Hindawi
Mathematical Problems in Engineering
Volume 2018, Article ID 5251261, 19 pages
https://doi.org/10.1155/2018/5251261

Research Article

Finding the Best Third-Party Logistics in the Automobile Industry: A Hybrid Approach

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Received 20 February 2018; Revised 27 July 2018; Accepted 4 November 2018; Published 18 November 2018

Academic Editor: Gaetano Giunta

Given the current economic climate, many companies are considering outsourcing some activities to reduce costs and to focus on their core competency; thus, by adopting a competency-focused approach they enhance their chances to survive in a growing and competitive market. Third-Party Logistics (3PL) is a system that facilitates logistic activities. First, however, the organizations need to assess which companies are suitable for outsourcing. The aim of this paper is to depict a structural system for 3PL selection and validate it in real-world automobile companies. We use the Delphi method to determine criteria for 3PL selection and apply Evaluation by an Area-based Method for Ranking (EAMR) to prioritize the candidate alternatives. This method is used in combination with a Shannon Entropy based approach for determining the required weights. Computational analysis shows which criteria and companies have high priority, and based on that candidate alternatives for outsourcing are evaluated. The results suggest how automobile companies select 3PL companies and allocate their work to them.

1. Introduction

Logistics and supply chain management issues have key roles in all organizations because these processes have a strong impact on both costs and customers' satisfaction, which results in increased financial security, greater chances to avoid bankruptcy, and a stronger position in their markets. Companies understand the increasing impact of these concepts on their competiveness.

As concepts, logistics, and supply chain management date back to the '80s and '90s, when industries were trying to find innovative ways to reduce their costs. Using Third-Party Logistics (3PL) was an effective way to achieve this because businesses found other companies using logistics and supply chain management with better quality and at a lower cost, leaving them more resources and capital to focus on developing competencies and innovation. However, the controversy of 3PL lies in figuring out which areas of work should be outsourced and which should not. Commonly, outsourcing in the supply chain (SC) occurs in areas of inventory management, warehouse management, transportation, physical distribution, disposal production, etc. By freeing themselves from the burden of logistics, companies can turn their attention to core activities that allow them to be innovative and produce high quality goods at a competitive price [1].

The introduction of 3PL has been a game changer for the industrial market. Indeed, the literature suggests that 60% of the USA Fortune 500 companies had at least one 3PL contract [2]. In other regions of the world, the percentage of businesses using 3PL varies; however, its use remains remarkably high. The average revenue use of 3PL is 385 billion dollars in Asia Pacific, 185 billion dollars in North America, and 210 billion dollars in Europe (Lyer, 2017). Given this growing demand, selecting and concluding contracts with 3PL is a major necessity among companies, and many qualitative and quantitative methods are used in academia to introduce a more sophisticated selection process. In addition, this kind of problem can be categorized as a multicriteria decision making problem (MCDM). One of the most popular approaches to 3PL selection is to consider a limited number of alternatives characterized by several attributes or criteria. This type of MCDM problem is also denoted as a multiattribute decision making (MADM) problem. MCDM is typically used by researchers in the area to assess evaluation criteria for the evaluation of 3PL and secure contracts with outsourcing organizations that meet the requirements to provide an effective service.

After introducing the concept of 3PL, many companies and industries attempted to implement it. During these times many papers have been published and showed that it was implemented successfully in industries such as transportation [3–5], warehousing [6], healthcare [7], or oil and gas [8].

The aim of this paper is finding best 3PL companies for automobile industry of Iran. The automobile industry of Iran is a prominent industry. Based on statistics in 2009, Iran was the twentieth biggest automobile producer in the world and the top producer in the Middle East, which meant that this industry played a key role in the country's economy [9]. However, in 2013, the rate of production of automobiles fell dramatically in Iran; its two main automobile companies, Iran Khodro and Saipa, were on the threshold of bankruptcy. The Iranians experienced a reduction in their export productions, and they could not respond to the demands of Iranian customers because the production quality was poorer than before. The faults in Iran's automobile industry along with sanctions imposed by the USA caused millions of dollars in losses.

After the sanctions against Iran's automobile industry were removed in 2015, both Iran Khodro and Saipa understood that they should reduce their dependence on foreign companies and keep some of their products on the Iran automobile market. However, by focusing on core competencies and outsourcing some of their work, the only way to maintain the balance to remain in such a competitive and growing market is by changing their old technology and developing new and updated technology like the rest of the world. Thus, the automobile market is an example of an industry that typically outsources some of their production and logistics processes, in order to focus on core competency activities, such as innovation.

This study was set to do an Evaluation by an Area-based Method of Ranking (EAMR) and Shannon Entropy to find and prioritize the best 3PL for Iranian automobile companies. EAMR is a method based on a decision matrix with positive/negative criteria, applying the arithmetic calculation to assess outcomes. According to Keshavarz Ghorabaee et al. (2016), EAMR is more reliable than other commonly used methods, like MULTIMOORA and the Analytical Hierarchy Process (AHP), because EAMR is based on a decision matrix as its primary weights for computation. Shannon Entropy can be applied to the method that gives us primary weights for the criteria. The present study suggests and uses a model of Shannon Entropy and EAMR in combination to create a hybrid model to find the best 3PL in the Iranian automobile industry. Previous literature either shows a combination of the AHP and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), a combination of the AHP and Multicriteria Optimization and Compromise Solution (VIKOR), an application of an AHP variant, the Analytic Network Process (ANP), or fuzzy methods to find the best 3PL provider. However, there is very little literature on the use of EAMR instead of the TOPSIS and VIKOR methods. Therefore, this study aims to contribute towards this gap in the literature, based on findings by Keshavarz Ghorabaee et al. (2016). Thus, this study proposes the following aims: (1) to test the effectiveness of a hybrid model to increase accuracy in selecting a 3PL partner in a real case and (2) to test the reliability of the EAMR method in comparison with other methods. The main questions of this study are as follows. (a) What are the effective factors for evaluating 3PL companies? (b) Which 3PL companies are the best for Iranians automobile companies to help them to increase their performance? The main contribution of this paper is that this research is done in real world and solving one of the most important problems in Iranian automobile industry in order to save much money. As mentioned above, the automobile industry of Iran needs "new and refreshed blood in its veins" and this work aims to show a sufficiently precise new map towards this goal. This research is a road map of the automobile industry of Iran to not only help them to transfer updated technology but also to increase the production rates and incomes significantly.

This paper is organized as follows. Section 2 provides a literature review of 3PL in supply chain management. Section 3 briefly discusses the research approach. Section 4 focuses on MCDM methods. Section 5 explores the applied research methodology and shows the proposed model. Section 6 addresses the computation and data analysis. Finally, Section 7 discusses the managerial implications and future research.

2. Literature Review

Before focusing on 3PL, it is useful to briefly describe some main aspects of Supply Chain Management (SCM) because this concept involves the complete logistics chain. SCM could be explained as a flow of goods and services, which focus on the third stage of production. SCM involves the storage and transport of raw materials, as well as the inventory of material-in-process and finished products. In simple terms, SCM considers the planning, organization, monitoring, and control activities as part of the supply chain, which contributes to adding value and maximizing the advantages of logistics [10].

Hence, logistics can be defined as the process of planning, organizing, coordinating, monitoring, and controlling raw materials, intermediate products, and finished goods, and the information related to the utilization of plant capacities in order to increase customer satisfaction [40]. According to statistical information, outsourcing 3PL is becoming significantly popular among companies. After the formal introduction of 3PL, many definitions and models were created. Diabat et al. [1] noticed that 3PL could be defined as a company that provides logistics services for other companies in certain areas, such as inventory, warehouse, and physical distribution. Mothilal, Gunasekaran, Nachiappan, and Jayaram [41] pointed out that 3PL is the best effort of providers, among other competitors, to offer value and focus on the key factors of customers to achieve a high profit.

Another model besides 3PL is the Third-Party Reverse Logistics (3PRL). Shaharudin, Zailani, and Ismail [42] mentioned that 3PRL is the outsourcing of some activities related to reverse logistics for collecting and recovering disposal production, reducing cost, and achieving a profit. A new term related to logistics services is Fourth-Party Logistics (4PL) which considers companies that provide novel, integrated, or customized services using the resources of other companies. Raut, Kharat, Kamble, and Kumar [25] used Data Envelopment Analysis (DEA) and Analytical Network Process (ANP) to evaluate 3PL companies. The result revealed that 3PL causes better transportation, inventory, and warehouse management. Bianchini [26] studied about finding 3PL companies by Analytical Hierarchy Process (AHP) and TOPSIS. The result indicated which 3PL companies should be selected by hybrid methods. Bulgurcu and Nakiboglu [27] depicted a model of 3PL selection by fuzzy AHP. They considered 29 factors and asked 25 experts about choosing 3PL companies. The result showed that price is the most important factor. Haldar et al. [28] illustrated a framework for 3PL evaluation and selection by hybrid DEA, TOPSIS, and Linear Programing (LP). The result pointed out that among 26 vendors only one vendor had outperformance. Gupta, Singh, and Suri [29] prioritized factors of analyzing service quality of 3PL by AHP. They discussed how to use AHP to help DMs to select best 3PL companies. Ilgin [16] exerts fuzzy TOPSIS and AHP to ranking and finding 3PRL. The main criteria of the survey used to develop that study were total revenue, total cost, level of prior experience, level of disassembly line modification, and ease of finding original equipment. Mavi, Goh, and Zarbakhshnia [43] depicted how to select 3PRL by using the fuzzy Stepwise Weight Assessment Ratio Analysis (fuzzy SWARA) and the fuzzy Multiobjective Optimization based on Ratio Analysis (fuzzy MOORA). The main criteria considered in this study were economic aspects, environmental aspects, social aspects, and risk. Tavana, Zareinejad, and Santos-Arteaga [23] pointed out a 3PRL selection by fuzzy TOPSIS and ANP. IT application aspects, the impact of 3PL use, the types of 3PL services, user satisfaction, reverse logistics functions, organizational performance, organizational role, and product lifecycle were the criteria in this research

Prakash and Barua [18] proposed a hybrid model of MCDM to select 3PRL. They used the fuzzy AHP and VIKOR for selection. Firm performance, resources capacity, service delivery, reverse logistics operations, IT, geographical location, and reputation were the criteria used for 3PRL selection. Gürcan, Yazıcı, Beyca, Arslan, and Eldemir [44] selected a 3PL partner by applying the AHP. Those authors regarded compatibility, long-term relationship, financial performance, and reputation as the criteria for 3PL selection. Govindan, Khodaverdi, and Vafadarnikjoo [15] used a grey Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach to identify the relationship among criteria. Criteria of this research were based on variables, such as service quality, flexibility, on-time delivery, cost, logistics information, customer service, reputation, financial stability, human resource, performance history, technological capability, and geographic location. Senthil, Srirangacharyulu, and Ramesh [20] created a robust model for 3PRL selection by MCDM methods. They used the AHP and the IKOR method for 3PRL selection. Criteria that were applied in their research for evaluating companies were organizational performance, reverse logistics process, organizational role, resources capacity, quality, enterprise alliance, location, experience, and communication.

Diabat et al. [1] used ISM to identify a relationship between the following: loss of control to third-party providers, fear of retrenchment, complicated tax structure, lack of application and knowledge, lack of qualification of employees, lack of sufficient warehousing, environmental subjects, and overcrowded roadways. Datta et al. [12] depicted a fuzzy model for evaluating 3PL for selection. Criteria of their research were financial performance, service level, client relationship, management, infrastructure, and enterprise culture. Govindan, Palaniappan, Zhu, and Kannan [14] provided information related to the procedure to use Interpretive Structural Modeling (ISM) for analyzing 3PRL. For that work, seven main attributes related to 3PL services, the impact of using 3PL, organizational performance, organizational role, user satisfaction, IT applications, and reverse logistics functions were considered.

Azadi and Saen [45] investigated the use of data envelopment analysis for selecting 3PRL. Key factors, such as revenue shipments, revenue from recycling, service quality experience, and service quality credence, were identified and analyzed in the aforementioned study. Govindan and Murugesan [13] illustrated a fuzzy multicriteria decision making method to analyze and select 3PRL while considering 3PL services, the impact of 3PL use, organizational performance, organizational role, and reverse logistics functions criteria.

Chen, Pai, and Hung [11] identified a procedure to select 3PL through the Preference Ranking Organization METHod for Enrichment of Evaluations (PROMETHEE) method. Variables such as the price, on-time delivery, service quality, financial structure, relationship closeness, and information technology were the criteria used to evaluate 3PL.

Table 1 shows an overview of MCDM methods that are used in previous researches for the 3PL selection process.

More general aspects of using decision support in logistics and supply chain management are discussed by Alexander et al. (2014) with a focus on sustainability. This survey paper discusses besides decision theory also behavioral and other nonnormative approaches. However, in the current research, we focus on normative (or to be more specific: prescriptive) approaches as used in the MCDM field but include an empirical foundation by using input data elicited from experts by questionnaires.

Table 1: Previous studies of methods for 3PL selection.

Author/ Authors	Methods																									
	PROMETHEE	Fuzzy decision making	ISM	Fuzzy extent analysis	Grey DEMATEL	Fuzzy TOPSIS	Fuzzy ANP	Simulation	QFD	fuzzy linear regression	Goal Programming	FAHP	VIKOR	AHP	TOPSIS	Semi-fuzzy approach	Taguchi loss function	ANP	DEA	FAHP	LP	EAMR	Shannon Entropy	COPRAS	ARAS	WASPAS
Chen et al. [11]	*																									
Datta et al. [12]		*																								
Diabat et al. [1]			*																							
Govindan & Murugesan [13]				*																						
Govindan et al. [14]			*																							
Govindan et al. [15]					*																					
Ilgin [16]						*	*	*																		
Percin [17]									*	*	*															
Prakash & Barua [18]												*	*													
Sahu & Pal [19]												*														
Senthil et al. [20]														*	*											
Sharif, Irani, Love & Kamal [21]																*										
Sharma & Kumar [22]									*								*									
Tavana et al. [23]														*	*											
Zhang, Zhang, & Liu [24]		*																								
Raut, Kharat, Kamble, & Kumar [25]																		*	*							
Bianchini [26]														*	*											
Bulgurcu & Nakiboglu [27]																				*						
Haldar et al., [28]															*				*		*					
A. Gupta, Singh, & Suri [29]														*												
Current Research													*		*							*	*	*	*	*

3. A Proposal for Using a Hybrid Model

The present study provides the EAMR method (cf. Keshavarz Ghorabaee et al., 2016) as a model to be used for the selection of 3PL in the automobile industry. While the original EAMR method (also denoted as EAMRIT-2F) uses interval type-2 fuzzy numbers for representing the alternatives according to considered criteria, we suggest using a novel simplified approach based on crisp numbers. This can be justified for the considered application problem because the involved decision makers were experts who did not have difficulties in providing exact numbers with confidence.

EAMR as well as EAMRIT-2F are methods in the field of Multiple Attribute Decision Making (MADM) models, which use a decision matrix for the ranking. The reason to use this type of model is related to the great reliability and robustness of results from this tool, which may be a problem for other types of MADM methods (see Hanne, 2012, for an overview of MCDM methods and a discussion of some related problems in applications). In various MADM methods, which are based on a decision matrix, it is necessary to determine weights that indicate the importance of criteria. It is well known that there are difficulties for a decision maker to determine such weights directly and, thus, various more or less sophisticated methods for calculating them have been suggested. Within the scope of this study, we use the Shannon Entropy method to find such criterion-specific weights. This approach makes it possible to take into account any inaccuracy in the underlying data (Lotfi and Fallahnejad, 2010) so that the usually significant sensitivity of the results of a MADM method to the chosen weights can be better addressed. A combination of these methods allows one to obtain a reliable design and a comprehensive model for decision-making.

4. Methodological Approach: Evaluation by an Area-Based Method of Ranking (EAMR)

EAMR is one of the decision matrix methods for MCDM problems. It is introduced originally by Keshavarz Ghorabaee et al. (2016) as EAMRIT-2F for problems that have beneficial and nonbeneficial criteria and appear in group decision making situation. Below we suggest a simplified version of the method, which works with crisp numbers instead of the type-2 fuzzy sets considered in the original approach and can be applied to problems in a less vague environment. The methodological approach for EAMR is described as follows.

Step 1. Create a decision matrix M_d:

$$M_d = \left[M_{ij}^d\right] = \begin{bmatrix} x_{11}^d & \cdots & x_{1m}^d \\ \vdots & \ddots & \vdots \\ x_{n1}^d & \cdots & x_{nm}^d \end{bmatrix}, \quad 1 \le i \le n,\ 1 \le j \le m,\ 1 \le d \le k \tag{1}$$

where k represents the number of decision makers, d is the index for the d^{th} decision maker, and M_{ij} represent the criterion value of alternative i for criterion j of a Decision Maker (DM). n is the number of alternatives and m the number of criteria.

Step 2. The average of the decision matrix will be created as follows:

$$x_{ij} = \frac{\left(x_{ij}^1 + x_{ij}^2 + \cdots + x_{ij}^k\right)}{\mathrm{k}} \tag{2}$$

$$\overline{Y} = \left[\overline{x_{ij}}\right] \tag{3}$$

where $\overline{x_{ij}}$ indicates average value performance (criterion value) of alternative i and criterion j and $\overline{Y}$ is the average decision matrix, which $1 \le i \le n,\ 1 \le j \le m$.

Step 3. Design the weighting matrix (weighting vector) W_p :

$$W_p = \left[w_j^p\right]_{m\times 1} = \begin{bmatrix} w_1^p \\ w_2^p \\ \vdots \\ w_m^p \end{bmatrix} \tag{4}$$

where p is the index of the p^{th} decision maker and w_j^p is the respective weight of criterion j, $1 \le j \le m,\ 1 \le p \le k$.

Step 4. Calculate the average weighting matrix (weighting vector) $\overline{W}$:

$$w_j = \frac{\left(w_j^1 + w_j^2 + \cdots + w_j^k\right)}{k} \tag{5}$$

$$\overline{W} = \left[w_j\right]_{m\times 1} \tag{6}$$

Step 5. Calculate the normalized average decision matrix from $\overline{Y}$, denoted as N:

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

$$e_j = \max_{i\in\{1,\dots,n\}} \left(x_{ij}\right) \tag{8}$$

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

where $1 \le i \le n,\ 1 \le j \le m$.

Step 6. Find the normalized weights of the decision matrix v:

$$v_{ij} = n_{ij} \times w_j \tag{10}$$

$$V = \left[v_{ij}\right]_{n\times m} \tag{11}$$

Step 7. Compute the normalized scores for beneficial criteria (G_{+i}) and nonbeneficial criteria (G_{-i}):

$$G_{+i} = \left(v_{+i1} + v_{+i2} + \cdots + v_{+in}\right) \tag{12}$$

$$G_{-i} = \left(v_{-i1} + v_{-i2} + \cdots + v_{-in}\right) \tag{13}$$

where, in this research, v_{+ij} and v_{-ij} are normalized weighted values for beneficial and nonbeneficial criteria, respectively.

Step 8. Find the rank of value (RV) based on G_{+i} and G_{-i}: $(1 \leq i \leq n)$. DMs are ranked alternatives based on the normalized weights of both beneficial and cost criteria. These rankings are derived from G_{+i} and G_{-i}.

Step 9. Calculate the appraisal score (S_i) based on the rank values:

$$S_i = \frac{RV(G_{+i})}{RV(G_{-i})} \quad (14)$$

where S_i shows the alternative which has the highest score.

We illustrate the EAMR calculation in a simple example:

The first step is to create the decision matrix. In the decision matrix, we have two alternatives and two criteria, which are a quality and a finance criterion. The first criterion is to be maximized and the second is to be minimized. Hence, decision matrix is

$$M_d = \left[M_{ij}^d\right] = \begin{bmatrix} 7.5 & 6.8 \\ 8.6 & 4.3 \end{bmatrix} \quad (15)$$

Step 2. The average of decision matrix is

$$\overline{Y} = \begin{bmatrix} 0.46 & 0.61 \\ 0.53 & 0.38 \end{bmatrix} \quad (16)$$

Step 3. The weighted matrix is created by using the Shannon Entropy method

$$w_p = \begin{bmatrix} 0.083 \\ 0.916 \end{bmatrix} \quad (17)$$

Step 4. The average weights of the weighted matrix are

$$\overline{w_p} = \begin{bmatrix} 0.083 \\ 0.916 \end{bmatrix} \quad (18)$$

Step 5. The normalized average decision matrix is as follows.

For normalizing, first the maximum number of each row is detected. Then other numbers divided by this number

$$N = \begin{bmatrix} 0.76 & 1 \\ 1 & 0.72 \end{bmatrix} \quad (19)$$

Step 6. The weighted normalized decision matrix is created:

$$V = \begin{bmatrix} 0.76 & 1 \\ 1 & 0.72 \end{bmatrix} \quad (20)$$

Step 7. Sum of normalized values of both positive and negative criteria is depicted

$$V = \begin{bmatrix} 0.06 & 0.9 \\ 0.08 & 0.66 \end{bmatrix}$$
$$G_{+i} = 0.147 \quad (21)$$
$$G_{-i} = 1.58$$

Table 2: Previous studies of criteria in 3PL selection.

References	Items
[14, 30–32]	IT
[14, 33]	Profit
[14, 33, 34]	Human resource
[14, 33, 34]	Inventory
[14, 32, 35, 36]	Service
[14, 33, 37]	Communication
[14, 34, 37]	Cost
[14, 34, 37]	Time
[14, 34, 37]	Quality
[33, 34, 37]	Relationship
[14, 33, 34, 37]	Flexibility
[20, 38, 39]	Location
[18, 38, 39]	Reputation
[38, 39]	Professionalism

Step 8. Finding rank of value both G_{+i} and G_{-i}

$$T = \begin{bmatrix} 0.43 & 0.57 \\ 0.56 & 0.42 \end{bmatrix} \quad (22)$$

Step 9. Compute the appraisal score

$$AS = \begin{bmatrix} 0.74 \\ 1.35 \end{bmatrix} \quad (23)$$

The result shows that alternative two has first rank and alternative one has second rank.

5. Research Methodology

5.1. Criteria for 3PL Selection. In previous papers, it is possible to find many criteria related to 3PL selection which are introduced and discussed. In this paper, we first extract these criteria (see Table 2).

5.2. Procedure of Research

Phase I (finding criteria for 3PL selection from previous papers). In this phase, all criteria that relate to 3PL selection are gathered from the existing literature.

Phase II (screening factors by the Delphi method). The Delphi method, as a strong tool for screening criteria and finding customized criteria (based on those from Phase I), is used to evaluate the importance of criteria according to expert opinions. The expert opinions about the criteria are requested by questionnaires. Only sufficiently relevant criteria are considered for the subsequent steps.

Phase III (finding criteria weights by using Shannon Entropy). As the decision matrix method needs primary

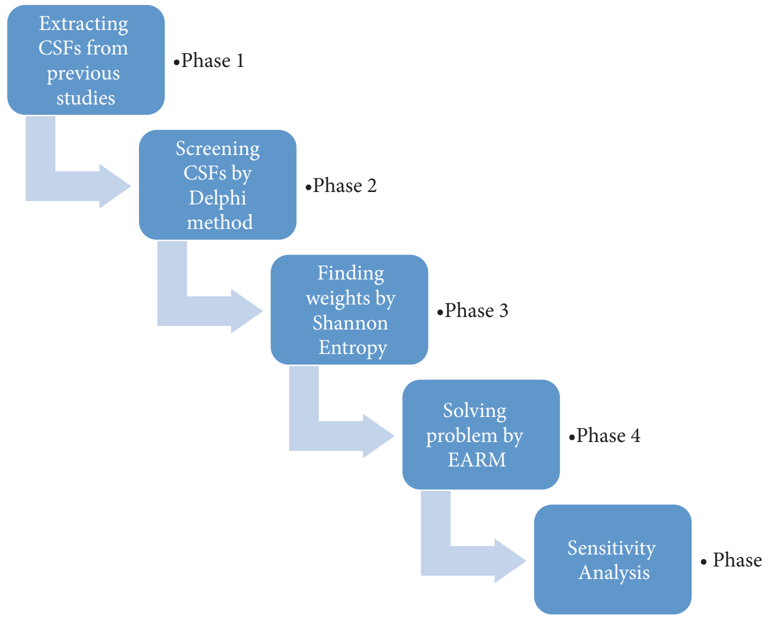

FIGURE 1: Procedure of research methodology.

TABLE 3: Likert scale for the Delphi method.

Not important	Less not important	Moderate	Less important	Strong important
1	2	3	4	5

weights for the criteria from Phase II, Shannon Entropy is implemented as an approach for determining them.

Phase IV (implementation EAMR and evaluating companies). The EAMR method is based on the above steps (i.e., using the decision matrix and weights for the selected criteria), and the results reveal how well the companies perform according to the determined criteria and weights. For each company a score is calculated based on the criteria evaluations and weight so that it is easy and straightforward to determine the best alternative (company).

Phase V (sensitivity analysis). The result of EAMR is compared to those from other suitable MADM methods for finding similarities or dissimilarities between them. It is done by using the Pearson coefficient. Figure 1 shows the procedure of research methodology in this paper.

6. Data analysis

6.1. Case Study. As mentioned above, the automobile industry has a key role in Iran's economy. This industry had a high ranking among important companies of the world. However, after UN and USA sanctions, the prominence of this industry decreased. In this era, various weaknesses of this industry emerged and production receded dramatically. In addition, the quality of the automobiles deteriorated. After negotiation between the six powerful countries and Iran and making a deal, many foreign companies show their interest in the investigation on this industry and renew the technology of the two giant automobile companies of Iran, Iran Khodro and Saipa. They like to outsource their work and only focus on their core competency to improve their technology and replace the old technology in favor of updated versions.

This work helps them to decrease the cost of goods and to improve competitiveness, making it possible for them to export their products to other countries. For this reason, they must find 3PL partners to outsource their work. This work helps them to focus on their most important work, while 3PL companies do the less important work. In this paper, nine 3PL companies were identified, and they were evaluated and ranked by relevant criteria and the EAMR method.

6.2. Screening Criteria. For implementing the Delphi method, all factors are first extracted from previous research. Then a questionnaire, based on the Delphi method, is designed and distributed among eleven (11) experts. For scoring preferences of DMs, a 5-Likert scale is used. The scale of this method is shown in Table 3.

After computation and analysis, if the average of a criterion is four or higher than four, then that factor(s) is(are) considered in the research. If the average of a criterion falls below four, then this criterion is eliminated. The reason for choosing four is that it allows to interpret a criterion as sufficiently important according to the Likert scale in Table 3.

Table 4: Preferences of DMs articulated by the Delphi method.

Criterion	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10	Expert 11
It	5	4	5	4	5	4	5	4	3	3	5
Profit	5	5	4	5	4	5	5	4	5	3	4
Human resource	4	5	5	4	5	2	4	5	3	3	4
Inventory	5	4	5	5	4	4	5	4	3	5	4
Service	5	5	5	5	4	5	4	5	4	3	5
Communication	4	5	4	5	5	4	5	4	5	4	3
Cost	5	5	5	5	4	4	4	3	5	4	3
Time	5	5	5	5	4	5	4	3	4	5	5
Quality	5	5	5	4	5	4	5	4	3	5	4
Relationship	4	3	4	3	4	4	3	4	3	5	4
Flexibility	3	3	4	5	3	5	4	3	5	4	3
Location	4	4	5	3	5	3	4	5	3	5	4
Reputation	3	3	5	4	5	4	3	5	4	5	5
Professionalism	5	4	5	4	5	5	3	5	3	5	3

Table 5: Results of the Delphi method.

Factors	Average Score	Accept/Reject
IT	4.272727273	Accept
Profit	4.454545455	Accept
Human resource	4	Accept
Inventory	4.363636364	Accept
Service	4.545454545	Accept
Communication	4.363636364	Accept
Cost	4.272727273	Accept
Time	4.545454545	Accept
Quality	4.454545455	Accept
Relationship	3.727272727	Reject
Flexibility	3.818181818	Reject
Location	4.090909091	Accept
Reputation	4.181818182	Accept
Professionalism	4.272727273	Accept

Results of the computation are shown in Table 4. Based on previous studies, fourteen (14) criteria were extracted. These criteria are IT, profit, human resource, inventory, service, communication, cost, time, quality, relationship, flexibility, location, reputation, and professionalism. After screening these criteria, only two of them were eliminated by expert opinions. They are relationship and flexibility. Table 4 also shows the preferences of DMs concerning these factors. In this table, the preferences of DMs regarding Critical Success Factors (CSFs) are shown. DMs determine their preferences by a 5-Likert scale.

In Table 5, the results of screening the criteria are shown. If the average of a criterion is less than four (4), this criterion will be eliminated. The remaining criteria are customized factors that are used for selecting 3PL companies.

In addition, the number of DMs that answer these questionnaires is eleven (11). In some research (Dunham, 1998; Powell, 2003), it is believed that the number of DMs can be between five (5) and fifteen (15).

To find the weights w_i, many methods can be applied, such as the Eigen vector method, the AHP, Shannon Entropy, and weighted least squares. In this paper, we used the Shannon Entropy approach. First, the decision matrix is created. The preferences of DMs are based on a Saaty scale (Saaty, 1994) as usually applied for the AHP. Table 6 shows the decision matrix based on a Saaty scale, which uses values

Table 6: Decision matrix (for the Shannon Entropy method and the EAMR method).

Companies	IT	Profit	Human Resource	Inventory	Service	Communication	Cost	Time	Quality	Location	Reputation	Professionalism
Company 1	7	9	9	4	5	3	1	6	3	7	8	3
Company 2	1	9	2	8	9	7	5	8	2	1	6	8
Company 3	6	1	7	3	2	1	6	4	5	1	3	8
Company 4	4	1	9	8	5	7	8	8	5	5	6	9
Company 5	1	6	7	5	4	2	3	7	6	9	7	8
Company 6	5	4	3	2	8	2	9	6	6	3	2	3
Company 7	7	7	9	6	1	6	7	8	2	7	6	2
Company 8	1	4	1	5	9	3	7	9	6	4	6	9
Company 9	3	7	9	7	6	8	9	9	1	9	4	1

Table 7: Saaty scale preferences.

Equally importance	Equally to moderate importance	Moderate importance	Moderate to strongly importance	Strongly importance	Strongly to very strongly importance	Very strongly importance	Very to extremely strongly importance	Extremely importance
1	2	3	4	5	6	7	8	9

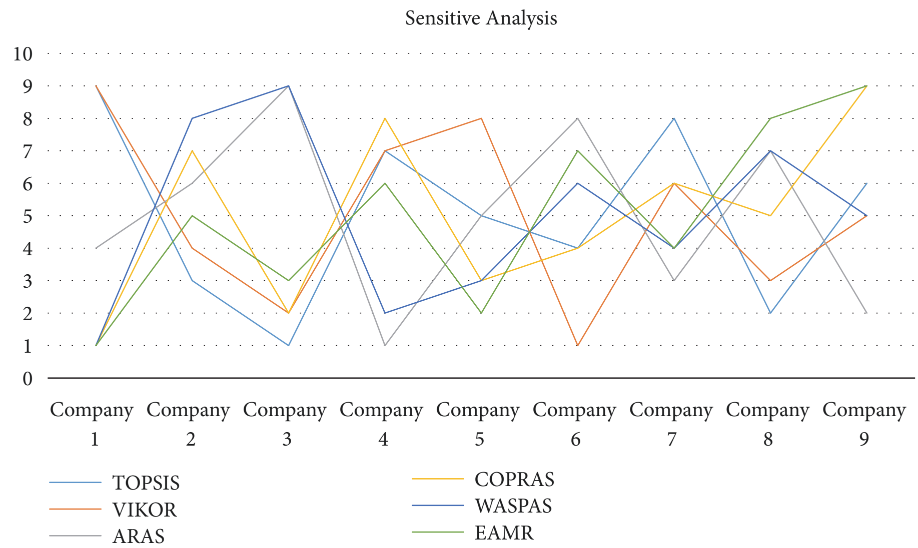

Figure 2: Sensitivity analysis.

from 1 to 9. During this step, DMs allocated scores based on this scale for determining the importance of each CSF based on their knowledge and experiences.

In Table 7, the relationship between scale values and their verbal interpretation of DM's preference is shown. The verbal interpretations are a guide for DMs on how to answer a questionnaire to determine their preferences.

In Table 8, the data of the decision matrix is normalized.

In Table 9, the computation to find final weights using Shannon Entropy is shown. As the EAMR method is based on a decision matrix, it needs criteria weights. These weights are obtained by using Shannon Entropy.

Here again, the decision matrix shown in Table 6 is used as a starting point for using EAMR.

Then the average of each alternative, based on Step 2, is computed and is illustrated in Table 10.

In Step 3, the weights obtained from Shannon Entropy are multiplied with the decision matrix as depicted in Table 11.

Next, in Step 4, the average matrix is created and revealed in Table 12.

Then, based on Step 5, the normalized matrix is illustrated, which is shown in Table 13.

Beneficial calculations and cost are weighted in Table 14.

The rank of value, based on G_{+i} and G_{-i}, are shown in Table 15.

In Table 16, the final ranking is shown.

6.3. Sensitivity Analysis. When using an MCDM method, it is usually assumed that all data are determinated. Nevertheless and due to differences in the used data and the ways to process them, different approaches usually lead to different results. Therefore, we want to find out how similar the results of the EAMR method are to those of other MCDM approaches. We only use methods, which are based on the decision matrix (like EAMR), and then the obtained results are compared using the Pearson correlation coefficient with those of other methods for finding out the similarity. The methods considered for comparison are TOPSIS, VIKOR, WASPAS, ARAS, and COPRAS, which work similarly to EAMR. The results are shown in Table 17.

The result of the Pearson test is shown in Table 18. This test shows the relationship between the EAMR result and other methods. If the statistics is significant (P value corresponding to a significance level of 5%), there is no relationship between two results.

The results show that, among these methods, solely EAMR has a correlation with the COPRAS method, and there is no any relationship with other methods. In fact, three methods show a negative correlation and the ARAS method shows even completely opposite results. As Figure 2 shows, the ranking patterns of the different methods look rather diverse and dissimilar, and the COPRAS method is the only method similar to EAMR.

Table 8: Normalized decision matrix data.

Companies	It	Profit	Human resource	Inventory	Service	Communication	Cost	Time	Quality	Location	Reputation	Professionalism
Company 1	0.200	0.188	0.161	0.083	0.102	0.077	0.018	0.092	0.083	0.152	0.167	0.059
Company 2	0.029	0.188	0.036	0.167	0.184	0.179	0.091	0.123	0.056	0.022	0.125	0.157
Company 3	0.171	0.021	0.125	0.063	0.041	0.026	0.109	0.062	0.139	0.022	0.063	0.157
Company 4	0.114	0.021	0.161	0.167	0.102	0.179	0.145	0.123	0.139	0.109	0.125	0.176
Company 5	0.029	0.125	0.125	0.104	0.082	0.051	0.055	0.108	0.167	0.196	0.146	0.157
Company 6	0.143	0.083	0.054	0.042	0.163	0.051	0.164	0.092	0.167	0.065	0.042	0.059
Company 7	0.200	0.146	0.161	0.125	0.020	0.154	0.127	0.123	0.056	0.152	0.125	0.039
Company 8	0.029	0.083	0.018	0.104	0.184	0.077	0.127	0.138	0.167	0.087	0.125	0.176
Company 9	0.086	0.146	0.161	0.146	0.122	0.205	0.164	0.138	0.028	0.196	0.083	0.020

Table 9: Weights of criteria.

	It	Profit	Human resource	Inventory	Service	Communication	Cost	Time	Quality	Location	Reputation	Professionalism
E_j	0.904	0.921	0.930	0.966	0.936	0.921	0.951	0.989	0.943	0.915	0.970	0.920
d_j	0.096	0.079	0.070	0.034	0.064	0.079	0.049	0.011	0.057	0.085	0.030	0.080
W_j	0.114	0.094	0.084	0.041	0.077	0.095	0.059	0.013	0.068	0.102	0.036	0.096

Table 10: Average scores of the decision matrix.

Companies	It	Profit	Human resource	Inventory	Service	Communication	Cost	Time	Quality	Location	Reputation	Professionalism
Company 1	0.910	0.961	0.861	0.186	0.438	0.324	0.067	0.092	0.233	0.813	0.323	0.327
Company 2	0.130	0.961	0.191	0.373	0.788	0.756	0.336	0.123	0.155	0.116	0.243	0.871
Company 3	0.780	0.107	0.669	0.140	0.175	0.108	0.403	0.061	0.388	0.116	0.121	0.871
Company 4	0.520	0.107	0.861	0.373	0.438	0.756	0.537	0.123	0.388	0.581	0.243	0.980
Company 5	0.130	0.641	0.669	0.233	0.350	0.216	0.201	0.107	0.465	1.046	0.283	0.871
Company 6	0.650	0.427	0.287	0.093	0.700	0.216	0.604	0.092	0.465	0.349	0.081	0.327
Company 7	0.910	0.748	0.861	0.280	0.088	0.648	0.470	0.123	0.155	0.813	0.243	0.218
Company 8	0.130	0.427	0.096	0.233	0.788	0.324	0.470	0.138	0.465	0.465	0.243	0.980
Company 9	0.390	0.748	0.861	0.326	0.525	0.864	0.604	0.138	0.078	1.046	0.162	0.109

Table 11: Average weights matrix.

Name of Companies	Average Weight
Company 1	0.461
Company 2	0.420
Company 3	0.328
Company 4	0.492
Company 5	0.434
Company 6	0.358
Company 7	0.463
Company 8	0.396
Company 9	0.487

As mentioned before, it is obvious that different MCDM methods may lead to different results due to differences regarding required input data and how the data are further processed within the method (Hanne, 2012). Although a comparison of different method results using correlation coefficients is done rather rarely, it can be expected that usually somewhat positive correlations are obtained. For instance, in the work of Hanne (1995), correlations between 0.286 and 0.916 are obtained in a comparison among four MCDM methods whereas Antucheviciene et al. (2011) report correlation values among six MCDM methods in the range from 0.36 to 0.83. In the paper by Mulliner et al. (2016), correlation values between 0.179 and 0.995 are shown for five MCDM methods. Thus, our results emphasize even more the problem of choosing a most suitable method as discussed by Hanne (2012) and further research towards a comparison of MCDM methods is advisable.

7. Management Implications and Conclusion

7.1. Management Implications. This result shows that among nine (9) companies the selected one benefits from its bigger size and its more extensive experiences in this field. In addition, the company with the highest score has a high technology level to complete its obligations. This high technology helps the company to complete their responsibilities at high speed and with good quality. In addition, the location of this company is near a considered customer company, so that access to it is very easy. Furthermore, companies that are located outside Iran and have suitable technology may be good choices for outsourcing as well. Iranian companies can create joint ventures with them and establish new companies inside Iran. In this way, updated technology can be transferred to Iran. Those companies can do their work not only at low cost and with high quality, but also with the help of Iranian companies to make the technology transfer successful. This renovation helps Iranian companies to increase their production quantity with high quality and at low cost. Moreover, those companies can compete with other foreign companies, do not lose their markets, and maintain competitiveness. Among these nine companies, three are from European countries and six from Asia. The result shows that among these nine companies, the high priority companies are from Europe and the worse performing companies from East Asia. This signifies that European companies provide better services, better quality, and lower cost for Iranian automobile companies and they have a high technology standard. If this high technology can be transferred to Iran, this can create much more jobs in SMEs and decrease the total cost of production. In addition, it creates opportunities for Iranian companies to export their productions and improve the situation of Iran's economy. Before that, these companies had business relations with European companies but Iran's sanctions suspended these relations. In addition, East Asian companies brought old and low quality technology to Iran. Although they were able to gain adequate market shares in Iran because of low prices and the absence of strong European rivals, many people are dissatisfied with their products. These cars break down very fast and access to after-sale services and spare parts is very difficult. Therefore, Iranian customers prefer to buy automobiles built in cooperation with European countries and companies rather than from other countries, especially East Asian companies.

7.2. Conclusion. Today, many companies are looking forward to outsourcing their works to other companies. Companies understand the advantages of outsourcing, mainly related to the opportunity to focus on core competencies. The 3PRL concept provides a suitable method for the selection of possible outsourcing decisions, taking into account the relevance of the criteria to evaluate processes that could be outsourced. This study depicts the process of finding the best companies for outsourcing under selected criteria. The first step provides information of previous studies related to the evaluation of outsourcing criteria. The second step provides important information regarding the adoption of criteria for selection in a specific case, using screening by the Delphi method. The aforementioned structural method allows the elimination of redundant criteria.

In the first step, fourteen criteria were extracted. Then, the Delphi method was applied, in which two of the criteria were eliminated. Criteria that were eliminated from the study are related to relationship and flexibility. The remaining criteria were IT, profit, human resource, inventory, service, communication, cost, time, quality, location, reputation, and professionalism. Subsequently, nine companies were evaluated by the EAMR method in order to find the best company among them. The result shows how companies can find the best organizations through the MADM methods for outsourcing their work. This road map provides managers with a great tool to make an accurate and correct decision. In the evaluation of the twelve criteria, IT, location, and professionalism played an important role in evaluating companies, whereas time, reputation, and inventory played an insignificant role.

This ranking was done by using Shannon Entropy. The main strength of this research is the combination of Shannon

Table 12: Normalized decision matrix.

Companies	It	Profit	Human Resource	Inventory	Service	Communication	Cost	Time	Quality	Location	Reputation	Professionalism
Company 1	0.778	1.000	1.000	0.444	0.556	0.333	0.111	0.667	0.333	0.778	0.889	0.333
Company 2	0.111	1.000	0.222	0.889	1.000	0.778	0.556	0.889	0.222	0.111	0.667	0.889
Company 3	0.667	0.111	0.778	0.333	0.222	0.111	0.667	0.444	0.556	0.111	0.333	0.889
Company 4	0.444	0.111	1.000	0.889	0.556	0.778	0.889	0.889	0.556	0.556	0.667	1.000
Company 5	0.111	0.667	0.778	0.556	0.444	0.222	0.333	0.778	0.667	1.000	0.778	0.889
Company 6	0.556	0.444	0.333	0.222	0.889	0.222	1.000	0.667	0.667	0.333	0.222	0.333
Company 7	0.778	0.778	1.000	0.667	0.111	0.667	0.778	0.889	0.222	0.778	0.667	0.222
Company 8	0.111	0.444	0.111	0.556	1.000	0.333	0.778	1.000	0.667	0.444	0.667	1.000
Company 9	0.333	0.778	1.000	0.778	0.667	0.889	1.000	1.000	0.111	1.000	0.444	0.111

Table 13: Weighted normalized decision matrix.

Companies	It	Profit	Human Resource	Inventory	Service	Communication	Cost	Time	Quality	Location	Reputation	Professionalism
Company 1	0.359	0.461	0.461	0.205	0.256	0.154	0.051	0.307	0.154	0.359	0.410	0.154
company 2	0.047	0.420	0.093	0.373	0.420	0.327	0.233	0.373	0.093	0.047	0.280	0.373
Company 3	0.219	0.036	0.255	0.109	0.073	0.036	0.219	0.146	0.182	0.036	0.109	0.292
Company 4	0.219	0.055	0.492	0.437	0.273	0.383	0.437	0.437	0.273	0.273	0.328	0.492
Company 5	0.048	0.290	0.338	0.241	0.193	0.097	0.145	0.338	0.290	0.434	0.338	0.386
Company 6	0.199	0.159	0.119	0.079	0.318	0.079	0.358	0.238	0.238	0.119	0.079	0.119
Company 7	0.360	0.360	0.463	0.309	0.051	0.309	0.360	0.411	0.103	0.360	0.309	0.103
Company 8	0.044	0.176	0.044	0.220	0.396	0.132	0.308	0.396	0.264	0.176	0.264	0.396
Company 9	0.162	0.379	0.487	0.379	0.325	0.433	0.487	0.487	0.054	0.487	0.217	0.054

Table 14: Beneficial calculation and cost of weighted.

Name of company	G_{+i}	G_{-i}
Company 1	2.7673	0.5637
Company 2	2.1009	0.9804
Company 3	1.2400	0.4741
Company 4	2.7882	1.3121
Company 5	2.4134	0.7240
Company 6	1.4302	0.6754
Company 7	2.4172	1.0800
Company 8	1.8943	0.9251
Company 9	2.5999	1.3541

Table 15: Rank of value based on G_{+i} and G_{-i}.

Name of Company	$\mathrm{RV}G_{+i}$	$\mathrm{RV}G_{-i}$
Company 1	0.141	0.070
Company 2	0.107	0.121
Company 3	0.063	0.059
Company 4	0.142	0.162
Company 5	0.123	0.090
Company 6	0.073	0.083
Company 7	0.123	0.134
Company 8	0.096	0.114
Company 9	0.132	0.167

Table 16: Final ranking.

Name of company	S_i	Rank
Company 1	2.021	1
Company 2	0.882	5
Company 3	1.077	3
Company 4	0.875	6
Company 5	1.372	2
Company 6	0.872	7
Company 7	0.921	4
Company 8	0.843	8
Company 9	0.790	9

Entropy and the EAMR method to create a hybrid approach to a rather easy-to-use and reliable company assessment. Regarding the steps carried out during this research the approach can be considered as effective and obtained results can be considered as comprehensible offering further insights into the specific market and industry situation. It is, however, interesting to see that the results may differ significantly when different MCDM methods are employed.

As mentioned before, automobile companies have key roles in Iran's economy. Automotive manufacturing is the second biggest industry in Iran and ranks in 20th place among automobile industries around the world. The foundation of this industry in Iran during the 1970s led to significant success, but after the revolution in Iran, it declined and lost its competitiveness. This factor was significantly important during Iran's sanctions. Since most of the automobile companies in Iran are governmental, the use of 3PL for renewing this industry is vital. This paper aims to address these issues to help automobile companies improve their allocation of 3PL partners. Thus, there are three areas of contribution in this paper from more practical ones to more theoretical ones. First, it provides an evaluation of current companies, which might serve as 3PL providers for Iranian automotive producers. Second, it provides an evaluation of the importance of different criteria relevant for 3PL providers. Third, it shows how a methodology based on (i) the Delphi method for expert opinion evaluation, (ii) using Shannon Entropy for criteria weight assessment, and (iii) EAMR for the multiattribute evaluation of alternatives (companies) can be used.

Data Availability

The data used to support the findings of this study are available from Amir Karbassi Yazdi upon request.

Table 17: Ranking from different methods.

Companies	TOPSIS	VIKOR	ARAS	COPRAS	WASPAS	EAMR
Company 1	9	9	4	1	1	1
Company 2	3	4	6	7	8	5
Company 3	1	2	9	2	9	3
Company 4	7	7	1	8	2	6
Company 5	5	8	5	3	3	2
Company 6	4	1	8	4	6	7
Company 7	8	6	3	6	4	4
Company 8	2	3	7	5	7	8
Company 9	6	5	2	9	5	9

Table 18: Pearson coefficient of methods.

	TOPSIS	VIKOR	ARAS	COPRAS	WASPAS
Sig	0.488	0.139	0.798	0.025	0.381
Coefficient	-0.267	-0.533	-1	0.733	0.333

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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