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Selecting the green supplier by identification and weighting parameters and fuzzy decision making approach: a case study of Iran Khodro Co

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Abstract: Effective evaluation and selection of suppliers is an important task that must be always considered. This is a vital issue due to its impacts on final products of organization. There is a need to supplier management due to function improvement and control of existing risks; and it is necessary to evaluate and select the supplier based on parameters consistent with environment. Cooperation with suppliers which are strong in terms of economic, social and environmental will improve function of supply chain. Firms need to suppliers that accept environmental parameters and evaluate cost of loss in their operational systems to assure environmental quality of the products. In terms of research, this paper is applied one and is descriptive in terms of data gathering.in this research, our case study ids Iran Khodro company. First, the parameters of selecting green suppliers are identified by use of literature and then a questionnaire is designed by Delphi-fuzzy method. The experts under investigation are from university professors, industrial experts and senior managers of Iran Khodro. Then, a questionnaire was sent for experts in order to pair comparisons and at last the suppliers introduced by the firm are evaluated and classified by fuzzy method. Results show that suitable parameters for selecting green supplier include social accountability of firm, contamination, green innovation, green product and environmental management system, quality of services, delivery, financial functionality, technology, communications, management system, process management, supply ability and flexibility. Based on determined parameters and by use of hierarchical analysis process and fuzzy method, the 2nd, 5th and 6th suppliers are the most suitable suppliers of green supply chain.

Key words: Management of green supply chain; Green supplier selection; Fuzzy multi criteria decision making

1. Introduction

Globalization, increase of rules in public and private organizations, and customers' demand about environmental issues all caused that organizations attend to necessary actions for implementing management of green a supply chain. Management of green supply chain integrates supply chain management with environmental requirements in all levels of product design and supplying raw material, production, transport and distribution processes, delivery to customer and finally waste and reuse management in order to maximizing the amount of energy efficiency and resources with improvement in overall function of supply chain. In the recent years, firms had used parameters such as cost, delivery, services, flexibility and.. to select their suppliers. All researchers in the field of supply chain management are agreed with the idea that suppliers have a significant role in competitive advantage of a firm. Thus, supply chains should change their move to the direction that is called 'green supply chain'. In the new manufacturing sphere, supplier is main part of supply chain and selecting the proper supplier helps the company to provide products with proper quality, with the amount required and suitable price in required time. Effective evaluation and selection of suppliers is an important task that must always be considered; it is a crucial issue because of its effects on final products of firm. There is a need to supplier management due to function improvement and control of existing risks; and it is necessary to evaluate and select the supplier based on parameters consistent with environment. Cooperation with suppliers which are strong in terms of economic, social and environmental will improve function of supply chain. Firms need to suppliers that accept environmental parameters and evaluate cost of loss in their operational systems to assure environmental quality of the products. In fact, green suppliers and evaluating and selecting them is a vital process in management of green supply chain.

Supply change management is a concept that all firms enjoy it with any type of activity and any size; specially, when a firm is looking for development and improvement of purchase, assign and design its products consistent with environment. Thus, it is of high importance to select a supplier that can help the firm to achieve its goal. The evidence for this claim is observed in recent studies in the field of supply chain management and selecting the supplier; it shows that main concern of researchers is identifying the gaps in literature about green companies and suppliers. In the recent years, the increase in rules of public and private firms (environmental friendly) and demand of customers

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from automobile factories such as Iran Khodro has led its senior managers to discuss about policies of green products. Therefore, bossiness partners such as environmental friendly suppliers must be in the spotlight due to required policies and manufacturing green products compatible with environment. On the other hand, Iran Khodro must strength its green and sustainable management in order to gain high level of international manufacturers. In addition to current fees, managers of supply chain must consider environmental dimensions and social costs of their decisions. According to previous studies about the topic it is now revealed that little research activities has conducted for automobile industry, especially Iran Khodro Company. The current study design a pattern to select the green supplier for Iran Khodro , besides it follows three main goals. First, extracting the parameters of green supplier for Iran khodro as one of the biggest automobile manufactures in Iran. Second, ranking of suppliers with green function and the last goal of this research is presenting an integrated combined method composed of three Delphi, fuzzy hierarchical analyses process and Vikor approaches.

1.1. Research background

Govindan et al(2013) state in an article that although there is much ;literature about selecting and evaluating the supplier but papers with the focus of environmental factors are rare and limited; and recently qualitative and quantitative environmental data are used in the domain of decision making and management of supply chain. The results of their study show that AHP method is one of the most useful methods for problems of selecting and evaluating the green supplier. Of the parameters used in these papers, they demonstrate that parameters of quality and environmental management system are the main parameters used in literature of traditional and environmental supplier.

Kenan et al (2014) show in their study the commitment of senior manager to management of green supply chain and design of product so that it leads to reduction, reuse, recycling and adjustment of materials and energy; the parameters of green supplier include inspection programs, environmental legal obligations and also designing the product to reduce and/or non-use of hazardous and toxic substances.

In a research conducted by Kou et al (2010), they evaluated and selected supplier by using three methods of analytic network process, artificial neural network and data coverage analysis. They used parameters such as quality, services, delivery and cost as traditional parameters, and environment and social accountability of the firm as environmental ones.

In addition to 6 parameters of quality, cost, delivery, time, flexibility and process management, Daewoo et al (2014) consider parameters of green liability, green image, cost of living, environmental efficiency, green design and system of environmental management as the parameters to assess and select the supplier in the discussed literature. They also classify environmental; parameters in terms of pollution control, pollution prevention, environmental management system, resources utilization and contamination.

2. Research method

The current study is applied in terms of goal and descriptive in terms of method. Its goal is to identify and classify the green suppliers in green supply chain of Iran Khodro Company. The population of this research is academic experts, senior managers, operational managers and customers of Iran Khodro. The data required for this research were also gathered by library studies and then questionnaire.

2.1. Analysis of the data

In the first step, the Delphi –fuzzy method is used to determine parameters of selecting green suppliers. The first level of this process, is selecting the experts. The basics of selecting this people are proximity of work field, experience and knowledge and also having motivations and interest for participation in this process. Meanwhile, the considered problem is justified for experts well. According to the opinion of Delbeck et al (1975), the most desirable mood is for 8-15 persons in this research. Two groups of people (professors of supply chain management and also experts and managers of automobile industry) are used in this research due to subject of the research (ea. knowledge management); finally, 10 experts were selected and arrangements for implementing the process were performed.

In the next step, the questionnaire will be sent for experts. The questionnaires will be collected after completion and results will be sent for experts again till they present their opinion about results of early stage. After collecting and analyzing opinions of experts, the mean (average) of their ideas is studied. If this difference is less than 0.2 it is concluded that they had reached consensus; unless the analysis of results will be send for them again.

This process continues till the experts reach consensus about all parameters. If they decide to add a parameter, it would be added to the questionnaire in the next stage.

2.2. Prioritization of parameters using fuzzy analytic hierarchy process

In this section, parameters of selecting the green supplier are weighted using Fuzzy analytic hierarchy process:

2.3. Prioritization of parameters selecting green supplier

Since number of experts is 10 persons in this method, thus there are 10 different matrices for comparison of parameters. If we assume that $\tilde{a}_{ij}^{k}$ is the relative component of respondent K to compare parameter i to j, then geometric average of corresponding parameters is calculated by equation below:

$$\tilde{a}_{ij} = \left(\prod_{k=1}^{n} \tilde{a}_{ij}^{k}\right)^{\frac{1}{n}} \quad \tilde{a}_{ij} = (\tilde{a}_{ij}^{1} \otimes \tilde{a}_{ij}^{2} \otimes \ldots \otimes \tilde{a}_{ij}^{10})^{\frac{1}{10}}$$

Using the formula above, comparison of indicators will be obtained:

Table 1: initial matrix of parameters' paired comparison after combining experts' ideas

	C1			C2			C3			C4			C5			C6			C7		
C1	1.00	1.00	1.00	0.90	1.12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.57	2.02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.11	[illegible]	[illegible]	[illegible]
C2	[illegible]	[illegible]	[illegible]	1.00	1.00	1.00	[illegible]	[illegible]	[illegible]	1.00	1.57	2.11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.00	1.00	1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.00	1.00	1.00	1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.00	1.00	1.00	1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.00	1.00	1.00	[illegible]	[illegible]	[illegible]
C7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.00	1.00	1.00

Calculating consistency rate for combined matrix of green parameters

First, we defuzzicate the fuzzy numbers by the equation below:

$$S_j = \frac{a_j + 4b_j + c_j}{6}, \quad j = 1,2,\ldots,m$$

Then, the weighted sum vector is calculated. To calculate this vector, the initial values of group comparisons (table 2) are multiplied in overall priority vector (final weight of indicators), and sum of each line is calculated:

Table 2: values of weighted sum vector for green parameters

parameter	WSV
C1	1.73
C2	1.59
C3	0.8
C4	1.17
C5	0.82
C6	0.767
C7	0.43

By dividing each parameter of the vector above on parameters priority vector, the consistency vector (C.V) is calculated:

Table 3: values of consistency vector for green parameters

parameter	C.V
C1	7.43
C2	7.46
C3	7.24
C4	7.47
C5	6.71
C6	7.5
C7	7.35
average	7.31

Then, consistency index (C.I) is calculated by the equation below:

$$C.I = \frac{7.31 - 7}{6} = 0.052$$

Where n is number of options and λ_{max} is average of consistency vector.

Finally, consistency rate is obtained:

$$C.R = \frac{C.I}{R.I}$$

Where R.I (rate index) shows value of random index. This index is extracted due to number of options and by table of random consistency index. As regards n= 7 in the relation above, thus R.I= 1.32. As a result, we have:

$$C.R = \frac{C.I}{R.I} = \frac{0.052}{1.32} = 0.033$$

Since the calculated consistency index is much less than 0.1, it can be said that group paired comparisons in the matrix of table (5) have good consistency, and the model is completely meaningful.

2.4. Calculating the fuzzy weights of green parameters

According to fuzzy analytic hierarchy process, the information of parameters combined matrix is analyzed the following steps; for example, the value of first parameter is calculated as below:

$$\tilde{r}_1 = (\tilde{a}_{11} \otimes \tilde{a}_{12} \otimes \tilde{a}_{13} \otimes \tilde{a}_{14} \otimes \tilde{a}_{15} \otimes \tilde{a}_{16} \otimes \tilde{a}_{17})^{\frac{1}{7}}$$

In the relation above, the triangular fuzzy number (0.32, 0.43, 0.6) is fuzzy value of first parameter against second one, and (0.9086, 1.1451, 1.4622) is fuzzy value of first parameter against 6 other ones.

Then, we determine fuzzy weights of parameters:

$$\tilde{W}_1 = \tilde{r}_1 \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3 \oplus \tilde{r}_4 \oplus \tilde{r}_5 \oplus \tilde{r}_6 \oplus \tilde{r}_7)^{-1}$$

We multiply each parameter in reverse of their total fuzzy. For example, we obtain fuzzy weight of first parameter as follows:

Table 4: fuzzy values of parameters paired comparisons

$\tilde{r}_i$	lr_i	mr_i	ur_i
$\tilde{r}_1$	1.4	1.78	2.14
$\tilde{r}_2$	1.27	1.59	1.96
$\tilde{r}_3$	0.765	0.951	1.185
$\tilde{r}_4$	0.927	1.17	1.46
$\tilde{r}_5$	0.765	0.921	1.124
$\tilde{r}_6$	0.599	0.75	0.951
$\tilde{r}_7$	0.398	0.47	0.583

$$\widetilde{W}_1 = \tilde{r}_1 \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3 \oplus \tilde{r}_4 \oplus \tilde{r}_5 \oplus \tilde{r}_6 \oplus \tilde{r}_7)^{-1}$$

$$\widetilde{W}_1 = (1.4,1.78,2.14) \otimes (1/(2.14 + 1.96 + 1.185 + 1.46 + 1.124 + 0.951 + 0.583), 1/(1.78 + 1.59 + 0.951 + 1.17 + 0.921 + 0.75 + 0.47), = 1/(1.4 + 1.27 + 0.765 + 0.927 + 0.765 + 0.599 + 0.398) = (0.15,0.233,0.349)$$

The fuzzy weight of first parameter is (0.15, 0, 233, 0.349). Table 5 shows total fuzzy weights:

Table 5: fuzzy weights of parameters

$\widetilde{W}_j$	lw_j	mw_j	uw_j	**Defuzzy weight**	**Rate**
$\widetilde{W}_1$	**0.15**	**0.233**	**0.349**	**0.24**	**1**
$\widetilde{W}_2$	**0.135**	**0.209**	**0.321**	**0.22**	**2**
$\widetilde{W}_3$	**0.081**	**0.124**	**0.193**	**0.13**	**4**
$\widetilde{W}_4$	**0.098**	**0.153**	**0.238**	**0.16**	**3**
$\widetilde{W}_5$	**0.081**	**0.121**	**0.183**	**0.12**	**5**
$\widetilde{W}_6$	**0.064**	**0.098**	**0.155**	**0.1**	**6**
$\widetilde{W}_7$	**0.042**	**0.062**	**0.095**	**0.06**	**7**

2.5. Prioritization of parameters selecting traditional supplier

As mentioned before, since number of experts is 10 persons in this method, thus there are 10 different matrices for comparison of parameters. The method of fuzzy analytic hierarchy process firstly transforms these matrices to a single one. Geometric average is one the best methods in order to combine tables of paired comparisons for all respondents. The reason is that paired comparisons create data in terms of 'ratio'; in addition the comparison matrix being reverse, makes this method more justified since geometric average maintains reverse features in matrix of paired comparisons. If we assume that is the relative component of respondent K to compare parameter i to j, then geometric average of corresponding parameters is calculated by equation below:

$$\tilde{a}_{ij} = \left(\prod_{k=1}^{n} \tilde{a}_{ij}^{k}\right)^{\frac{1}{n}}$$

$$\tilde{a}_{ij} = (\tilde{a}_{ij}^{1} \otimes \tilde{a}_{ij}^{2} \otimes \ldots \otimes \tilde{a}_{ij}^{10})^{\frac{1}{10}}$$

$$\tilde{a}_{12} = ((1,2,3) \otimes (1,1,1) \otimes (1.67,0.2,0.25) \otimes (4,5,6) \otimes (2,3,4) \otimes (0.2,0.33,0.5) \otimes (6,7,8) \otimes (2,3,4) \otimes (1,2,3) \otimes (2,3,4))^{\frac{1}{10}} = (1.23,1.73,2.26)$$

Using the formula above, comparison of indicators is obtained interms of group.

2.6. Calculating the consistency rate for combined matrix of traditional parameters

First, we defuzzicate the fuzzy numbers using the relation below:

$$S_j = \frac{a_j + 4b_j + c_j}{6}, \quad j = 1,2,\ldots,m.$$

Then, the weighted sum vector (WSV) is calculated. To calculate this vector, the initial values of group comparisons (Table 6) are multiplied in overall priority vector (final weight of indicators), and sum of each line is calculated.

By dividing each parameter of the vector above by parameters' priority vector, the consistency vector (C.V) is calculated.

Then, consistency index (C.I) is calculated by the equation below:

$$CI = \frac{\lambda_{max} - n}{n} = \frac{14.536 - 13}{13} = 0.118$$

Where n is number of options and λ_{min} is average of consistency vector.

Finally, consistency rate is obtained:

$$C.R = \frac{C.I}{R.I}$$

Where R.I (rate index) shows value of random index. This index is extracted due to number of options and by table of random consistency index. As regards n= 13 in the relation above, thus R.I= 1.56. As a result, we have.

Table 6: initial matrix of paired comparison after combining data for traditional parameters

	C1			C2			C3			C4			C5			C6			C7		
C1	1	1	1	1.23	1.73	2.26	2.08	2.59	3.14	1.23	1.66	2.08	2.26	2.94	3.56	3.65	4.47	5.18	2.81	3.44	4.09
C2	0.44	0.57	0.81	1	1	1	1.39	1.84	2.37	0.69	0.98	1.37	1.39	1.88	2.39	2.56	3.62	4.65	2.06	2.55	3.02
C3	0.31	0.38	0.49	0.42	0.54	0.72	1	1	1	0.42	0.54	0.74	0.93	1.1	1.32	1.31	1.63	2.08	1.25	1.6	1.91
C4	0.48	0.6	0.81	0.73	1.02	1.45	1.34	1.85	2.39	1	1	1	1.2	1.5	1.8	2.58	3.31	3.93	1.99	2.64	3.38
C5	0.28	0.34	0.44	0.42	0.53	0.72	0.76	0.98	1.2	0.55	0.67	0.84	1	1	1	1.2	1.54	2	1.2	1.52	1.78
C6	0.19	0.22	0.27	0.211	0.28	0.39	0.48	0.61	0.76	0.25	0.32	0.43	0.5	0.65	0.84	1	1	1	0.62	0.88	1.23
C7	0.24	0.29	0.35	0.33	0.39	0.49	0.58	0.67	0.8	0.29	0.38	0.5	0.56	0.66	0.84	0.81	1.13	1.62	1	1	1
C8	0.31	0.4	0.53	0.56	0.66	0.82	0.89	1.19	1.53	0.44	0.57	0.78	0.75	0.96	1.3	1.3	1.65	2.14	1.41	1.7	2.11
C9	0.18	0.23	0.31	0.35	0.44	0.55	0.55	0.67	0.85	0.41	0.55	0.72	0.5	0.63	0.8	0.85	1.04	1.28	0.66	0.83	1.03
C10	0.49	0.63	0.87	0.95	1.1	1.3	1.29	1.66	2.06	0.76	1.14	1.53	1.54	1.98	2.45	2.45	3.28	4.14	2.04	2.57	3.13
C11	0.16	0.18	0.22	0.22	0.28	0.38	0.344	0.44	0.6	0.19	0.22	0.27	0.28	0.37	0.54	0.63	0.82	1.04	0.43	0.55	0.76
C12	0.13	0.15	0.17	0.16	0.19	0.24	0.26	0.32	0.4	0.16	0.19	0.23	0.24	0.3	0.41	0.41	0.51	0.63	0.3	0.38	0.5
C13	0.18	0.23	0.31	0.31	0.36	0.43	0.45	0.54	0.69	0.21	0.27	0.4	0.49	0.61	0.82	0.71	0.91	1.23	0.69	0.9	1.15

Table 7: values of weighted sum vector for traditional parameters

Parameter	WSV
C1	3.03
C2	2.044
C3	1.061
C4	1.99
C5	0.848
C6	0.376
C7	0.668
C8	1.246
C9	0.571
C10	2.165
C11	0.286
C12	0.214
C13	0.44

$$C.R = \frac{C.I}{R.I} = \frac{0.118}{1.56} = 0.076$$

Since the calculated consistency index is much less than 0.1, this it can be said that group paired comparisons in the matrix of table (6) have good consistency, and the model is completely meaningful.

2.7. Calculating the fuzzy weights of traditional parameters

According to fuzzy analytic hierarchy process, the information of parameters combined matrix is analyzed the following steps; first, we identify geometric average of parameter J to other parameters. Thus, we have:

Table 8: values of consistency vector for traditional parameters

parameter	C.V
C1	15.156
C2	15.35
C3	14.98
C4	15.13
C5	14.023
C6	13.53
C7	14.255
C8	15.255
C9	13.82
C10	15.56
C11	13.872
C12	14.301
C13	13.737

$$\tilde{r}_1 = (\tilde{a}_{11} \otimes \tilde{a}_{12} \otimes \tilde{a}_{13} \otimes \tilde{a}_{14} \otimes \tilde{a}_{15} \otimes \tilde{a}_{16} \otimes \tilde{a}_{17} \otimes \tilde{a}_{18} \otimes \tilde{a}_{19} \otimes \tilde{a}_{110} \otimes \tilde{a}_{111} \otimes \tilde{a}_{112} \otimes \tilde{a}_{113})^{\frac{1}{13}}$$

For example, the value of first parameter is calculated as below:

$$\tilde{r}_1 = \begin{pmatrix} (1,1,1) \otimes (1.23,1.73,2.26) \otimes (2.08,2.59,3.14) \otimes (1.23,1.66,2.08) \otimes (2.26,2.94,3.56) \\ (3.65,4.47,5.81) \otimes (2.81,3.44,4.09)(1.89,2.51,3.2) \otimes (3.23,4.37,5.37) \otimes \\ (1.15,1.58,2.05) \otimes (4.44,5.43,6.35) \otimes (5.85,6.69,7.47) \otimes (3.23,4.36,5.4) \end{pmatrix}^{\frac{1}{13}} = (2.272,2.876,3.456)$$

In the relation above, the triangular fuzzy number (1.23, 1.73, 2.26) is fuzzy value of first parameter against second one, and (2.272, 2.876, 3.456) is fuzzy value of first parameter against 12 other ones.

Table 9: fuzzy values of paired comparisons for traditional parameters

$\tilde{r}_i$	lr_i	mr_i	ur_i
$\tilde{r}_1$	2.272	2.876	3.456
$\tilde{r}_2$	1.454	1.847	2.271
$\tilde{r}_3$	0.879	1.091	1.355
$\tilde{r}_4$	01.455	1.878	2.376
$\tilde{r}_5$	0.864	1.094	1.364
$\tilde{r}_6$	0.511	0.641	0.816
$\tilde{r}_7$	0.608	0.752	0.935
$\tilde{r}_8$	0.943	1.183	1.492
$\tilde{r}_9$	0.582	0.721	0.894
$\tilde{r}_{10}$	1.589	1.993	2.431
$\tilde{r}_{11}$	0.383	0.472	0.607
$\tilde{r}_{12}$	0.271	0.326	0.405
$\tilde{r}_{13}$	0.526	0.654	0.836

Then, we determine fuzzy weights of parameters:

$$\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3 \oplus \tilde{r}_4 \oplus \tilde{r}_5 \oplus \tilde{r}_6 \oplus \tilde{r}_7 \oplus \tilde{r}_8 \oplus \tilde{r}_9 \oplus \tilde{r}_{10} \oplus \tilde{r}_{11} \oplus \tilde{r}_{12} \oplus \tilde{r}_{13})^{-1}$$

We multiply each parameter in reverse of their total fuzzy. For example, we obtain fuzzy weight of first parameter as follows:

$$\tilde{w}_1 = \tilde{r}_1 \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3 \oplus \tilde{r}_4 \oplus \tilde{r}_5 \oplus \tilde{r}_6 \oplus \tilde{r}_7 \oplus \tilde{r}_8 \oplus \tilde{r}_9 \oplus \tilde{r}_{10} \oplus \tilde{r}_{11} \oplus \tilde{r}_{12} \oplus \tilde{r}_{13})^{-1}$$

$$\tilde{w}_1 = (2.272,2.876,3.456) \otimes \begin{pmatrix} 1 \Big/ \begin{pmatrix} 0.836+0.405+0.607+2.431+0.894+1.492+0.935+0.816+1.364+2..376 \\ +1.355+2.271+3.456 \end{pmatrix}, \\ 1 \Big/ \begin{pmatrix} 0.654+0.326+0.472+1.993+0.721+1.183+0.752+0.641+1.094+1.878+ \\ 1.091+1.847+2.876 \end{pmatrix}, \\ 1 \Big/ \begin{pmatrix} 0.526+0.271+0.383+1.589+0.582+0.943+0.608+0.511+0.864+1.455+ \\ 0.879+1.454+2.272 \end{pmatrix} \end{pmatrix}$$

$$= (0.118,0.185,0.280)$$

The fuzzy weight of first parameter is (0.118, 0.185, 0.28). Table 5 shows total fuzzy weights.

2.8. Prioritization and ranking of green suppliers using Fuzzy- Vikor method

As mentioned before, at fist suppliers are evaluated by three experts (group B) due to parameters. Also, modulation matrix of experts' opinions with weights of each parameter is indicated in table (10). (To aggregate parameters, the parameters1-7 show green parameters that include social accountability of firm, environmental management system, green manufacturing, green purchase, green design, contamination and green innovation).

According to levels mentioned before, at first we form 'decision' matrix (table 10); then, we form 'normal' matrix that is indicated below.

Then, we determine the best and the worth value for each parameter.

We calculate the distances from ideal option and also regression value for each of them due to the best and the worth value of each parameter. Then, we calculate $\tilde{Q}_i$ or $\tilde{S}_i$ and $\tilde{R}_i$ due to the best and the worth fuzzy value.

In this step, options are ranked based on values of R, S and Q. Table (14) shows ranking of potions.

Table 10: fuzzy weights of traditional parameters

$\tilde{W}_j$	lw_j	mw_j	uw_j	rate
$\tilde{W}_1$	**0.118**	**0.185**	**0.28**	**1**
$\tilde{W}_2$	**0.076**	**0.119**	**0.184**	**4**
$\tilde{W}_3$	**0.046**	**0.07**	**0.11**	**6**
$\tilde{W}_4$	**0.076**	**0.121**	**0.192**	**3**
$\tilde{W}_5$	**0.045**	**0.07**	**0.11**	**7**
$\tilde{W}_6$	**0.026**	**0.041**	**0.066**	**11**
$\tilde{W}_7$	**0.032**	**0.048**	**0.076**	**8**
$\tilde{W}_8$	**0.049**	**0.076**	**0.121**	**5**
$\tilde{W}_9$	**0.03**	**0.046**	**0.072**	**9**
$\tilde{W}_{10}$	**0.083**	**0.128**	**0.197**	**2**
$\tilde{W}_{11}$	**0.02**	**0.03**	**0.49**	**12**
$\tilde{W}_{12}$	**0.014**	**0.021**	**0.033**	**13**
$\tilde{W}_{13}$	**0.027**	**0.042**	**0.068**	**10**

Table 11: modulation matrix of evaluating suppliers relative to parameters of green supply chain

	C1	C2	C3	C4	C5
A1	(0.267,0.45,0.633)	(0.233,0.4,0.567)	(0233,04,0.567)	(0.233,0.4,0.567)	(0.367,0.55,0.733)
A2	(0.5,0.65,0.8)	(0.567,0.7,0.833)	(0567,07,0.833)	(0.5,0.65,0.8)	(0.433,0.6,0.767)
A3	(0.233,0.4,0.567)	(0.267,0.45,0.633)	(0233,04,0.567)	(0.267,0.45,0.633)	(0.433,0.6,0.767)
A4	(0.333,0.5,0.667)	(0.367,0.5,0.633)	(0.2,0.35,0.5)	(0.2,0.35,0.5)	(0.333,0.5,0.667)
A5	(0.4,0.55,0.7)	(0.333,0.5,0.667)	(0.3,05,0.7)	(0.433,0.6,0.767)	(0.5,0.65,0.8)
A6	(0.333,0.45,0.567)	(0.3,0.5,0.7)	(0333,05,0.667)	(0.3,0.45,0.6)	(0.3,0.45,0.6)
A7	(0.2,0.35,0.5)	(0.3,0.5,0.7)	(0.367,0.55,0.733)	(0.4,0.55,0.7)	(0.4,0.55,0.7)
A8	(0.333,0.5,0.667)	(0.267,0.4,0.533)	(0333,05,0.667)	(0.5,0.65,0.8)	(0.5,0.65,0.8)
A9	(0.3,0.5,0.7)	(0.433,0.6,0.767)	(0.5,0.65,0.8)	(0.7,0.8,0.9)	(0.633,0.75,0.867)
A10	(0.267,0.45,0.633)	(0.3,0.5,0.7)	(0433,06,0.767)	(0.367,0.5,0.633)	(0.4,0.55,0.7)
A11	(0.233,0.4,0.567)	(0.267,0.4,0.533)	(0.3,0.45,0.6)	(0.433,0.55,0.667)	(0.5,0.65,0.8)
A12	(0.233,0.4,0.567)	(0.367,0.55,0.733)	(0.367,0.55,0.733)	(0.267,0.45,0.633)	(0.2,0.35,0.5)
Weight of parameter	(0.059,0.093,0.14)	(0.038,0.06,0.092)	(0.023,0.035,0.055)	(0.038,0.061,0.096)	(0.023,0.035,0.055)

	C6	C7	C8	C9	C10
A1	(04,0.55,0.7)	(0.5,0.65,0.8)	(0.5,0.65,0.8)	(0.3,0.45,0.6)	(0.367,0.55,0.733)
A2	(0.433,0.6,0.767)	(0.467,0.6,0.733)	(0.617,0.75,0.867)	(0.433,0.6,0.767)	(0.8,0.9,0.967)
A3	(0.333,0.5,0.667)	(05,0.6,0.7)	(0.433,0.6,0.767)	(0.367,0.55,0.733)	(0.367,0.55,0.733)
A4	(0.467,0.6,0.733)	(0.4,0.55,0.7)	(0.3,0.45,0.6)	(0.267,0.4,0.533)	(0.5,0.65,0.8)
A5	(0.433,0.6,0.767)	(0.633,0.75,0.867)	(0.567,0.7,0.833)	(0.617,0.75,0.867)	(0.667,0.8,0.9)
A6	(0.367,0.5,0.633)	(0.5,0.65,0.8)	(0.233,0.4,0.567)	(0.3,0.45,0.6)	(0.533,0.65,0.767)
A7	(0.267,0.4,0.533)	(0.567,0.7,0.833)	(0.567,0.7,0.833)	(0.233,0.4,0.567)	(0.3,0.45,0.6)
A8	(03,0.45,0.6)	(0.367,0.5,0.633)	(0.5,0.65,0.8)	(0.367,0.55,0.733)	(0.533,0.65,0.767)
A9	(0.433,0.6,0.767)	(0.517,0.65,0.767)	(0.433,0.6,0.767)	(0.2,0.35,0.5)	(0.3,0.45,0.6)
A10	(04,0.55,0.7)	(0.467,0.55,0.65)	(0.367,0.5,0.633)	(0.3,0.5,0.7)	(0.5,0.65,0.8)
A11	(0.567,0.7,0.833)	(0.333,0.5,0.667)	(0.3,0.45,0.6)	(0.4,0.55,0.7)	(0.5,0.65,0.8)
A12	(0.367,0.55,0.733)	(0.433,0.6,0.767)	(0.433,0.6,0.767)	(0.2,0.35,0.5)	(0.4,0.55,0.7)
Weight of parameter	(0.013,0.021,0.033)	(0.016,0.024,0.038)	(0.025,0.038,0.061)	(0.015,0.023,0.036)	(0.042,0.064,0.099)

	C11	C12	C13	C14	C15
A1	(0.433,0.6,0.767)	(0.333,0.5,0.667)	(0.4,0.55,0.7)	(0.5,0.65,0.8)	(0367,055,0.733)
A2	(0.367,0.55,0.733)	(0.617,0.75,0.867)	(0.683,0.8,0.9)	(0.433,0.6,0.767)	(0.333,0.5,0.667)
A3	(0.467,0.6,0.733)	(0.433,0.55,0.667)	(0.367,0.5,0.633)	(0.267,0.45,0.633)	(0.333,0.5,0.667)
A4	(05,0.65,0.8)	(0.433,0.6,0.767)	(0.5,0.65,0.8)	(0.267,0.45,0.633)	(0.2,035,0.5)
A5	(0.333,0.5,0.667)	(0.4,0.55,0.7)	(0.367,0.55,0.733)	(0.683,0.8,09)	(0.583,0.7,0.8)
A6	(05,0.65,0.8)	(0.433,0.6,0.767)	(0.233,0.4,0.567)	(0.433,0.6,0.767)	(0.433,0.6,0.767)
A7	(04,0.55,0.7)	(0.367,0.55,0.733)	(0.3,0.45,0.6)	(0.333,0.5,0.667)	(0333,045,0.567)
A8	(0.55,0.7,0.833)	(0.5,0.65,0.8)	(0.367,0.55,0.733)	(0.2,0.35,0.5)	(0.367,0.5,0.633)
A9	(05,0.65,0.8)	(0.5,0.65,0.8)	(0.267,0.45,0.633)	(0.45,0.6,0.733)	(0267,045,0.633)
A10	(0.333,0.5,0.667)	(0.4,0.55,0.7)	(0.233,0.4,0.567)	(0.133,0.25,0.367)	(0367,055,0.733)
A11	(0.333,0.5,0.667)	(0.433,0.6,0.767)	(0.617,0.75,0.867)	(0.233,0.4,0.567)	(0.5,065,0.8)
A12	(0.367,0.55,0.733)	(0.367,0.55,0.733)	(0.333,0.5,0.667)	(0.433,0.6,0.767)	(0.3,045,0.6)
Weight of parameter	(0.01,0.015,0.245)	(0.007,0.011,0.017)	(0.014,0.021,0.034)	(0075,0117,0175)	(0.068,0.105,0.161)

	C16	C17	C18	C19	C20
A1	(0.433,0.6,0.767)	(0.5,0.65,0.8)	(0.367,0.55,0.733)	(0.433,0.6,0.767)	(0.233,0.4,0.567)
A2	(0.567,0.7,0.833)	(0.567,0.7,0.833)	(0.433,0.6,0.767)	(0.3,0.5,0.7)	(0.3,0.5,0.7)
A3	(0.233,0.4,0.567)	(0.133,0.25,0.367)	(0.333,0.5,0.667)	(0.367,0.5,0.633)	(0.333,0.5,0.667)
A4	(0.333,0.5,0.667)	(0.267,0.4,0.533)	(0.367,0.55,0.733)	(0.367,0.55,0.733)	(0.2,0.35,0.5)
A5	(0.417,0.55,0.667)	(0.333,0.5,0.667)	(0.433,0.6,0.767)	(0.567,0.7,0.833)	(0.567,0.7,0.833)
A6	(0.467,0.6,0.733)	(0.433,0.6,0.767)	(0.5,0.65,0.8)	(0.3,0.5,0.7)	(0.567,0.7,0.833)
A7	(0.2,0.35,0.5)	(0.233,0.4,0.567)	(0.367,0.55,0.733)	(0.3,0.45,0.6)	(0.3,0.45,0.6)
A8	(0.433,0.55,0.667)	(0.5,0.65,0.8)	(0.683,0.8,0.9)	(0.3,0.5,0.7)	(0.417,0.55,0.667)
A9	(0.4,0.55,0.7)	(0.3,0.4,0.5)	(0.333,0.5,0.667)	(0.467,0.6,0.733)	(0.4,0.55,0.7)
A10	(0.5,0.65,0.8)	(0.7,0.8,0.9)	(0.267,0.45,0.633)	(0.333,0.5,0.667)	(0.433,0.55,0.667)
A11	(0.5,0.65,0.8)	(0.333,0.5,0.667)	(0.4,0.55,0.7)	(0.433,0.55,0.667)	(0.233,0.4,0.567)
A12	(0.367,0.55,0.733)	(0.367,0.5,0.633)	(0.5,0.65,0.8)	(0.483,0.65,0.8)	(0.233,0.4,0.567)
Weight of parameter	(0.041,0.062,0.097)	(0.049,0.077,0.119)	(0.041,0.061,0.092)	(0.032,0.049,0.078)	(0.021,0.031,0.048)

Table 12: normal matrix of evaluating suppliers relative to parameters of green supply chain

	C1	C2	C3	C4	C5
A1	(-0.222,0.333,0.889)	(0,0.5,1)	(0,0.474,0.947)	(0.19,0.571,0.952)	(-0.15,0.3,0.75)
A2	(-0.5,0,0.5)	(-0.444,0,0.444)	(-0.421,0,0.421)	(-0.143,0.214,0.571)	(-0.2,0.225,0.65)
A3	(-0.111,0.417,0.944)	(-0.111,0.417,0.944)	(0,0.474,0.947)	(0.095,0.5,0.905)	(-0.2,0.225,0.65)
A4	(-0.278,0.25,0.778)	(-0.111,0.333,0.778)	(0.105,0.553,1)	(0.286,0.643,1)	(-0.05,0375,08)
A5	(-0.333,0.167,0.667)	(-0.167,0.333,0.833)	(-0.211,0.316,0.842)	(-0.095,0.286,0.667)	(-0.25,015,0.55)
A6	(-0.111,0.333,0.778)	(-0.222,0.333,0.889)	(-0.158,0.316,0.789)	(0.143,0.5,0.857)	(0.05,0.45,0.85)
A7	(0,05,1)	(-0.222,0.333,0.889)	(-0.263,0.237,0.737)	(0,0.357,0.714)	(-0.1,0.3,0.7)
A8	(-0.278,0.25,0.778)	(0.056,0.5,0.944)	(-0.158,0.316,0.789)	(-0.143,0.214,0.571)	(-0.25,015,0.55)
A9	(-0.333,0.25,0.833)	(-0.333,0.167,0.667)	(-0.368,0.079,0.526)	(-0.286,0,0.286)	(-0.35,0,0.35)
A10	(-0.222,0.333,0.889)	(-0.222,0.333,0.889)	(-0.316,0.158,0.632)	(0.095,0.429,0.762)	(-0.1,0.3,0.7)
A11	(-0.111,0.417,0.944)	(0.056,0.5,0.944)	(-0.053,0.395,0.842)	(0.048,0.357,0.667)	(-0.25,015,0.55)
A12	(-0.111,0.417,0.944)	(-0.278,0.25,0.778)	(-0.263,0.237,0.737)	(0.095,0.5,0.905)	(0.2,0.6,1)
	C6	C7	C8	C9	C10
A1	(-0.235,0.265,0.765)	(-0.313,0.188,0.688)	(-0.289,0.158,0.579)	(0.025,0.45,0.85)	(0.1,0.525,0.9)
A2	(-0.353,0.176,0.706)	(-0.188,0.281,0.75)	(-0.395,0,0.395)	(-0.225,0.225,0.65)	(-0.25,0,0.25)
A3	(-0.176,0.353,0.882)	(-0.125,0.281,0.688)	(-0.237,0.237,0.684)	(-0.175,0.3,0.75)	(0.1,0.525,0.9)
A4	(-0.294,0.176,0.647)	(-0.125,0.375,0.875)	(0026,0474,0895)	(0.125,0.525,0.9)	(0,0.375,0.7)
A5	(-0.353,0.176,0.706)	(-0.438,0,0.438)	(-0.342,0.079,0.474)	(-0.375,0,0.375)	(-0.15,015,0.45)
A6	(-0.118,0.353,0.824)	(-0.313,0.188,0.688)	(0.079,0.553,1)	(0.025,0.45,0.85)	(0.05,0.375,0.65)
A7	(0.059,0.529,1)	(-0.375,0.094,0.563)	(-0.342,0.079,0.474)	(0.075,0.525,0.95)	(0.3,0.675,1)
A8	(-0.059,0.441,0.941)	(0,0.469,0.938)	(-0.289,0.158,0.579)	(-0.175,0.3,0.75)	(0.05,0.375,0.65)
A9	(-0.353,0.176,0.706)	(-0.25,0.188,0.656)	(-0.237,0.237,0.684)	(0.175,0.6,1)	(0.3,0.675,1)
A10	(-0.235,0.265,0.765)	(-0.031,0.375,0.75)	(-0.026,0.395,0.789)	(-0.125,0.375,0.85)	(0,0.375,0.7)
A11	(-0.471,0,0.471)	(-0.063,0.469,1)	(0026,0474,0895)	(-0.125,0.3,0.7)	(0,0.375,0.7)
A12	(-0.294,0.265,0.824)	(-0.25,0.281,0.813)	(-0.237,0.237,0.684)	(0.175,0.6,1)	(0.15,0.525,0.85)

	C11	C12	C13	C14	C15
A1	(-0.433,0.2,0.8)	(-0.094,0.469,1)	(-0.025,0.375,0.75)	(-0.152,0.196,0.522)	(-0.25,0.25,0.722)
A2	(-0.367,0.3,0933)	(-0.469,0,0.469)	(-0.325,0,0.325)	(-0.109,0.261,0.609)	(-0.139,0.333,0.778)
A3	(-0.367,0.2,0733)	(-0.094,0.375,0.813)	(0.075,0.45,0.8)	(0.065,0.457,0.826)	(-0.139,0.333,0.778)
A4	(-0.5,0.1,0.667)	(-0.281,0.281,0.813)	(-0.175,0.225,0.6)	(0.065,0.457,0.826)	(0.139,0.583,1)
A5	(-0.233,0.4,1)	(-0.156,0.375,0.875)	(-0.075,0.375,0.8)	(-0.283,0,0.283)	(-0.361,0,0.361)
A6	(-0.5,0.1,0.667)	(-0.281,0.281,0.813)	(0.175,0.6,1)	(-0.109,0.261,0.609)	(-0.306,0.167,0.611)
A7	(-0.3,0.3,0.867)	(-0.219,0.375,0.938)	(0.125,0.525,0.9)	(0.022,0.391,0.739)	(0.028,0.417,0.778)
A8	(-0.567,0,0.567)	(-0.344,0.188,0.688)	(-0.075,0.375,0.8)	(0.239,0.587,0.913)	(-0.083,0.333,0.722)
A9	(-0.5,0.1,0.667)	(-0.344,0.188,0.688)	(0.075,0.525,0.95)	(-0.065,0.261,0.587)	(-0.083,0.417,0.889)
A10	(-0.233,0.4,1)	(-0.156,0.375,0.875)	(0.175,0.6,1)	(0.413,0.717,1)	(-0.25,0.25,0.722)
A11	(-0.233,0.4,1)	(-0.281,0.281,0.813)	(-0.275,0.075,0.425)	(0.152,0.522,0.87)	(-0.361,0.083,0.5)
A12	(-0.367,0.3,0933)	(-0.219,0.375,0.938)	(0.025,0.45,085)	(-0.109,0.261,0.609)	(-0.028,0.417,0.833)

	C16	C17	C18	C19	C20
A1	(-0.316,0.158,0.632)	(-0.13,0.196,0.522)	(-0.079,0.395,0.842)	(-0.375,0.188,0.75)	(0,0.474,0.947)
A2	(-0.421,0,0.421)	(-0.174,0.13,0.435)	(-0.132,0.316,0.737)	(-0.25,0.375,1)	(-0.211,0.316,0.842)
A3	(0,0.474,0.947)	(0.435,0.717,1)	(0.026,0.474,0.895)	(-0.125,0.375,0.875)	(-0.158,0.316,0.789)
A4	(-0.158,0.316,0.789)	(0.217,0.522,0.826)	(-0.079,0.395,0.842)	(-0.313,0.281,0.875)	(0.105,0.553,1)
A5	(-0.158,0.237,0.658)	(0.043,0.391,0.739)	(-0.132,0.316,0.737)	(-0.5,0,0.5)	(-0.421,0,0.421)
A6	(-0.263,0.158,0.579)	(-0.087,0.261,0.609)	(-0.184,0.237,0.632)	(-0.25,0.375,1)	(-0.421,0,0.421)
A7	(0.105,0.553,1)	(0.174,0.522,0.87)	(-0.079,0.395,0.842)	(-0.063,0.469,1)	(-0.053,0.395,0.842)
A8	(-0.158,0.237,0.632)	(-0.13,0.196,0.522)	(-0.342,0,0.342)	(-0.25,0.375,1)	(-0.158,0.237,0.658)
A9	(-0.211,0.237,0.684)	(0.261,0.522,0.783)	(0.026,0.474,0.895)	(-0.313,0.188,0.688)	(-0.211,0.237,0.684)
A10	(-0.368,0.079,0.526)	(-0.261,0,0.261)	(0.079,0.553,1)	(-0.188,0.375,0.938)	(-0.158,0.237,0.632)
A11	(-0.368,0.079,0.526)	(0.043,0.391,0.739)	(-0.026,0.395,0.789)	(-0.188,0.281,0.75)	(0,0.474,0.947)
A12	(-0.263,0.237,0.737)	(0.087,0.391,0.696)	(-0.184,0.237,0.632)	(-0.438,0.094,0.656)	(0,0.474,0.947)

Table 13: the best and the worth fuzzy value of each parameter

parameter	C1	C2	C3	C4	C5
Best value	(0,0.5,1)	(0,0.5,1)	(0.105,0.553,1)	(0.286,0.643,1)	(0.2,0.6,1)
Worth value	(-0.5,0,05)	(-0.444,0,0.444)	(-0.421,0,0.421)	(-0.286,0,0.286)	(-0.35,0,035)
parameter	C6	C7	C8	C9	C10
Best value	(0.059,0.529,1)	(-0.063,0.469,1)	(0.079,0.553,1)	(0.175,0.6,1)	(0.3,0.675,1)
Worth value	(-0.471,0,0471)	(-0.438,0,0.438)	(-0.395,0,0.395)	(-0.375,0,0.375)	(-0.25,0,025)
parameter	C11	C12	C13	C14	C15
Best value	(-0.233,0.4,1)	(-0.094,0.469,1)	(0.175,0.6,1)	(0.413,0.717,1)	(0.139,0.583,1)
Worth value	(-0.567,0,0567)	(-0.469,0,0.469)	(-0.325,0,0.325)	(-0.283,0,0.283)	(-0.361,0,0.361)
parameter	C16	C17	C18	C19	C20
Best value	(0.105,0.553,1)	(0.435,0.717,1)	(0.079,0.553,1)	(-0.063,0.469,1)	(0.105,0.553,1)

Worth value	(-0.421,0,0.421)	(-0.261,0,0.261)	(-0.342,0,0.342)	(-0.5,0,0.5)	(-0.421,0,0.421)

Table 14: total distances from ideal option, $\tilde{Q}$, and regression values

option	S	S_g	R	R_g	Q	Q_g
A1	(-0.088,0.319,1.355)	0.476	(0.007,0.035,0.196)	0.068	(-0.665,0.056,0.86)	0.077
A2	(-0.169,0.163,1.104)	0.315	(-0.003,0.035,0.229)	0.074	(-0.71,0.01,0.85)	0.04
A3	(-0.013,0.427,1.493)	0.583	(0.021,0.055,0.18)	0.078	(-0.614,0.13,0.868)	0.128
A4	(-0.014,0.419,1.454)	0.569	(0.011,0.061,0.163)	0.074	(-0.636,0.139,0.824)	0.117
A5	(-0.156,0.167,1.108)	0.321	(0.002,0.03,0.245)	0.077	(-0.696,0.001,0.884)	0.048
A6	(-0.087,0.302,1.27)	0.447	(0.005,0.031,0.163)	0.058	(-0.669,0.044,0.768)	0.047
A7	(-0.01,0.42,1.492)	0.58	(0.012,0.046,0.212)	0.079	(-0.631,0.11,0.934)	0.131
A8	(-0.072,0.308,1.233)	0.444	(0.018,0.068,0.159)	0.079	(-0.639,0.121,0.749)	0.088
A9	(-0.085,0.298,1.257)	0.442	(0.013,0.044,0.163)	0.066	(-0.653,0.068,0.764)	0.062
A10	(-0.054,0.351,1.413)	0.515	(0.031,0.084,0.245)	0.111	(-0.607,0.165,0.976)	0.175
A11	(-0.059,0.336,1.38)	0.499	(0.011,0.061,0.245)	0.094	(-0.648,0.114,0.966)	0.137
A12	(-0.063,0.352,1.426)	0.517	(0.006,0.044,0.229)	0.08	(-0.66,0.084,0.947)	0.114

Table 15: ranking of green manufacturers based on values of R, S and Q

option	R	S	Q
A1	3	6	5
A2	4	1	1
A3	7	12	9
A4	5	10	8
A5	6	2	3
A6	1	5	2
A7	9	11	10
A8	8	4	6
A9	2	3	4
A10	12	8	12
A11	11	7	11
A12	10	9	7

According to values of R, S and Q, final ranking of suppliers will be as follows:

Table 16: final ranking of green suppliers

Option	Rank	Option	Rank
A2	**1**	A12	**7**
A6	**2**	A4	**8**
A5	**3**	A3	**9**
A9	**4**	A7	**10**
A1	**5**	A11	**11**
A8	**6**	A10	**12**

3. Conclusions

The aim of this research was presenting a model with high reliability in order to select green supplier. The fuzzy-Delphi combined model, fuzzy analytic hierarchy process and fuzzy- Vikor methods were used in this research. In the initial phase of this research, a comprehensive study was conducted on parameters of selecting green supplier; 15 parameters for selecting traditional supplier and 14 parameters for selecting green supplier were obtained. In the second phase, 13 and 7 parameters were screened for selecting traditional and green supplier, respectively (by use of fuzzy- Delphi method by experts). Then, they were integrated, prioritized and weighted using fuzzy analytic hierarchy process. In the next phase, considered suppliers were ranked using fuzzy-Vikor method in order to select for green supply chain. In the current study, all three methods of qualitative data were used in order to assess parameters and options. According to the research conducted of the field, there is not a comprehensive research available in the literature about unreliability about identifying, assessing and selecting the green supplier.

On one hand, several researches have conducted about supplier selection and important parameters of this activity, but a few number of these studies had focused on green and/or environmental standards. On one the other hand, attention to 'green' principle and its observance in supply chain is a vital matter due to strategic situation of country in terms of air and water pollution and limitation of resources.

The issue of supplier selection is very important in automobile industry. Despite this importance, the parameters of supplier selection, especially green supplier (based on the knowledge of researcher about local articles and proposals) are not explored yet.

The aim of this research is to provide an applicable framework of supplier selection of Iran Khodro Company. In this regard, these parameters are identified and localized by experts using fuzzy- Delphi process and then green suppliers are prioritized using fuzzy-Vikor method.

References

Asqarpur, M.' Decision and investigation of operation', Tehran university publications, 9th edition, 2004.

Govindan, K. et al., (2013). Multi criteria decision making approaches for green supplier evaluation and selection: a literature review. Journal of Cleaner Production.

Govindan, K., Khodaverdi, R. & Jafarian, A., (2013). A fuzzy multi criteria approach for measuring sustainability performance of a supplier based on triple bottom line approach. Journal of Cleaner Production, 47, pp.345–354.

Yeh, W.-C. & Chuang, M.-C., (2011). Using multi-objective genetic algorithm for partner selection in green supply chain problems. Expert Systems with Applications, 38(4), pp.4244–4253.

Bai, C. & Sarkis, J.,)2010(. Integrating sustainability into supplier selection with grey system and rough set methodologies. International Journal of Production Economics, 124(1), pp.252–264.

Narasimhan, R., Talluri, S. & Mendez, D., (2001). Supplier evaluation and rationalization via data envelopment analysis: an empirical examination. Journal of supply chain management, 37(2), pp.28–37.

Kuo, R. J., Wang, Y. C., & Tien, F. C. (2010). Integration of artificial neural network and MADA methods for green supplier selection. Journal of Cleaner Production, 18(12), 1161–1170.

BuyukozkanG., CifciG. (2011a). A novel hybrid MCDM approach based on fuzzy DEMATEL, fuzzy ANP and fuzzy TOPSIS to evaluate green suppliers. Expert Systems with Applications.38

Buyukozkan G., CifciG. (2011b). A novel fuzzy multi-criteria decision framework for sustainable supplier selection with incomplete information. Computers in Industry. 62

Govindan, K., Khodaverdi, R. & Jafarian, A., (2013). A fuzzy multi criteria approach for measuring sustainability performance of a supplier based on triple bottom line approach. Journal of Cleaner Production, 47, pp.345–354.

Kannan, D. et al., (2014). Selecting green suppliers based on GSCM practices : Using fuzzy TOPSIS applied to a Brazilian electronics company. European Journal of Operational Research, 233(2), pp.432–447.

Kuo, R. J., Wang, Y. C., & Tien, F. C. (2010). Integration of artificial neural network and MADA methods for green supplier selection. Journal of Cleaner Production, 18(12), 1161–1170.

Dou, Y., Zhu, Q. & Sarkis, J., (2014). Evaluating green supplier development programs with a grey-analytical network process-based methodology. European Journal of Operational Research, 233(2), pp.420–431.