to the i^{th} object is defined by:

$$Z = \sum_{j=1}^{m} A_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} A_{gi}^{j} \right]^{-1} \tag{1}$$

To obtain $\sum_{j=1}^{m} A_{gi}^{j}$, perform the fuzzy addition operation of A- extent analysis values for a particular matrix such that:

$$\sum_{j=1}^{m} A_{gi}^{j} = \left[\sum_{j=1}^{m} a_j \sum_{j=1}^{m} b_j \sum_{j=1}^{m} c_j \right] \tag{2}$$

To obtain $\sum_{i=1}^{n} \sum_{j=1}^{m} A_{gi}^{j}$, perform the fuzzy addition operation of A-extent analysis values for a particular matrix such that:

$$\sum_{i=1}^{n} \sum_{j=1}^{m} A_{gi}^{j} = \left[\sum_{j=1}^{m} a_j \sum_{j=1}^{m} b_j \sum_{j=1}^{m} c_j \right] \tag{3}$$

And then calculate the inverse of this vector.

Step 2. The degree of possibility of $A_1 = (a_1, b_1, c_1)$, $A_2 = (a_2, b_2, c_2)$ can be determined as:

$$V(A_2 \geq A_1) = hgt(A_1 \cap A_2) = c_2 \tag{4}$$

Figure 2 shows the intersection between A_1 and A_2, where d is the ordinate of the maximum intersection point D between c_1 and c_2, both values of $V(A_2 \geq A_1)$ and $V(A_1 \geq A_2)$ are required to compare A_1 and A_2.

Figure 2. The intersection between $A_2\ and A_1$

Step 3. The degree of possibility for a convex fuzzy number to be greater than K convex fuzzy number A (i = 1, 2… k) can be described by $V(A \geq A_1, A_2, \ldots, A_K) = V(A \geq A_1)$ and $V(A \geq A_2)$ and… $V(A \geq A_K) = \min V(A_i \geq A_k)$, $i = 1,2,3, \ldots, k$.

Hypothesize that $d'(A)_i = minV(A_i \geq A_k)\ for\ k = 1,2,3, \ldots. n, k \neq i$.

Then, the weight vector is expressed by $W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))T$, where $A_i = 1,2, \ldots, n$ are n factors.

Step 4. Calculating the normalized weight vector by $W = (d(A_1), d(A_2), \ldots, d(A_i))^T$ where W is a non-fuzzy number.

3.2 Phase 2 (TOPSIS)

According to Perçin (2009) TOPSIS measures the shortest distance from the ideal solution and the farthest distance from the negative-ideal solution. TOPSIS phase starts from the weighted normalized decision matrix from FAHP for corresponding criteria. The positive ideal solutions are found as maximum and minimum values of weighted normalized elements in each column for benefit criteria, and reverse of it for cost criteria and vice versa are used for negative ideal solution.

According to Kumar and Singh (2012) the main steps of the TOPSIS algorithm are explained in the following steps:

Step 1. Evaluating decision matrix refers to *m* alternatives and *n* criteria:

$$D = \begin{bmatrix} a_{11} & a_{12} & \ldots & a_{1j} & \ldots & a_{1n} \\ a_{21} & a_{22} & \ldots & a_{2j} & \ldots & a_{2n} \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ a_{i1} & a_{i2} & \ldots & a_{ij} & \ldots & a_{in} \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ a_{m1} & a_{m2} & \ldots & a_{mj} & \ldots & a_{mn} \end{bmatrix} \quad (5)$$

where a_{ij} shows the rating of the ith Decision Making Unit (DMU) with respect to jth criteria. $i = 1,2,3, \ldots, m$ is the number of *DMU* and $j = 1,2, \ldots, n$ is the number of criteria. The normalized decision matrix is calculated as:

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}} \qquad i = 1,2, \ldots m; j = 1,2, \ldots n \quad (6)$$

where R is normalized matrix of elements r_{ij}.

$$R = [r_{ij}] \quad (7)$$

Step 2. Constructing the weighted normalized matrix by multiplying the elements by weights of corresponding criteria as:

$$V_{ij} = r_{ij} * W_j \quad (8)$$

Where V_{ij} is weighted normalized matrix and W_j is the weight (from fuzzy AHP) for j^{th} criteria.

Step 3. Determining the positive V_j^+ and negative ideal V_j^+ solutions by finding the maximum and minimum values of weighted normalized elements in each column:

$$V_j^+ = \{(maxV_{ij} \ / \ i \in I).(minV_{ij} \ / \ i \in I)\} \ for \ each \ j \quad (9)$$

$$V_j^- = \{(minV_{ij} \ / \ i \in I).(maxV_{ij} \ / \ i \in I)\} \ for \ each \ j \quad (10)$$

where *I* is associated with benefit criteria and J is associated with cost criteria.

Step 4. Calculating the separation measures for each alternative using n-dimensional Euclidean distance. The positive ideal distance measure is given as:

$$S_{i^+} = \sum (V_{ij} - V_j^+)^2 \ ; i = 1.2 \ldots .m; and \ j = 1.2 \ldots .n \quad (11)$$

The negative ideal distance measure is given as:

$$S_{i^-} = \sum (V_{ij} - V_j^-)^2 \ ; i = 1.2 \ldots .m; and \ j = 1.2 \ldots .n \quad (12)$$

Step 5. Calculating the relative closeness to ideal solution using:

$$C_i = \frac{S_{i^+}}{S_{i^-}}; \quad 0 \leq C_i \leq 1. \ \ i = 1.2 \ldots .m \quad (13)$$

$$S_{i^-} \text{ and } S_{i^+} \geq 0 \quad (14)$$

Step 6. Rank the preference order as C_i.

4. Conclusions and future work

In this paper, the importance of logistics outsourcing and various global factors for 3PL selection and evaluation have been highlighted. Logistics outsourcing has become mandatory for the manufacturers/assemblers due to the globalization of business. 3PL selection and evaluation plays a crucial role in supply chain management. User compatibility, geographical coverage, total revenue, and the scope of service provider must be taken into account during selection. However, the criteria cannot be the same for all firms since they have different goals and culture. Methods for selection and evaluation of 3PL have been explored through literature review. This work provides a proposed methodology for a simple approach to assess alternative service providers and help the decision maker to select the best one. The integration form of FAHP and TOPSIS is proved to be a good tool to incorporate the changing importance of criteria for ranking the 3PL. FAHP is used to select the best 3PL by pairwise comparison for fuzzy numbers, and TOPSIS is used to evaluate the 3PL selection and provide the order preference of 3PLs. The proposed framework for selection of 3PL is very effective to analyze the criteria with their importance and to rank the alternatives. It may help researchers and practitioners as a selection framework at larger scale. Future work will be done to implement the proposed approach for a real-life case study.

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