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Green Logistics Outsourcing Employing Multi Criteria Decision Making and Quality Function Deployment in the Petrochemical Industry

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A B S T R A C T

The present study seeks to provide a comprehensive and coherent model for assessing and ranking the outsourcing green logistics, while identifying the indigenous factors involved in the outsourcing process. The employed research methodology is a hybrid fuzzy multi criteria decision making for distinguishing relationships between factors and their degree of importance and combines the techniques quality function deployment (QFD). The results showed that among the main factors "government green decision making" is the most influential and "quality" is the most susceptible factor. The highest weight allocates to "customer satisfaction". The results of house of quality showed that the "convenient and appropriate logistics services" ranked as first, the "implementation of transportation infrastructure for green policies" ranked as second, "having the necessary expertise and experience in similar industries" ranked third which reflects the importance of these requirements comparing to other requirements. The calculation results indicate that the fourth supplier is the final choice of decision making process.

1. Introduction

Outsourcing of logistics services is a kind of predetermined external preparation and exploits foreign companies to perform the whole or a part of organizations logistic activities such as transportation, distribution, warehouse keeping, inventory management and materials control which used to be supplied by the same organization (Sink and Langley, 1997; Isiklar et al., 2007).

When logistics services are outsourced in an organization, supplier company turns into a significant actor within a supply chain stage and accordingly delivers products and services to the ultimate customer; therefore, he/she better takes part in determination of organization's goals and strategies and gets engaged in its losses and profits (Elram, 1990). It should be noted that if the selected suppliers for logistics were not

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qualified, company would encounter a wide variety of problems such as poor logistic services, production cost increase and total cost of goods as the results of high logistics expenses including transportation, inventory maintenance and administrative costs. High investment costs, waste materials cost because of goods transformation and relocation, and inventory storage costs can be mentioned among other petrochemical industries problems in logistics. These problems ultimately spoil organizations credit and reputation and as the result, it will simply lose its market share (Soh, 2010).

Industry contributes to a wide variety of environmental pollutants. Considering the necessities such as joining the World Trade Organization (WTO), the expansion of international environmental provisions and the emphasis of consumers on the use of eco-friendly green products, the strategic outsourcing of green logistics is an indispensable part of this industry. Apart from threatening human beings, Pollutions created by the petrochemical industry, comprises a great deal of environmental risks and have disastrous consequences to the environment. Industry owners are trying to take advantage of the products, which are presented, to consumers using environmental protection and biological resources to protect consumers and take environmental considerations as a competitive advantage (Rahimzadeh et al., 2015).

When an enterprise selects to outsource, it may mainly choose to unbundle corporate functions and outsource an internal supporting service such as human resources, information technology, procurement as well as finance. The other choice is to choose a vertical disintegration. This is when suppliers make inputs that use into firm's final product or service. How this is performed, either a corporate function or vertical strategy, represents four types of how to define the outsourcing such as operational, strategical, multi-sourcing and business process outsourcing (Hoff., 2009). Outsourcing is assigning some of the internal practices of an organization to its supplier outside the organization through a long-term contract. Outsourcing could improve the performance of companies by means of minimizing and agility of organization, reducing and controlling costs, gaining external resources, dividing risks and management in difficult and feasible tasks (Khodaverdi and Bojnurdi, 2010). Outsourcing decision in the manufacturing industry is very hot topic from last few decades and companies' management tries to find out the way of leveraging capabilities internal and external both (Syed et al., 2017). Sink and Langley (1997) considered the most significant outsourcing advantage of logistics services as its straight focus on merits and key capabilities which brings about productivity increase, services improvement, transportation cost reduction and supply chain reconstruction.

Green logistics is the process of minimizing damage to the environment due to the logistics operations of a company. Logistics cover transportation of material and products as well as workforce and resource intensive processes such as purchasing, inventory management, warehousing, order fulfillment process and distribution. Green Logistics is a sort of logistics contributes to sustainable production and distribution of goods, considering environmental and social factors, and aims to minimizing and evaluating the ecological effects of logistics practices (Saroha, 2014). Therefore, the organization's goals are not only proceeded economic impact of logistics policies, but also decline the negative impacts on society, such as the influence of pollution on the environment. These consequences include resource consumption, land use, acidification, toxic effects on ecosystems and emissions of greenhouse gases. Green logistics practices include green transportation, green warehousing, green packaging and green reverse logistics, and so on. For many, green logistics is referring to green transportation, since green logistics often stems from decreasing the environmental impact of shipping, which is the largest source of greenhouse gas emissions in the logistics (Rodrigue et al., 2001).

Green logistics is related to synergy and efficiency within whole supply chain process. Since there is a two-way (interactive) relationship between environmental performance improvement and economic performance improvement, environmental performance improvement decreases costs, improves economic performance and customers' perspectives about governmental and non-governmental environment supporters' corporations and their products and increases competitive advantage in supply chain. It is also worth mentioning that identifying an appropriate foreign supplier based on qualitative and quantitative factors is affected by the existing uncertainty and obscurity of describing and ranking potential suppliers (Yang and Chen, 2006). Therefore, this paper aims at identifying related criteria to strategic outsourcing for green logistics and also using qualitative and quantitative decision making methods for evaluating and ranking related criteria in an appropriate manner. Thus, organizations managers should have correct understanding of involved factors and be aware of their relationships (interactions) to improve organizations performance in the scope of logistic activities by making correct decisions. Regarding the structure of Kurdistan Petrochemical Company and the fact that this company covers many different activities, it is trying to outsource some of its logistic activities. To do that, picking an appropriate supplier who is capable of leading company to its goals is of great importance. Therefore, we have presented a combinational approach using QFD, fuzzy network analysis process based on fuzzy DEMATEL and Superiority and Inferiority Ranking method (SIR).

The main purpose of this research is to evaluate the components of outsourcing for green logistics, using the method of extending the quality of performance and decision-making tools with multiple criteria. Other research objectives include: Identifying the effective factors of green logistics outsourcing in the Kurdistan petrochemical company, Determining the relationship between designated indicators and their importance by using the fuzzy analytic network process (ANP) method, ranking logistic contractors based on weighted indices in SIR method, selecting the appropriate supplier of green logistics services in the Kurdistan petrochemical company, modeling the organization's successful decision-making process for Outsourcing Green Logistics. We do not have any hypotheses in this paper but we assume that triangle fuzzy numbers are used. The proposed method involves the Fuzzy ANP, QFD, and SIR. The QFD method with its unique traits, can determine the dependence of criteria and technical specifications. We used Fuzzy ANP method to measure inter correlation of the evaluation criteria. The ANP does not need a hierarchical structure, since depict the results in relationships between decision-making levels in a grid, and consider interactions and feedbacks between criteria and alternatives. The SIR method is classified as a new and relatively complicated multi criterion decision-making based on the ranking of options. The ANP, beside SIR method, creates a decision making tool in order to reaches the best output of the relations feedback and options distance to the upside criteria. In addition, with the development of the base model, a new model is obtained that can be used in larger dimensions.

Then, conducted researches on outsourcing for logistics are reviewed and examined. In the next step, the proposed methodology and desired method are discussed and their usage is clarified regarding case study and finally conclusion is presented based on the obtained results and future scopes for research and development are noted.

2. Literature Review

The selection of a qualified supplier has been of great importance and many studies have been conducted to achieve an appropriate framework for selecting the best supplier in logistics services scopes (Roohbakhsh et al., 2015). Meade and Sarkis (2002) applied ANP method for selecting the best supplier for reversed logistic services. Decision making factors and studied groups in ANP model include products status in its life cycle, organizational performance criteria, required reversed logistic process functions by organization and reversed logistics organizational role. In another research, Bottani and Rizzi (2006) expanded a fuzzy technique for order preference by the level of similarity to ideal solution (FTOPSIS) approach for ranking and selecting the best logistics service supplier considering 9 criteria including financial stability, services flexibility, performance, price, physical equipment and information systems, quality, compatibility, strategic perspective, confidence and flexibility.

Jharkharia and Shankar (2007) exploited ANP approach to select the best supplier for logistics services by considering 4 main criteria including compatibility, cost, quality, and reputation. Efendigil et al. (2008) presented an integrated approach, by combining Fuzzy analytic hierarchy process (AHP) and artificial neural network (ANN) to select the best reversed logistics supplier. Liu and Wang (2009) presented a 3 step approach for evaluating and selecting logistic services suppliers. In the first step, a Fuzzy Delphi method was used to recognize critical criteria. Then, a fuzzy linear deduction method was used for inappropriate examination. In the final step, a fuzzy linear deduction approach was used for final selection. Soh (2010) used Fuzzy AHP for selecting decision making model and evaluating logistic services suppliers including 5 evaluation criteria such as investment, service level, communications, infrastructure, each of them contained its own sub criteria. Ho et al. (2012) also proposed 9 criteria for evaluating and selecting logistics services suppliers based on Menon et al. (1998). These 9 criteria are as follows: price, on time distribution, error rate, financial stability, creative management, respecting promises, meeting operational and qualitative requirements, senior manager's availability and appropriate reaction to unforeseen and inevitable problems.

Wan et al. (2015) presented fuzzy linear programming to select logistics services suppliers. In the same year, Shi et al. (2016) performed an experimental study on logistics services suppliers for third person purchase in China. Tavana et al. (2015) also used an AHP and SWOT fuzzy intuitive integrated approach for outsourcing reversed logistics. Barua and Prakash (2016) presented a Multi Criteria Decision Making (MCDM) combinational approach for selecting and evaluating reversed logistics services in electronic systems in India. Govindan and Chaudhuri (2016) analyzed the jeopardies that suppliers have encountered in relation to one of their customers. The proposed approach in this research is DEMATEL. Yang et al. (2016) expanded communications using various trading limitations effects in exploiting contractors and the relationships among their criteria considering the existing researches in management scope. They also examined two mechanisms on outsourcing performance. Ameknassi et al. (2016) evaluated logistic outsourcing decisions in supply chain. In previous researches, all the above approaches can be used to encounter multiple and contradictory criteria but none of the developed approaches considered company s beneficiaries and current goals while weighting and evaluating different criteria. Furthermore, in previous researches in logistic outsourcing scope, strategic outsourcing for green logistics has not been discussed. In other words, the absence of a quality performance expansion plan for green logistics tempted us to propose a combinational model based on QFD and FANP approaches with the help of FDEMATEL and SIR to outsource green logistics in Iran petrochemical industry. We also provided a model that will help organizations to perceive criteria involved in choosing the supplier of green logistics practices and their communication, in order to leads managers to appropriate solutions for better management of strategic outsourcing for green logistics activities.

3. Methodology

This research is mainly aims at evaluating outsourcing components for green logistics using a combination of quality performance expansion and multi criteria decision making tools. Therefore, the first and most significant step is to find green logistics outsourcing components.

The research method is descriptive survey. Because in survey research using the data questionnaire from the qualitative level will be brought to a quantitative level. The data collection tool will be a questionnaire. The purpose of this research is to provide an appropriate combination of strategic outsourcing for green logistics. The proposed method involves the Fuzzy ANP, QFD and SIR. The QFD method with its unique traits, can determine the dependence of criteria and technical specifications. We used the FANP method to measure inter correlation of the evaluation criteria. The ANP does not need a hierarchical structure, since depict the results in relationships between decision-making levels in a grid, and consider interactions and feedbacks between criteria and alternatives. The SIR method is classified as a new and relatively complicated multi criterion decision-making based on the ranking of options. The ANP, beside SIR method, creates a decision making tool in order to reaches the best output of the relations feedback and options distance to the upside criteria. In addition, with the development of the base model, a new model is obtained that can be used in larger dimensions. Experts of this research consist of 15 senior logistics experts and management of petrochemical company in Kurdistan province with a work experience about 4 years above. At the first, the selected experts also were aware about green logistic as well as outsourcing definitions and principles. According to Saati (2002), ten experts are sufficient for paired comparison studies. Also Reza and Vassilis (1988) suggested that the number of experts as interviewees should not be high, proposed a total of 5 to 15 people.

In literature review section, we have used library method for data collection and a poll was conducted to ask experts about their viewpoints to determine sub criteria in which case through questionnaire and field research. Furthermore, information collection tools are questionnaire, interview and databases in this research. To perform QFD, FDEMATEL, FANP and SIR techniques, we have employed excel software. Validity of this research has been determined by content and appearance validity. Since the proposed criteria in questionnaire are acquired by previous researches and literature review, they have content and appearance validity. We have also used SPSS software to trace questionnaires reliability. Alpha coefficient was calculated in software output as 0.794 which demonstrates high reliability of the mentioned questionnaire.

3.1. *Different steps of FANP Combinational approach with the help of FDEMATEL, QFD and SIR*

The proposed approach in this paper has been illustrated in Figure 1 for selecting the best third party logistics (3PL). As illustrated in Figure 1, green logistics outsourcing concept is studied by referring to papers and valid books in the first step and outsourcing components for green logistics are extracted from these studies.

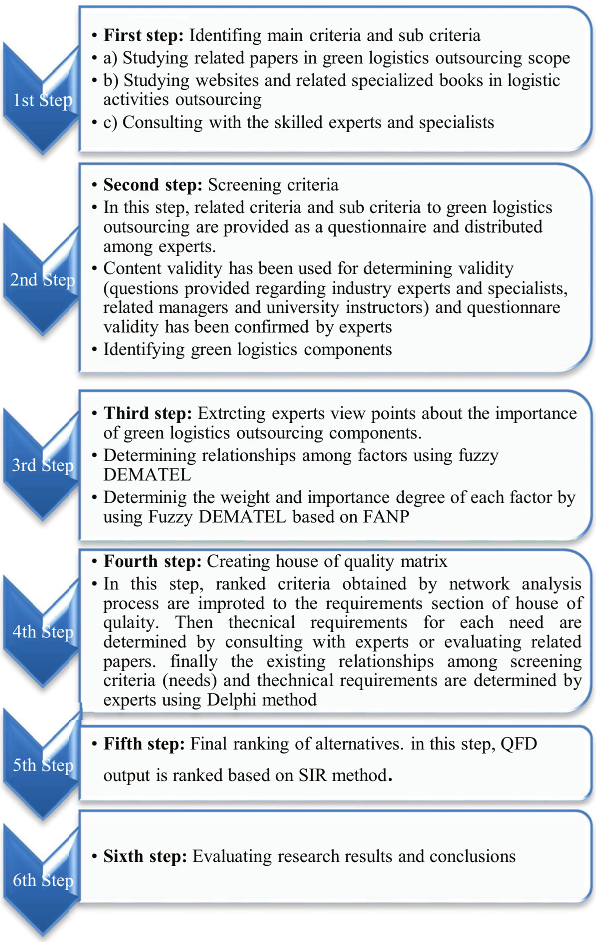

Fig. 1. Framework of Study

Considering the conducted literature review, some appropriate sub criteria for green logistics are identified and extracted regarding experts' viewpoints. Considering the obtained information's dispersion and different importance of each component, related experts' viewpoints are extracted about important components in a questionnaire frame and their unanimous opinion is screened based on all criteria s Content Validity Ratio (CVR) method to evaluate significant components (Hajizadeh and Asghari, 2011).

$$CVR \quad \frac{n_{E}-N/2}{N/2} \tag{1}$$

In which n_E is the number of experts who selected "necessary" option and N is the number of all the experts. After calculating CVR according to Lawshe's view, based on the number of specialists who have evaluated the questions. The minimum CVR for 15 persons should be 49/0 and according to the number of evaluators, those with a calculated CVR value for them are less than the desired amount, should be excluded from the test. Table 1 summarizes the results of CVR calculations.

Finally, after calculating the CVR, six components were selected as important factors to the final solution of the model.

In the second step, identified components (criteria) and sub criteria are weighted based on fuzzy ANP. In the third step, the harmonious components obtained by fuzzy analytical network process are used as inputs of house of quality (needs) in QFD approach and after ultimate evaluation and creating house of quality matrix, the final weight is obtained regarding technical features and then SIR method is applied for ultimate ranking.

Table 1
Results of CVR calculations

Criteria	Main criteria	Sub-criteria	Ne	CVR
C1	Flexibility /Time	Flexibility in service capacity growth	12	0.60
		Ability to adapt customer needs	9	0.20
		Categorized Services	13	0.73
		Commitment to settled delivery time	12	0.60
C2	Work experience	High skills	12	0.60
		Reliability	12	0.60
		Experience	14	0.87
C3	Technology	Information systems capabilities (Software)	10	0.33
		Physical equipment such as logistics	11	0.47
C4	Risk	Ability to identify and prevent potential problems	11	0.47
		Financial stability	10	0.33
C5	Quality	Customer satisfaction	14	0.87
		Delivery without fail	13	0.73
		Delivery fit order quantity	13	0.73
		Convenient and appropriate ordering	11	0.47
C6	Social factors	Customer pressure to produce eco-friendly products	10	0.33
		Customer Awareness of Green Logistics	11	0.47
C7	Company's green management (operation)	Green supply management	12	0.60
		Green logistics and distribution management	14	0.87
		Green Packaging Production Management	14	0.87
		Green storage management	14	0.87
C8	Environmental pollution	Traffic noise pollution	11	0.47
		Exhaust emission volume	10	0.33
		Sanitation amount	11	0.47
		Carbon emissions	11	0.47
		Solid waste	11	0.47
C9	Economic factors	Increase in profit	9	0.20
C10	Environmental laws	Capitalizing on Pollution reduction	11	0.47
		Total solid waste productivity	11	0.47
C11	Logistics industry	Establish Green Knowledge Logistics Institutes	13	0.73
		Extending green logistics policy	15	1
		Creating Green Logistics Performance Assessment System	12	0.60
C12	Governmental Green Decision Making	Increasing green logistics advertisement	13	0.73
		Planning for Green Logistics	12	0.60
		Create green logistics Rules	12	0.60
C13	Logistic Costs	Responsibility Warranty expenses	10	0.33
		Willing to reduction in service costs	9	0.20
		Flexible provision in Cost payments	9	0.20

3.2. *Application of decision-making theory in the supply chain*

Decision-making methods in the supply chain can be used in various industries, in addition indicate a significant impact and different results. Some researches in this area shown in Table 2. As can be see, studies in different industries has different outcomes with various decision-making methods

Table 2.
Some of researches conducted with decision making methods

Application	Solving method	Statistical population	Subject	Author/ Year
According to the results, the research helps improve supplier, research and development, reduction in product's prices, and quality management system in the organization.	QFD and ELECTRE	Faravari Sakht Company	Supplier selection and evaluation using QFD and ELECTRE in quality management system environment (case study: Faravari Sakht Company	Tavassoli et al. (2018)
Presents a method for identifying the causal relationships between strategic objectives in a strategy map of a Balanced Scorecard.	ANP and DEMATEL	manufacturing company	Identifying causal relationships in strategy maps using ANP and DEMATEL	Quezada et al. (2018)
Internal analysis of different types of risks, Providing prioritized risk values, supports useful insights.	DEMATEL	Food production factory	Interrelationships of risks faced by third party logistics service providers: A DEMATEL based approach	Govindan & Chaud-huri (2016)
Develop a new integrated method to pick up suppliers that includes reverse logistics requirements.	Fuzzy DEMATEL and Group Fuzzy-TOPSIS	Company	Applying a new Fuzzy Dematel and Group Fuzzy-TOPSIS method to pick up suppliers in the reverse logistics network.	Fallah (2014)
Despite the various ambiguities, It could solve the supplier s selection problem	Fuzzy	Company	Multi-attribute group decision-making for choosing a supplier with a fuzzy approach	Shahghol-ian et al. (2012)
This research will conserve natural resources, also decline waste and improve the organizational performance	QFD, FDEMATEL, FANP and SIR	Kurdistan petrochemical industry	Evaluating Green Logistics Outsourcing Employing Multi Criteria Decision Making and Quality Function Deployment in the Petrochemical Industry	Present study (2018)

3.3. *FANP approach based on FDEMATEL*

ANP was presented by Saaty in 1996 for the first time to help us with multi criteria decision making. This process aims at creating a model for breaking multi criteria decision problems into smaller pieces and offering the best decision making by rational initialization of simpler components and then integrating these values together. This method includes two main parts. The first part consists of compound categories of main criteria and sub criteria and also an alternative category and the second part contains a network of vectors and arcs which demonstrate dependence, correlation and the existing feedback in decision making system.

This method is defined based on paired comparisons which are similar to conducted comparisons in AHP method. The result of this calculation is a super matrix which brings about the possibility of ranking each criterion regarding its weight after calculating super matrixes relationships and their conceptual evaluation. In this research, fuzzy method is applied in order to consider intellectual (subjective) problems and uncertainty in decision making scope and acquire higher validity in comparison with its similar methods (Saaty, 2008). Fuzzy logic is a new technique to replace the previous methods for designing and modeling a system with complex and advanced mathematics requirements with verbal values and experts' knowledge and complete it to a large extent. In fact, in fuzzy logics the certain (crisp) results can be extracted using a set of uncertain knowledge defined by verbal values and expressions (Piktan, 2004).

In crisp membership sets, each element within the set should be offered as a crisp number that can belong to the set or not. In fuzzy logics, although a membership function defines membership in a set. In fuzzy sets logics, each element can belong to various sets with different degrees of membership but this is impossible in crisp sets. A fuzzy number is a special fuzzy set which is shown as follows:

$$F = \{(X, \mu_F(X), X \in R)\} \quad (2)$$

In which x includes real values: $\mu_F(X)$, R: $-\infty < X < +\infty$ is a continuous function.

Regarding this feature that each fuzzy number is defined by a membership function, we can have different fuzzy numbers based on their functions. Triangle fuzzy number is one of the most acceptable and practical fuzzy numbers which is used in this research and demonstrated as M (l, m, u) in which l<<m<<u.

Membership function of a triangle fuzzy number is as follows:

$$\mu_M(X) = \begin{cases} 0 & X<1 \\ \frac{x-1}{m-1} & 1<<x<<m \\ \frac{u-x}{u-m} & m<<x<<u \\ 0 & x>u \end{cases} \quad (3)$$

While A (a₁, a₂, a₃) and B (b₁, b₂, b₃) as 2 triangle fuzzy numbers, the following calculations are met (Taherkhani, 2016).

$$A+B= (a_1, a_2, a_3) + (b_1, b_2, b_3) \quad (a_1+b_1, a_2+b_2, a_3+b_3) \quad (4)$$
$$A-B = (a_1, a_2, a_3) - (b_1, b_2, b_3) = (a_1-b_3, a_2-b_2, a_3-b_1) \quad (5)$$
$$A*B= (a_1, a_2, a_3) *(b_1, b_2, b_3) \quad (a_1b_1, a_2b_2, a_3b_3) \quad (6)$$
$$A/B= (a_1, a_2, a_3) / (b_1, b_2, b_3) \quad (a_1/b_3, a_2/b_2, a_3/b_1) \quad (7)$$
$$KA= (ka_1, ka_2, ka_3) \quad (8)$$
$$(A)^{-1} \quad (1/a_3, 1/a_2, 1/a_1) \quad (9)$$

Fuzzy DEMATEL method has been used to determine the relationships among factors in this paper. Fuzzy DEMATEL method evaluates the structere of the effects among criteria and tries to solve organizations problems and improve them by applying group decision making in a fuzzy environment(Liu et al., 2018).

The methodology of DEMATEL helps to find the interdependence between the factors and divides the factors into cause and effect group (Gandhia et al., 20015). This approach has been used by various researchers to analyze interrelationships among criteria in multi criteria decision problems (Chang et al., 2011; Mangla et al., 2014; Wei et al., 2010). The required steps are as follows (Jeng and Tzeng, 2012):

First step: Creating fuzzy direct relationships matrix by determining the effect of Criterion I on J with the help of Table 3.

Table 3
Verbal criteria for pairwise comparison

Fuzzy Numbers	Verbal terms for paired comparison	
(0.75, 0.75, 1)	Very high effect	$\tilde{4}$
(0.5, 0.75, 1)	High effect	$\tilde{3}$
(0.25, 0.5, 0.75)	Low effect	$\tilde{2}$
(0, 0.25, 0.5)	Very low effect	$\tilde{1}$
(0, 0, 0.25)	Without effect	0

Second step: Normalizing direct relationships matrix using equations (9) and (10):

$$\tilde{X} = K.\tilde{A} \tag{10}$$

$$k = min\left[\frac{1}{max_{1\le i\le n}\sum_{j=1}^{n}\tilde{A}_{ij}}, \frac{1}{max_{1\le i\le n}\sum_{i=1}^{n}\tilde{A}_{ij}}\right] \quad i,j = 1,2 \dots n \tag{11}$$

Third step: Calculating total communication matrix using equation (12):

$$\tilde{T} = \tilde{X}(I - \tilde{X})^{-1} \tag{12}$$

Fourth step: Determining $\tilde{D}$ and $\tilde{R}$ using the following equations:

$$\tilde{T} = [\tilde{t}_{ij}]n \times n, \quad i,j = 1,2 \dots n \tag{13}$$

$$\tilde{D} = \left[\sum_{j=1}^{n}\tilde{t}_{ij}\right] = [\tilde{t}_i]\, n \times 1 \tag{14}$$

$$\tilde{R} = \left[\sum_{i=1}^{n}\tilde{t}_{ij}\right] = [\tilde{t}_j]1 \times n \tag{15}$$

Fifth step: Calculation of $(\tilde{D} + \tilde{R})$ and $(\tilde{D} - \tilde{R})$ and drawing effects relationships in Cartesian coordinates axes.

In the next step, we use normalized total relationships matrix obtained by DEMATEL method. After normalizing, homogenous super matrix is converged to make a limited matrix and finally the ultimate weights are determined using fuzzy analytical network process based on fuzzy DEMATEL.

$$\lim_{K\to\infty}(W^{2k+1})^k \tag{16}$$

3.4. *Quality function development (QFD)*

In this step, after determining the weight of each component, a kind of advanced QFD is used to transform customer's qualitative needs which are regarded as outsourcing components for green logistics to engineering and technical requirements. QFD is one of the quantitative means for translating customer s needs and demands to technical requirements within products design and developments phases (Chan and Wu, 2002). In the same way, outsourcing components for green logistics are set to be harmonic using fuzzy analytical network process and they ll be included as input value of the first house of quality i.e. needs. Petrochemical company s experts (using Delphi technique) have presented technical features in "technical requirements section" of Table 2 in order to respond to these sorts of needs. Undoubtedly, the importance degree of all the technical features are not the same and a few of them are more significant than the others. Accordingly, a specialized questionnaire was given to 3 people of quality control department to find the importance of each technical feature and unanimously weight the relationships between their needs and organizational requirements using 9 (strong relationship), 3 (average relationship) and 1 (weak relationship) in the related row. Finally, after completing house of quality matrix using equations (17) and (18), net and relative weights, and needs ranking are calculated and written in the end of the matrix.

$$W_j = W_i * d_{ij} \quad i = 1,2,\dots,n \tag{17}$$

$$\acute{W}_j \quad \frac{w_j}{\sum_{j=1}^{m} w_j} \quad j \quad 1,2,\dots,m \tag{18}$$

3.4. *Superiority Inferiority Ranking (SIR)*

It is a new-born method in decision making which uses alternatives ranking fundamentals. Ranking organizations based on superiority and inferiority is the output of Preference Ranking Organization Method for Enrichment Evaluations famous approach (PROMETHEE)[1], an effective model introduced with the help of MCDM. Regarding the importance of technical requirements, SIR method has been used to rank suppliers in this paper. SIR ranks the existing alternatives by creating superiority and inferiority matrixes. Assume a decision maker is in charge of actual performance of$g_i(A_i)$to compare m existing alternatives $A_i(i = 1, \dots, m)$ with criteria $g_i(i = 1, \dots, n)$ furthermore if the f_i is a generalized non-descending function for g_i criterion and can be determined by decision maker, then, for comparing each two alternatives A_k, A_i the equation $P_i(A_i, A_k) = f_j\left(g_j(A_i) - g(A_k)\right)$ demonstrates the preference level of A_k, A_i regarding j criterion. In this step, experts' comments are used, third function is chosen as the most desired one and is defined as equation (19):

$$\begin{cases} \frac{d}{p} & d \le p \\ 1 & d > p \end{cases} \tag{19}$$

For each A_i alternative, superiority criterion $S_j(A_i)$ and inferiority criterion $I_j(A_i)$are defined as (20) and (21) equations by considering j criterion (Zareie nezhad and Hojjati, 2013).

$$S_j(A_i) \quad \sum_{k \quad 1}^{m} P_j(A_i, A_k) \tag{20}$$

$$I_j(A_i) \quad \sum_{k \quad 1}^{m} P_j(A_k, A_i) \tag{21}$$

In which P_j is the preference severity and $j = 1, \dots, n, i, k = 1, \dots, m$. SIR flow can be calculated by using superiority matrix $S = \lfloor S_j(A_i) \rfloor_{m\times n}$ and inferiority matrix $I = \lfloor I_j(A_i) \rfloor_{m\times n}$. We often apply SAW [2] and TOPSIS methods to obtain superiority and inferiority flows of 2 models. In this paper, we determine the weight of each alternative based on simple additive weighting (SAW) considering requirements. The values of superiority flow for A_i, $(A_i)\emptyset^{>}$and inferiority flow $\emptyset^{<}(A_i)$ are calculated based on SAW model as follows:

$$\emptyset^{>} = \sum_{j=1}^{n} w_j S_j\,(A_i) \tag{22}$$

$$\emptyset^{<} = \sum_{j=1}^{n} w_j I_j\,(A_i) \tag{23}$$

Finally, net flow and relative flow are calculated using the following equations:

$$\emptyset_n(A_i) = \emptyset^{>}(A_i) - \emptyset^{<}(A_i) \tag{24}$$

$$\emptyset_r(A_i) = \frac{\emptyset^{>}(A_i)}{\emptyset^{>}(A_i) + \emptyset^{<}(A_i)} \tag{25}$$

3.4.1. Final Ranking

In general, superiority ranking $R_{>}$ and inferiority ranking $R_{<}$ are totally different. Accordingly, combining them with each other $(R_{>} \cap R_{<})$ provides the ultimate ranking method (Xiaozhan, 2001).

[1] Preference Ranking Organization Method for Enrichment Evaluations

[2] Simple Additive Weighting

3.5. *Case study*

The case study of this paper is related to a company in petrochemical industry. The reason that we chose the area of petrochemical was the importance of this industry in Iran. Moreover, due to some new problems arose in this industry, management groups of active companies are very interested in decreasing the overall cost while increasing quality. The most significant problem is that inconsistency and parallel activities in these subdivisions cause increase in cost, decrease in quality and production and increase in risk. Also, petrochemical industries have important effect on environment and are highly reliant on non-renewable fossil fuels (Samuel et al., 2013).

Kurdistan petrochemical company was established within the radius of 5 kilometers from Sanandaj. Company's input contains Ethylene gas which is imported by the west line originated from Asaluyeh with 2200 km length. The manufactured product is mainly used for producing packaged film and this product is often exported to abroad. This company allocated a series of its activities to foreign countries which are also responsible for purchase, feed supply and spare parts. Kavian petrochemical company which is located in Asaluyeh is one of the main suppliers of this company that also produces feeds of several other companies in the west line such as Kurdistan, Kermanshah and Mahabad petrochemical companies. Other supplier companies include Prada and Rosubgari which are responsible for supplying a series of this company s activities. It should be noted that the mentioned suppliers purchase their chemical materials, spare parts and some other items from several European countries.

Petrochemical industry has played a crucial role in internal economic growth as it creates value-added and reduces the sale of oil and gas on which the economy has been dependent for decades. Due to these reasons, Kurdishan province was selected for the case study as one of the most important regions of new petrochemical industry. Kurdistan petrochemical company located at Kurdistan province and this is the main reason why Kurdistan province was chosen for the study.

4. Findings

In the present study a Fuzzy DEMATEL was firstly used in order to determine relationships, impacts and susceptibility severity of factors, then a Fuzzy ANP method to rank different factors, the QFD method to transform organizations needs to technical requirements and also determine their significance and finally, SIR method for ranking suppliers in addition to identifying effective factors on green logistics strategic outsourcing.

4.1. *Evaluation and selection of factors*

Various papers have been studied and lots of meetings were held with experts and senior managers in order to identify effective factors on green logistics strategic outsourcing so far. Since there are a large number of identified variables, we have used weight limitation in our model to identify variables, reduce inputs and also determine the importance of inputs in comparison to each other and evaluate their validity. To do that, we provided a questionnaire including 38 questions, each a representative for a factor and 15 questionnaires (= the number of responders) were distributed among the experts and all the questionnaires proved to be comprehensive and coherent. These questionnaires were designed based on 3-point Likert scale in qualitative form. Then, CVR method was used in order to determine the most significant factors. CVR selected factors with the least validity of more than 0.49 (according to their output values obtained by Excel software) and resulted in 19 factors as the most significant factors for solving presented model which are presented in Table 4.

Table 4
Effective factors for green logistics strategic outsourcing

Code	Sub factors	Main factors
C_{11}	Flexibility in increasing services capacity	Flexibility C_1
C_{12}	Categorizing services	
C_{13}	Commitment to the agreed delivery time	
C_{21}	High skill	Work experience C_2
C_{22}	Fame	
C_{23}	Experience	
C_{31}	Providing customer satisfaction	quality C_3
C_{32}	Delivery without failure	
C_{33}	Order-based delivery	
C_{41}	Green packaging and manufacturing management	Green (operation) management of company C_4
C_{42}	Green distribution and transportation management	
C_{43}	Green warehousing management	
C_{44}	Green supply management	
C_{51}	Establishing educational institution of green logistics knowledge	Logistics green industry C_5
C_{52}	Generalizing the policy of green logistics	
C_{53}	Creating an evaluation system for green logistics performance	
C_{61}	Increasing advertisements of green logistics	Governments green decision making C_6
C_{62}	Planning for green logistics	
C_{63}	Setting rules and regulations for green logistics	

The final model is derived by the present research which was provided based on literature review and obtained results by experts' interview and university instructors and its content validity was verified (Figure 2).

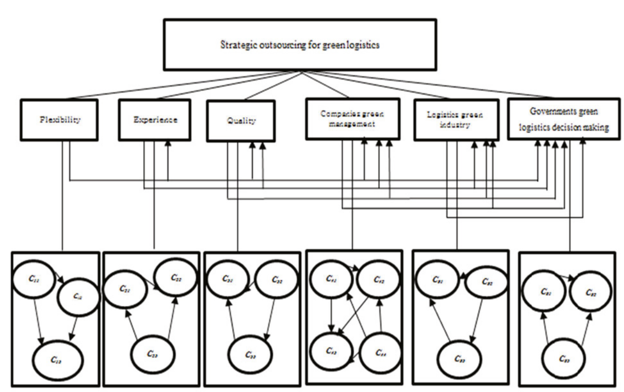

Fig. 2. Research Network Structure

Since we need to determine factors relationships and how they affect each other in order to solve the model by fuzzy ANP method, we have applied fuzzy DEMATEL in this paper. Based on evaluating steps of identifying internal relationships among factors obtained by fuzzy DEMATEL, experts determine effect of each factor on the other ones and evaluate effect serevity of factors on each other based on verbal variables and then, arithematic mean is used to consider all experts viewpoints. After solving fuzzy DEMATEL process and defuzzification of each factor and sub factor by using artimatic mean, the obtained

The Fuzzy direct relation matrices among factors and Fuzzy lower limit of direct relation matrices are presented among factors in Tables 5 and 6. Results of factors inflence and susceptibility are presented in Tables 7 and 8.

Table 5
Fuzzy direct relation matrix

	C1			C2			C3			C4			C5			C6		
	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U
C1	0	0	0	0	0.25	0.5	0.55	0.8	1	0.1	0.35	0.6	0	0.03	0.28	0	0.1	0.35
C2	0.68	0.93	0.95	0	0	0	0.68	0.93	1	0.53	0.78	0.93	0.34	0.59	0.84	0	0.18	0.43
C3	0.08	0.23	0.45	0	0.25	0.5	0	0	0	0.18	0.4	0.65	0	0.25	0.5	0	0.1	0.35
C4	0.65	0.9	0.98	0.38	0.63	0.88	0.6	0.85	1	0	0	0	0.28	0.53	0.78	0	0.18	0.43
C5	0.58	0.83	0.95	0.6	0.85	1	0.48	0.73	0.98	0.65	0.9	1	0	0	0	0.05	0.3	0.55
C6	0.55	0.78	0.93	0.08	0.33	0.58	0.55	0.8	1	0.6	0.85	1	0.53	0.78	1	0	0	0

Table 6
Fuzzy lower limit of direct relation matrix

	C_{11}	C_{12}	C_{13}	C_{21}	C_{22}	C_{23}	C_{31}	C_{32}	C_{33}	C_{41}	C_{42}	C_{43}	C_{44}	C_{51}	C_{52}	C_{53}	C_{61}	C_{62}	C_{63}
C_{11}	0	0.5	0.594	0.094	0.5	0.313	0.594	0.594	0.594	0	0	0	0.063	0.125	0.031	0.063	0	0	0
C_{12}	0.156	0	0.656	0	0.344	0	0.656	0.594	0.5	0.156	0.156	0.156	0.156	0.125	0	0	0	0	0
C_{13}	0.094	0	0	0	0.656	0.156	0.75	0	0	0	0.313	0	0	0	0	0	0	0	0
C_{21}	0.594	0.594	0.594	0	0.656	0	0.75	0.75	0.594	0.594	0.594	0.594	0.594	0.188	0.156	0.156	0	0	0
C_{22}	0.563	0.156	0.406	0	0	0	0.594	0.75	0.656	0.281	0.438	0.281	0.281	0.313	0.344	0.156	0.156	0.156	0.156
C_{23}	0.656	0.594	0.594	0.656	0.594	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0	0	0	0.031	0.031
C_{31}	0	0.031	0.156	0.031	0.313	0	0	0	0.344	0.344	0.344	0.094	0.094	0	0	0.031	0.031	0	0
C_{32}	0	0.094	0.156	0.031	0.313	0	0.5	0	0.156	0.313	0.313	0.313	0.313	0	0	0	0	0	0
C_{33}	0.313	0	0.5	0.031	0.313	0.156	0.313	0.094	0	0	0.156	0	0	0	0	0	0	0	0
C_{41}	0.5	0.5	0.313	0.031	0.313	0.156	0.5	0.656	0.344	0	0.406	0.25	0	0	0	0	0	0	0
C_{42}	0.5	0.5	0.563	0.031	0.313	0.156	0.5	0.656	0.5	0	0	0.406	0	0	0	0	0	0	0
C_{43}	0.5	0.5	0.469	0.031	0.313	0.156	0.156	0.656	0.5	0	0	0	0.156	0	0	0	0	0	0
C_{44}	0.5	0.5	0.313	0.031	0.313	0.156	0.156	0.25	0.5	0.406	0.406	0.313	0	0	0	0	0	0	0
C_{51}	0.406	0.313	0.094	0.469	0.313	0.656	0.656	0.281	0	0.656	0.5	0.5	0.5	0	0	0.156	0	0.156	0.25
C_{52}	0.406	0.406	0.25	0.5	0.5	0.656	0.344	0.281	0	0.656	0.344	0.5	0.5	0.313	0	0.25	0.094	0.188	0.094
C_{53}	0.406	0.313	0.25	0.5	0.5	0.656	0.344	0.281	0	0.406	0.344	0.5	0.5	0.125	0	0	0	0.438	0.094
C_{61}	0.406	0.313	0.094	0.344	0.5	0.563	0.5	0.281	0	0.563	0.5	0.656	0.656	0.5	0.344	0.5	0	0.406	0
C_{62}	0.406	0.156	0.094	0.344	0.5	0.563	0.344	0.281	0.188	0.563	0.656	0.656	0.656	0.5	0.25	0.594	0	0	0.156
C_{63}	0.406	0.313	0.094	0.344	0.5	0.563	0.5	0.5	0.094	0.656	0.656	0.656	0.656	0.188	0.156	0.313	0.188	0.5	0

Table 7
Related $\widetilde{D}$ ‹$\widetilde{R}$ ‹$\widetilde{D}+\widetilde{R}$ ‹$\widetilde{D}-\widetilde{R}$ values to main factors

Factors	$\widetilde{D}^{def}$	$\widetilde{R}^{def}$	$\widetilde{D}+\widetilde{R}$	$\widetilde{D}-\widetilde{R}$
Flexibility	0.899	1.685	2.584	-0.786
Work experience	1.597	1.252	2.85	0.345
Quality	0.828	1.964	2.792	-1.136
Company's green operation management	1.511	1.569	3.08	-0.058
Logistics green industry	1.738	1.179	2.916	0.559
overnments green decision making	1.739	0.662	2.401	1.077

Table 8
Related $\widetilde{D}$ ‹$\widetilde{R}$ ‹$\widetilde{D}+\widetilde{R}$ ‹$\widetilde{D}-\widetilde{R}$ to sub factors

Factors/sub factors	$\widetilde{D}^{def}$	$\widetilde{R}^{def}$	$\widetilde{D}+\widetilde{R}$	$\widetilde{D}-\widetilde{R}$
Flexibility in incresing services capacity	0.261	0.19	0.451	0.071
Services pakaging	0.22	0.195	0.416	0.025
Commitment to agreed delivery time	0.149	0.245	0.394	-0.1
High skill	0.254	0.218	0.472	0.036
Validity	0.207	0.327	0.534	-0.12
Experience	0.284	0.2	0.484	0.085
Providing customer satisfaction	0.206	0.234	0.44	-0.03
Delivery without failure	0.217	0.177	0.382	-0.01
Order-based delivery	0.185	0.197	0.504	0.011
Manufacturing management and green packaging	0.257	0.247	0.549	-0.04
Transportation management and green distribution	0.256	0.293	0.512	-0.06
Green warhousing management	0.228	0.284	0.513	0.082
Green supply management	0.298	0.216	0.326	-0.02
Creating educational institutions for green logistics	0.151	0.175	0.322	0.041
Generalizing the policy of green logistics	0.182	0.14	0.322	-0.02
Creating an evaluation system for green logistics performance	0.152	0.17	0.313	0.021
Increasing advertisement of green logistics	0.167	0.146	0.354	-0.06
Planning for green logistics	0.149	0.205	0.329	0.034
Setting ruls and regulations for green logistics	0.182	0.147	0.382	-0.01
Generalizing the policy of green logistics	0.217	0.177	0.504	0.011
Creating an evaluation system for green logistics performance	0.185	0.197	0.549	-0.04

According to Table 4, Factors with positive $\widetilde{R}+\widetilde{D}$ prove their own definite influence but factors with negative $\widetilde{R}-\widetilde{D}$ represent their definite susceptibility. Therefore, "governments green decision making" by the effect value of 1.076 is the most effective and "quality" with the net value of -1.136 is the most susceptible one within main factors. Finally cause and effect relationships are presented in a Cartesian coordinate system by drawing $\widetilde{R}+\widetilde{D}$ and $\widetilde{R}-\widetilde{D}$ coordinates based on $\widetilde{T}$ matrix. The resulted cause and effect diagram is shown in Figure 3.

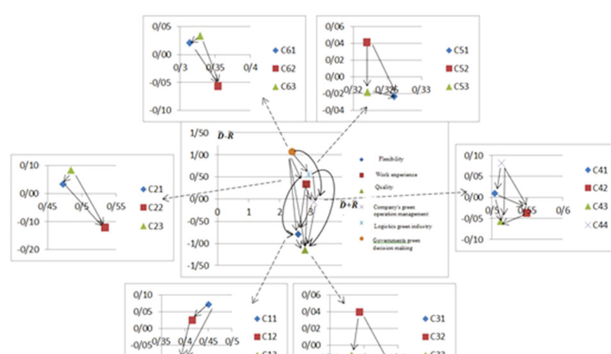

Fig. 3. Cause and effect diagram between main and sub-factors

Figure 3 represents the importance level, influence and susceptibility by the main factors. The horizontal axis ($\widetilde{R}+\widetilde{D}$) shows the importance level of factors and the vertical axis ($\widetilde{D}-\widetilde{R}$) is a representative for influence or susceptibility. Thus, we can conclude that factors priorities in terms of influence are as follows regarding ($\widetilde{D}-\widetilde{R}$) value.

1. Governments green decision making ($\widetilde{D}-\widetilde{R}$ 1.076)
2. Logistics green industry ($\widetilde{D}-\widetilde{R}$ 0.559)
3. Work experience ($\widetilde{D}-\widetilde{R}$ 0.345)
4. Company's green (operation) management ($\widetilde{D}-\widetilde{R}$ -0.058)
5. Flexibility/time ($\widetilde{D}-\widetilde{R}$ -0.786)
6. Quality ($\widetilde{D}-\widetilde{R}$ -1.136)

In this step, we start solving fuzzy ANP based on total communications matrix which shows factors influence and susceptibility levels. In this section, total communication matrix is normalized at first and then harmonious super matrix is created. It should be noted that unmatched matrix is the same as total communication matrix. After normalizing, we converge harmonious super matrix in power 9 to create a limited super matrix. After solving analytical network process model by Excel software, the obtained results by limited super matrix will be presented in Table 9.

As Table 9 demonstrates, the highest weight is allocated to "providing customer satisfaction" which stands in the first order in terms of priority. Other factors are prioritized as follows: delivery without failure, commitment to agreed delivery time, order-based delivery, transportation management and green distribution, and finally, flexibility in increasing services capability stand in second, third, fourth, fifth and sixth order respectively among 19 factors and allocate about 49.2 % of total weight to themselves. This percent verifies the high importance of these sub factors. Figures 4 and 5 represent main factors and sub factors final priority charts using FANP method, respectively.

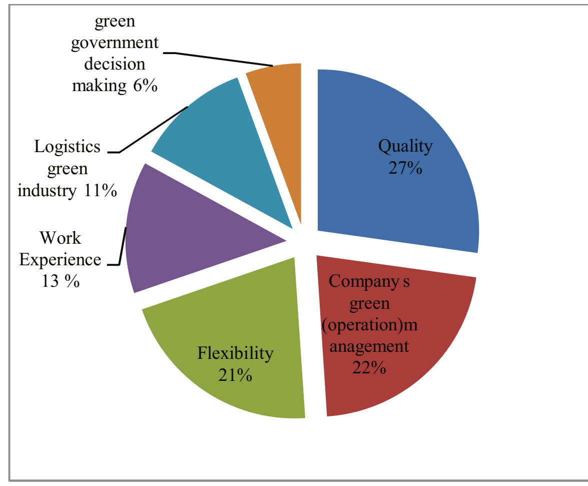

Fig. 4. Main factors relative priority chart

Table 9
Weights and priorities of effective factors in strategic outsourcing

Main factors weight and priority		Sub factors	Code	Sub factors relative wight and priority	Sub factors final weights and priority	Sub factors final weights and priority	Sub factors relative wight and priority
Flexibility C_1	0.208	Flexibility in increasing services capacity	C_{11}	0.324	(2)	0.067	(6)
	(3)	Categorising services	C_{12}	0.295	(3)	0.061	(8)
		Commitment to the agreed delivery time	C_{13}	0.381	(1)	0.079	(3)
Work Experience C_2	0.132	High skill	C_{21}	0.239	(3)	0.032	(16)
	(4)	fame	C_{22}	0.464	(1)	0.061	(7)
		experience	C_{23}	0.296	(2)	0.039	(13)
Quality C_3	0.272	Providing customer satisfaction	C_{31}	0.414	(1)	0.113	(1)
	(1)	Delivery without failure	C_{32}	0.296	(2)	0.08	(2)
		Order-based delivery	C_{33}	0.29	(3)	0.079	(4)
Company s green (operation) management C_4	0.217	Green packaging and manufacturing management	C_{41}	0.242	(2)	0.053	(9)
	(2)	Green distribution and transportation management	C_{42}	0.338	(1)	0.074	(5)
		Green warhousing mangement	C_{43}	0.22	(3)	0.048	(10)
		Green supply management	C_{44}	0.2	(4)	0.043	(11)
Logistics green industry C_5	0.114	Establishing educational institution of green logistics knowledge	C_{51}	0.358	(1)	0.041	(12)
	(5)	Generalizing the policy of green logistics	C_{52}	0.318	(3)	0.036	(15)
		Creating an evaluation system for green logistics performance	C_{53}	0.324	(2)	0.037	(14)
Governments green decision making C_6	0.056	Increasing advertisement of green logistics	C_{61}	0.316	(3)	0.018	(19)
	(6)	Planning for green logistics	C_{62}	0.364	(1)	0.02	(17)
		Setting ruls and regulations for green	C_{63}	0.32	(2)	0.018	(18)

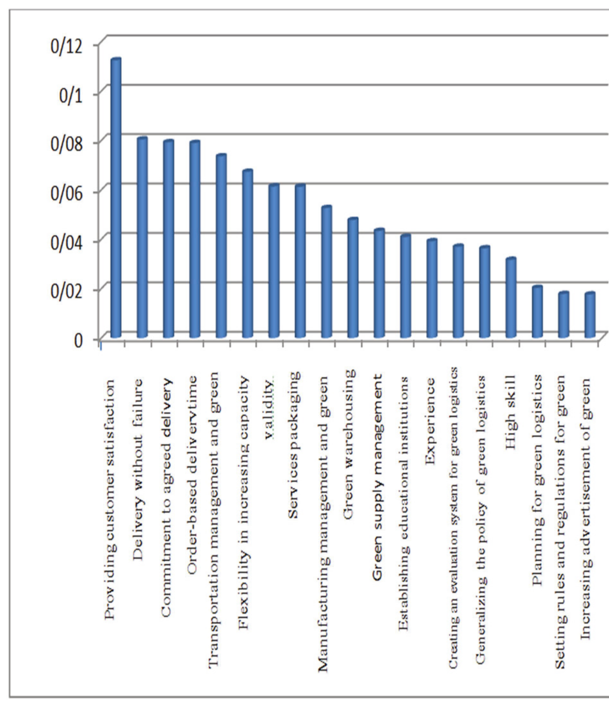

Fig. 5. Sub factors final priority chart

The results of indicate that the highest weight of criteria is the quality, green management (operation), flexibility, work experience respectively (Figure 5). Work experience was the fourth priority, which is consistent with the Dejiang (2009), in which the work experience is in the fourth priority.

4.2. *Creating house of quality matrix*

Figure 6 indicates the House of quality matrices in this research.

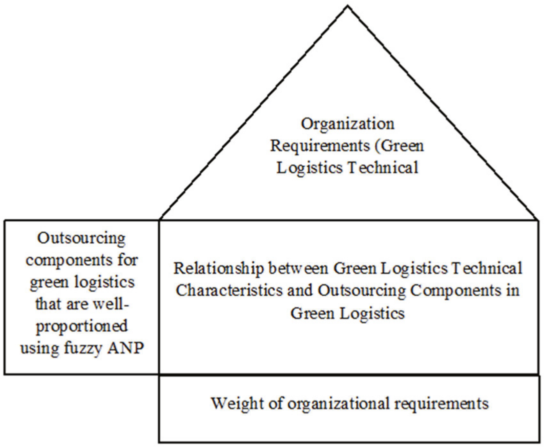

Fig. 6. House of quality matrices

Table 7 demonstrates a house of quality matrix which was filled by the experts. The results arising from house of quality demonstrate that "offering comfortable and appropriate custom logistics services" stands in the first order, "implementing transportation infrastructures in accordance with issuing green policies" stands in the second order, and "Acquiring required skills and work experience in similar industries" stands in the third order which shows the importance of these requirements in comparison to the other ones. After determining the importance of requirements, in the next step, 6 decision makers (Hojat, 1395) determined the importance of each requirement based on 3-point Likert scale to select 4 options (green logistics outsourcing companies). Then, their comments were summed up using geometric mean and decision making matrix was created. Since 7 criteria have been used to evaluate 4 companies in green logistics outsourcing in this research, we will have a $D_{4\times 7}$ decision making matrix. This matrix has been presented in Table 10.

Table 10

Expanding qualitative performance

Needs or alternatives weights		Organizations requirements								
		1. capability of being Compatible with customers' needs	2. Acquiring required skills and work experience in similar industries	3. offering comfortable and appropriate custom logistics services	4. integrating green supply chain	5. teaching green logistics	6. organization and government support	7. implementing transportation infrastructures in accordance with issuing green policies		
1. flexibility	0.208	9	7	7	7	1	1.67	7		
2. work experience	0.1323	7	9	7	5	7		9		
3. quality	0.272	7	5	9	5	1.67	1	5		
4. company's green management	0.2175	1.67	7	2.33	9	7	7	7		
5. logistics green industry	0.1143	0.67	7	7	5	9	7	7		
6.Governments green decision making	0.0559	2.33		7	2.33	2.33	9	2.33		
weight	Absolute weight	5.272753	6.3293	6.528275	6.136747	4.269887	3.44506	6.459547	38.44087	summation
	Relative weight	0.137	0.165	0.17	0.16	0.111	0.09	0.168	0.889	

After creating decision making matrixes for each criterion (maximum and minimum), superiority threshold, indifference threshold and the type of superiority function. In the present study, third type function has been used based on experts and instructors. By changing scores from 1 to 9, priority with vary based on a linear trend and if the difference is more than 5 there will be full preference. This function is the same as equation (19) which was mentioned in solution methods section. Criteria's weights have also been calculated by using ANP technique which was combined by QFD. Therefore, final decision making matrix by SIR technique is presented in Table 11.

Table 11

Final decision making matrix by SIR technique

Criteria	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*
type	+	+	+	+	+	+	+
w	0.137	0.165	0.17	0.16	0.111	0.09	0.168
A1	2.08	8.277	4.217	6.257	3	6.257	6.257
A2	6.257	7	2.08	3	4.217	2.08	4.217
A3	4.217	6.257	2.08	1	1	4.217	8.277
A4	8.277	4.217	6.257	7	4.217	8.277	8.277
function	3	3	3	3	3	3	3
q	—	—	—	—	—	—	—
P	5	5	5	5	5	5	5

We use simple additive weighting model to obtain inferiority and superiority flows matrixes. SAW model is one of the simplest and clearest means which is mainly used for comparing results of different methods. In this research, we extracted S, I, n and r superiority flow values based on SAW method as Table 12.

Table 12

Flow values based on SAW model

Superiority flow values	**Inferiority flow values**	**Net flow values**	**Relative flow values**
S- flows	**I- flows**	**n- flows**	**r- flows**
Ø^> (A_1) = 0.884	Ø^< (A_1) = 0.535	Ø_n (A_1) = 0.349	$\emptyset_r(A_1) = 0.623$
Ø^> (A_2)=0.449	Ø^< (A_2)= 1.109	Ø_n (A_2)=-0.66	Ø_r (A_2)= 0.288
Ø^> (A_3)=0.368	Ø^< (A_3)= 1.193	Ø_n (A_3)=-0.82	Ø_r (A_3)= 0.236
Ø^> (A_3)=0.368	Ø^< (A_4)= 0.293	Ø_n (A_4)=1.263	Ø_r (A_4)= 0.842

Therefore, using SAW method and according to Table (8), ranking $R_>$ (superiority flow values) and $R_<$ (inferiority flow values) are as follows:

$R_>$: $A_4 \rightarrow A_1 \rightarrow A_2 \rightarrow A_3$

$R_<$: $A_4 \rightarrow A_1 \rightarrow A_2 \rightarrow A_3$

Furthermore, ranking R_n (net flow values) and R_r (relative flow values) is as follows by using SAW method and according to table (8):

R_n: $A_4 \rightarrow A_1 \rightarrow A_2 \rightarrow A_3$

R_r: $A_4 \rightarrow A_1 \rightarrow A_2 \rightarrow A_3$

The obtained results by performed calculations in SIR model using SAW methods demonstrated that A_4 is the best factor. Therefore, we can certainly acknowledge that A_4 can be regarded as the final decision making choice.

5. Discussion and conclusion

In this research, we tried our best to exploit three combinational methods of QFD, SIR, FANP with the help of FDEMATEL to find the best supplier. Strategic outsourcing for green logistics is a topic which has been neglected to some extent. Accordingly, this research extracts and categorizes outsourcing components (criteria) and sub criteria for green logistics (first step) by evaluating previous studies and then 13 criteria and 38 sub criteria are identified based on experts and specialists' comments and their importance is evaluated in a questionnaire framework (second step). Finally, 6 criteria and 19 sub criteria are identified (third step) and evaluated according to research target and combined QFD and FANP decision making methods with the help of FDEMATEL and SIR.

This research mainly addresses QFD method. Every single step in this research even analytical network process method is done in a QFD model frame. This problem can follow the presented target to access a desirable and acceptable level of suppliers in order to acquire a special quality of technical features and services characteristics and flatten the way toward this target. Considering relationships among products technical features, evaluation criteria and also criteria's correlation approach us to this target (forth step). On the other hand, ANP method is able to consider internal correlations among evaluation criteria using a wide variety of network analyses and enhances the power of solving this problem (fifth step). Finally, SIR method changes house of quality matrix into 2 matrixes of Inferiority and Superiority by getting advantage of its 6 types functions feature and calculates each criterion's distance to its ideal value and another weight is obtained by evaluation criteria as the result (sixth step). We hope the proposed method finds many ways in practical scopes and plays a negligible role in outsourcing implementation for green logistics.

Various multi criteria decision making approaches have been used to overcome logistics outsourcing. The obtained results are as follows: In 2015, Wan et al. offered fuzzy linear programming for selecting logistics services supplier. They formulated and provided logistics outsourcing supplier's selection as a kind of group decision making problem with intuitive fuzzy preference relations (IFRs). In 2016, Govindan, and Chaudhuri analysed the relationships among dangers which threaten logistics services suppliers while facing one of their customers. Their proposed approach was DEMATEL.

As mentioned before, outsourcing evaluation for green logistics was done using combinational QFD and fuzzy multi criteria decision making approaches in a Petrochemical industry. In other words, QFD was used in petrochemical industry for green logistics which is regarded to be a new research and contributes to logistics literature.

Green principles and strategies have become vital for companies as the public awareness increased against their environmental impacts. A company's environmental performance is not only related to the company's inner environmental efforts, but also it is affected by the suppliers' environmental performance and image (Büyüközkan and Çifçi, 2012).

The implication of this study addresses for some further studies for researches. Considering environmental protection has become one of the key issues in the organization's policy and vision, this research will conserve natural resources, as well as reduce waste and improve the performance of the organization. Since fuzzy analytical network, superiority and inferiority methods were used in this research, applying combinational fuzzy QFD and multi criteria decision making methods such as fuzzy interval, VIKOR, Fuzzy Interval TOPSIS and Fuzzy SIR can be great scope to work for further researches. Moreover, while calculating QFD, it is also possible to evaluate the effect of features correlations by adding correlation matrixes calculations. It is also possible to evaluate relationships by considering sub criteria in QFD matrix and determining related technical requirements to the selected criteria in the house of quality matrix. Optimizing criteria using Data Envelopment Analysis (DEA) and linear programming is another scope which is worth trying.

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