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Identify and Ranking Key Indicators Performance of Green Supply Chain Using Combinational Method DEMATEL and ANP With Fuzzy Approach (The Case Food Industry in Iran)

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Abstract

With the growth of public awareness for environmental protection, green production was raised as an important issue for each producer, which will guarantee its activity in long term. Creating suppliers, performance assessment system is so necessary and important that it measures suitability of the suppliers for long-term cooperation with the company. Many activities have been performed for selection of the suppliers but those who pay attention to environmental issues, social responsibility of the organizations, and compatibility with the environment are limited. In this study, we seek to present a framework for assessment of the green suppliers with accountability components of the organizations regarding society which considers cost issues for the selection of suppliers and their responsibilities toward society and the surrounding world. This study was done to Identify and ranking key indicators performance of Green Supply Chain Using combinational method DEMATEL and ANP with fuzzy approach so that developing Green Supply Chain in industry in Iran can be achieved .First, definitions of performance of Green Supply Chain and its importance then, research method and findings analysis as well as research results will be discussed.

Keywords: Green supply chain, ANP, TOPSIS, Fuzzy, Food industry.

1. Introduction

Supply chains are critical links that connect an organization's inputs to its outputs. Traditional challenges have included lowering costs, ensuring just-in-time delivery, and shrinking transportation times to allow better reaction to business challenges. However, the increasing environmental costs of these networks and growing consumer pressure for Eco-friendly products has led many organizations to look at supply chain sustainability as a new measure of profitable logistics management.[1] This shift is reflected by an understanding that sustainable supply chains frequently mean profitable supply chains .

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Many companies are limited to measuring the sustainability of their own business operations and are unable to extend this evaluation to their suppliers and customers. This makes determining their true environmental costs highly challenging and reduces their ability to remove waste from the supply chains. However much progress has been made in defining supply chain sustainability and benchmarking tools are now available that enable sustainability action plans to be developed and implemented.

With the increase of laws and regulations, governmental supervision and public awareness with environmental protection, producers will not be able to neglect environmental issues if they ask for activity in global markets and competition with other companies. In addition to compliance with environmental laws, the companies require implementation of the strategies voluntarily in order to sell their products in a special country to minimize environmental effects of their products. since combination of environmental, economic and social performances has been turned into a major business challenge in order to achieve sustainable development. For this reason, environmental management has been regarded as a main concern of the companies in business and this leads to more emphasis of the organizational beneficiaries such as shareholders, governments, customers, personnel, competitors and society on environmental protection which increases pressures for environmental support and protection. We can name some plans such as environmental design (green design), lifecycle analysis, and environmental management of quality, green supply chain management, and standards of ISO 14000 as environment aligned activities.International organizations are always looking to achieve competitive advantage through innovation and new approaches. Some of these organizations by improving environmental performance and compliance with environmental standards, increase knowledge about customers and reduce negative environmental impacts the competitive advantage of products and services can be reached. Globalization, increasing regulations, government agencies and non-government clients on compliance with environmental demands and pressures has caused organizations to review the necessary steps for the implementation of green supply chain management, to improve the environmental performance of economic and pay. Green supply chain management, supply chain management is integrated with environmental requirements at all stages of product design, selection and procurement of raw materials, manufacture, process, distribute, transport, delivery to

customers and ultimately the consumer, recycled Management and reuse to maximize the amount of energy and resource efficiency with improved performance of the entire supply chain. (Chen & Paulraj, 2004). Sustainability means creating a society of social - economic, cultural and environmental issues is a long-term focus, while supply chain management of all aspects of the product cycle such as raw materials, processing, manufacturing, distribution, retail, customer use covers. When the firm is part of the supply chain in the long-term sustainability is not just a business, but the entire supply chain, from the bottom up or the top down will take. (Cooper and Lambert, 1997).

2. Literature review

2.1 Multi Criteria Decision Analysis

Multi Criteria Decision Analysis (MCDA) or Multi Criteria Decision Making (MCDM) is a branch of a general class of Operations Research models which is used in diverse fields such as engineering, economics, management science, transportation planning. This method deals with the process of making decisions in the presence of candidate priority alternatives with respect to various attributes. This class is further separated into Multi Objective Decision Making (MODM) and Multi Attribute Decision Making (MADM). These methodologies share the common characteristics of conflict among criteria, incommensurable units, and difficulties in design/selection of alternatives

2.2 DEMATEL METHOD

The DEMATEL method is used to construct interrelations between criteria factors (Fontela, Gabus 1974, 1976) and to find the central criteria to represent the effectiveness of factors/aspects. It has been successfully applied in many areas, such as marketing strategies, control systems, safety problems, developing the competencies of global managers and group decision-making (Chiu et al. 2006; Liou et al. 2007; Wu, Lee 2007; Lin, Wu 2008). Furthermore, a hybrid model combined with AHP/ANP method has also been used for example, e-learning evaluation (Tzeng et al. 2007). Airline safety measurement (Liou et al. 2007. Therefore, in this paper the DEMATEL is applied to detect complex relationships and build an impact relation map (IRM) of the criteria, but also to obtain the influence levels of each element over others. The DEMATEL method is used to construct the interrelations between criteria to build an IRM. The method consists of following basic steps.

At first the initial average matrix of pair-wise comparisons from experts is calculated. In this step, respondents are asked to indicate the degree of direct influence each factor/element i exerts on each factor/element j , which is denoted by aij . We assume that the scales 0, 1, 2, 3 and 4 represent the range from "non-influence" to "very high influence". Each respondent would produce a direct matrix, and an average matrix A is then derived through the mean of the same factors/elements in the various direct matrices of the respondents. The average matrix A is represented as following equation:

$$\boldsymbol{A} = \begin{bmatrix} a_{11} & \cdots & a_{1j} & \cdots & a_{1n} \\ \vdots & & \vdots & & \vdots \\ a_{i1} & \cdots & a_{ij} & \cdots & a_{in} \\ \vdots & & \vdots & & \vdots \\ a_{n1} & \cdots & a_{nj} & \cdots & a_{nn} \end{bmatrix}. \qquad (1)$$

In the second step the initial influence matrix is calculated. The initial direct influence mat X(X=[x_{ij}]$_{n\times n}$) can be obtained by normalizing the average matrix A. Specifically, the matrix X can be obtained through equations (2) and (3), in which all principal diagonal elements are equal to zero.

$$X = s \cdot A \qquad (2)$$

$$\lambda = \min\left[\frac{1}{\max_i \sum_{j=1}^{n} |a_{ij}|}, \frac{1}{\max_j \sum_{i=1}^{n} |a_{ij}|}\right] \qquad (3)$$

Then in the third step the full direct/indirect influence matrix is derived. A continuous decrease of the indirect effects of problems along the powersof $\boldsymbol{X}$, e.g., $\boldsymbol{X}^2$, $\boldsymbol{X}^3$,..., $\boldsymbol{X}^k$ and $\lim_{k\to\infty} X^k = [0]_{n\times n}$, where, $0 \le x < 1$and $0 \le \Sigma_{ij}\, x i_j$ or Σ x ij < 1only one column or one row sum equals 1.

The total-influence matrix is listed as follows:

$$\boldsymbol{T} = \boldsymbol{X} + \boldsymbol{X}^2 + \cdots + \boldsymbol{X}^k = \boldsymbol{X}(\boldsymbol{I} + \boldsymbol{X} + \boldsymbol{X}^2 + \cdots + \boldsymbol{X}^{k-1})(\boldsymbol{I} - \boldsymbol{X})(\boldsymbol{I} - \boldsymbol{X})^{-1} = \boldsymbol{X}(\boldsymbol{I} - \boldsymbol{X}^k)(\boldsymbol{I} - \boldsymbol{X})^{-1}$$

Then

$$\boldsymbol{T} = \boldsymbol{X}(\boldsymbol{I} - \boldsymbol{X})^{-1}, \qquad (4)$$

Where $\lim_{k\to\infty} \boldsymbol{X}^k = [0]_{n\times n}$ and $\boldsymbol{T} = [t_{ij}]_{n\times n}$, $i, j = 1, 2, \ldots, n.$

Then the method presents each row sum and column sum of matrix T as follows:

$$\boldsymbol{r} = (r_i)_{n\times 1} = [\sum_{j=1}^{n} t_{ij}]_{n\times 1}, \qquad (5)$$

$$\boldsymbol{c} = (c_j)_{n\times 1} = (c_j)'_{1\times n} = [\sum_{i=1}^{n} t_{ij}]'_{1\times n}, \qquad (6)$$

Where *ri* denotes the row sum of the *i* th row of matrix T and shows the sum of direct and indirect effects of factor/element *i* on the other factors/elements. Similarly, *c j* denotes the column sum of the *j* th column of matrix T and shows the sum of direct and indirect effects that factor/element *j* has received from the other factors/criteria. In addition, when $i = j$ (i.e., the sum of the row and column aggregates) $(ri + ci)$ provides an index of the strength of influences given and received, that is, $(ri + ci)$ shows the degree of the central role that factor *i* plays in the problem. If $(ri - ci)$ is positive, then factor *i* is affecting other factors, and if $(ri - ci)$ is negative, then factor *i* is being influenced by other factors (Tzeng et al. 2007). In the fourth step a threshold value is determined and the IRM is constructed on a X, Y graph. Setting a threshold value, □, to filter the minor effects denoted by the factors of matrix T is necessary to isolate the relation structure of the factors. Based on the matrix T, each factor *tij* of matrix T provides information about how factor *i* affects factor *j* . In practice, if all the information from matrix T converts to the IRM, the map would be too complex to show the necessary information for decision making. In order to reduce the complexity of the IRM, the decision-maker sets a threshold value for the influence level: only factors whose influence value in matrix T is higher than the threshold value can be chosen and converted into the IRM. The threshold value can be decided through the brainstorming of experts. When the threshold value and relative IRM have been decided, the IRM can be shown.

2.3 Analytical network processes (ANP)

One of the primary concerns on the implementation of traditional AHP is the interdependencies which could happen among components of hierarchy. Saaty (1996a, 1996b) extended the idea of AHP for a more comprehensive form of pairwise comparison called ANP. ANP has five stages and the first stage determines relationships and their dependencies. The second stage measures the impacts of each criterion on other criteria based on pairwise comparison and all eigenvalues and eigenvectors are calculated. All responses are gathered based on Likert scale from one to nine and geometric mean is used to find the average of all feedbacks. Therefore, we have,

$\lambda max \ .W = A.W$,

Where λmax is the maximum eigenvalue associated with matrix *A*. Third, consistency ratios are calculated and if it is less than 0.1 we can accept the results, otherwise the data are not consistent. Forth, super matrix is established. Super matrix concept resembles to Markov sequence process. Super matrix can limit the coefficients to calculate all priorities, thereby cumulative effect of each element on other elements in interaction. In this phase, special vector resulting from paired comparison matrix is used as matrix weights. Internal relationships between elements/criteria are captured in a separate matrix so that super matrix represented by W is created. Zero value or blank space refers to no internal relationships between elements/criteria or clusters. Fifth, the best alternative is selected. If the super matrix created through previous phases covers all over the network, weights of priorities can be found in alternatives column in a normalized super matrix. Raising the super matrix to power, the super matrix is converged and therefore its weights are stabilized. Finally, the alternative with the highest priority is considered as the first top alternative.

2.4 Green supply chain

Supply chain, all companies and business activities required to design, manufacture, delivery, or use of a product or service are included. Any business to survive and thrive in its supply chain and any of its affiliated chain plays a role. So far, various definitions of supply chain are resented. The following are some definitions of supply chain expression The supply chain consists of a network of channel partners operating from within and outside the organization that affects the utility of the output of the supply chain.

✓ A supply chain consists of two or more organizations that are legally separated by the flow of materials, information related to finance. These organizations can include companies that parts, components and finished products are produced and logistics service providers and their customers (end) in the fall.

✓ Supply chain involving a network of distribution facilities and the procurement of materials, transportation of raw materials and final products, and deliver the products to customer's plays.

Thus, a supply chain of a company and its customers and suppliers, the company has been formed. In this series, the basic group of members that provides a simple supply chain. Three other members of the supply chain are developed. First, at the beginning of the supply chains, from supplier to supplier or supplier's initial and second at the end of the chain, are the ultimate customer or client. Finally, there's a whole bunch of other companies in the chain are there to serve. These companies provide services such as procurement, finance, marketing and information technology can offer.Supply chain management (SCM) is the management of the flow of goods. It includes the movement and storage of raw materials, work-in-process inventory, and finished goods from point of origin to point of consumption. Interconnected or interlinked networks, channels and node businesses are involved in the provision of products and services required by end customers in a supply chain (Harland, 1996). Supply chain management has been defined as the "design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand and measuring performance globally. Supply chain management coordinating all activities with the activities of a company's suppliers and customers. Effective supply chain management with the aim of measuring the effectiveness of various models (evaluation) has been created. A few companies of its objectives in the field of technological innovation and achieve satisfactory results and the need to measure performance. Performance evaluation based on reliable data is one of the factors for the full value of their investment, it is considered necessary. Despite the importance of performance measurement, introduced over a decade of supply chain management and develop a performance evaluation of the literature on the theory and practice of supply chain, not pay enough attention to evaluate the performance of the supply chain. Although it is said that supply chain performance evaluation can facilitate a better

understanding of the supply chain, and have a positive impact on agents' behavior to improve the overall performance. Prefers that suppliers and customers together in a harmonious style, participating in free flow, to work together by talking. Rapid flow of information between customers, suppliers, supply centers and transportation systems, corporate development, supply chain enables. Ensuring that supply chain management is a set of attitudes and manufacturer of integrated warehouse and stores the quantity of goods to the correct location, To illustrate that while the level of customer service servicing costs will be minimal.

3. Research Methodology

This study was applied in terms of aim and descriptive-explorative in terms of data collection. It is descriptive as the descriptive study is the set of methods and the aim is describing the studied phenomena. The present study describe the business intelligence performance via considering the features, dimensions and the limits and as it attempted to present a model by DEMATEL, ANP combinational method with fuzzy approach, it is also considered modeling. The study was all the companies' food industry in Iran. The present study considered the basis of data collection as the specialization and skill of the people in business intelligence. Organized sampling was applied. This sampling is the best method to apply the comments of people being skillful in a specific subject. 11 experts on implementation of green supply chain were identified. For data collection, library and field study was used. For review of literature (theoretical basics and review of literature) and the selection of the criteria and study indices, library method, journals, conferences and valid scientific sites were applied. The main study data to study the study questions were obtained via field method via distributing the questionnaire among the experts based on Delphi method. The questionnaire of the study was consisting of three parts: First section- Pair-wise comparisons of the main criteria to the goal Second section- Pair-wise comparisons of the main criteria with each other (interactions of the main criteria with each other(Third section- Pair-wise comparisons of the selected indices with the main criteria The design of the questions was as the respondents should select response ranging 1 to 9 for each choice. Indeed, the expert's responses were converted to triangular fuzzy number (m, α, β) by the matrix extracted by study population and the table of converting the linguistic items to fuzzy number. To evaluate the content validity of the

questionnaire, Delphi and expert techniques were applied. Then, the content validity of the questionnaire was verified by the experts. Content validity measured the questions of the variable being provided. Its evaluation method is mostly based on specialized judgment and experiences of professional people. Ac- cording to construct validity, as the study process was based on theoretical framework, the construct validity is defined and as the extraction of the factors is relied upon many papers and articles, it seems that prediction validity is fulfilled. To measure the reliability of this study, besides using the calculations of incompatibility rate of the responses of each expert, the incompatibility rate of collecting the experts' comments was calculated and the reliability of the study was supported. After the collection of the questionnaires, the information was classified and FANP technique was used to weight each of the indices. Then, the data entered excel and by Super decision software, the study models were designed.

4. Data Analysis

Based on the aim of the study, at first based on the identified criteria and sub-criteria, the network analysis model was designed in super decision software. Based on this model, ANP chart is as shown in Figure 1.

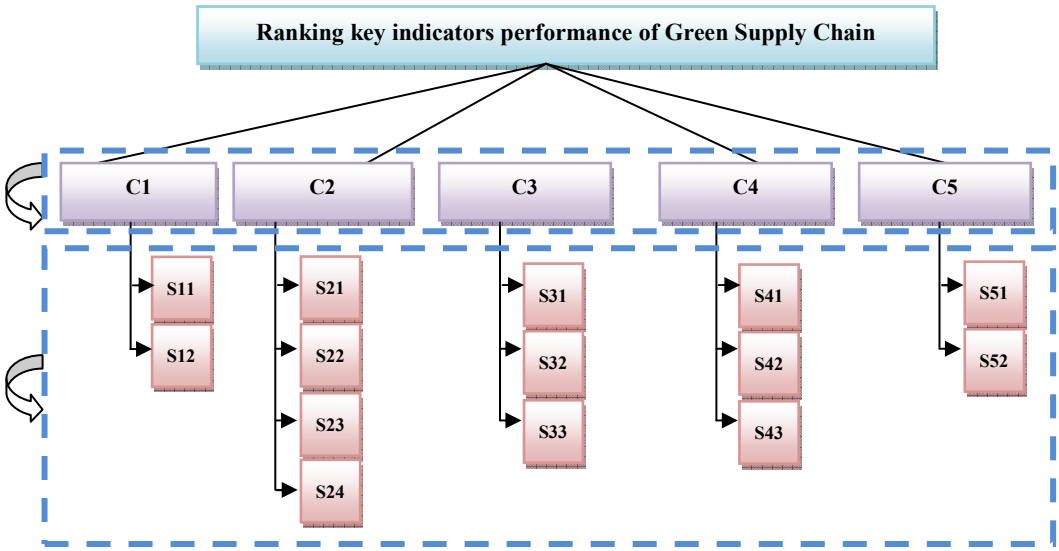

Figure1. ANP chart of the priority of the criteria and Ranking key indicators performance of Green Supply Chain

For pair-wise comparison of the elements Saaty 9 degree elements was applied. Saaty 9-degree scale was proposed by hierarchy analysis theory. In this study, for quantification of the values, fuzzy approach was used. Fuzzy scale corresponding with Saaty 9-degree in fuzzy network analytic process are shown in Table 1.

The calculations of Fuzzy Analytic Network Process (FANP) In this stage, the fuzzy calculations of the comparison of the criteria and sub-criteria of the model based on the study purpose. The computations were done with fuzzy coding in Excel. First, the main criteria based on goal are prioritized (W21) with fuzzy calculations. Then, fuzzy average of the views of people was calculated. To calculate the average of the comments of n respondents, the mean of fuzzy is calculated as:

$$\text{fuzzyaverage} = \left[\frac{l_1 + l_2 + \ldots + l_n}{n}, \frac{m_1 + m_2 + \ldots m_n}{n}, \frac{u_1 + u_2 + \ldots + u_n}{n}\right]$$

The results of pair-wise comparisons are shown in Table 2.

Table 2. The criteria and sub-criteria of the model and the applied indices

Main criteria		Sub-criteria	Index
Cost	C1	ROI	S11
		Inventory levels of circulating	S12
Process	C2	Effectiveness of distributed scheduling	S21
		Ways to order	S22
		The accuracy of prediction methods	S23
Customer	C3	Level of information sharing	S31
		Customer Satisfaction	S32
		How to deliver quality	S33
		advertisement	S34
Environment factor	C4	Environmental factors (sanctions, war and terrorism)	S41
		Retardation of technological change and new technologies	S42
		Government support (import, taxes, loans, etc.)	S43
Supplier	C5	Quality Capabilities Supplier	S51
		Supplier cooperation	S52

Table2. The fuzzyficated matrix of pair-wise comparison of the main criteria

	C1	C2	C3	C4	C5
C1	(1, 1, 1)	(2.96, 3.17, 3.38)	(5.04, 5.25, 5.46)	(3.56, 3.87, 4.19)	(4.93, 5.43, 5.93)
C2	(0.3, 0.32, 0.34)	(1, 1, 1)	(3.26, 3.67, 4.08)	(5.53, 6.04, 6.55)	(4.64, 5.14, 5.65)
C3	(0.18, 0.19, 0.2)	(0.25, 0.27, 0.31)	(1, 1, 1)	(3.54, 4.15, 4.75)	(4.72, 5.43, 6.13)
C4	(0.24, 0.26, 0.28)	(0.15, 0.17, 0.18)	(0.21, 0.24, 0.28)	(1, 1, 1)	(6.11, 6.61, 7.11)
C5	(0.17, 0.18, 0.2)	(0.18, 0.19, 0.22)	(0.16, 0.18, 0.21)	(0.16, 0.15, 0.16)	(1, 1, 1)

The fuzzy sum of the elements of each row is calculated as:

$$\sum_{j=1}^{5} M_{g_1}^{j} = (1.00,1.00,1.00) \oplus (2.96,3.17,3.38) \oplus (5.04,5.25,5.46) \oplus (3.56,3.87,4.19) \oplus (4.93,5.43,5.93)$$

$$\sum_{j=1}^{5} M_{g_2}^{j} = (0.30,0.32,0.34) \oplus (1.00,1.00,1.00) \oplus (3.26,3.64,4.08) \oplus (5.53,6.04,6.55) \oplus (4.64,5.14,5.65)$$

$$\sum_{j=1}^{5} M_{g_3}^{j} = (0.18,0.19,0.20) \oplus (0.25,0.27,0.31) \oplus (1.00,1.00,1.00) \oplus (3.54,4.15,4.75) \oplus (4.72,5.43,6.13)$$

$$\sum_{j=1}^{5} M_{g_4}^{j} = (0.24,0.26,0.28) \oplus (0.15,0.17,0.18) \oplus (0.21,0.24,0.28) \oplus (1.00,1.00,1.00) \oplus (6.11,6.61,7.11)$$

$$\sum_{j=1}^{5} M_{g_5}^{j} = (0.17,0.18,0.20) \oplus (0.18,0.19,0.22) \oplus (0.16,0.18,0.21) \oplus (0.16,0.15,0.16) \oplus (1.00,1.00,1.00)$$

The fuzzy sum of the elements of sum column is calculated:

Thus,

$$\sum mg_1 = (17.491,18.718,19.957)$$
$$\sum mg_2 = (14.728,16.165,17.614)$$
$$\sum mg_3 = (9.690,11.034,12.389)$$
$$\sum mg_4 = (7.713,8.276,8.855)$$
$$\sum mg_5 = (1.672,1.714,1.793)$$

The sum of the elements of inverse average column is as:

$$\sum_{j=1}^{5} \sum_{j=1}^{5} M_{g_6}^{j} = (17.491,18.7181,19.9576) \oplus (14.72892803,16.16518646,17.61443784) \oplus (9.690815401,11.03478826,12.38904893) \oplus (7.713063087,8.276157109,8.85507689) \oplus (1.672247323,1.714186417,1.793925753)$$

$$\sum\sum m_{gl} = (51.296, 55.908, 60.610)$$

$$\left(\sum_{j=1}^{6}\sum_{j=1}^{6} M_g^j\right)^{-1} = (0.016, 0.018, 0.019)$$

To normalize the average of the preferences of each criterion, the average of the criterion is divided by the sum of averages. As the values are fuzzy, the fuzzy average of each row is multiplied by the inverse sum of fuzzy average. The inverse sum of fuzzy average in the third step is calculated. Thus,

S1=(17.491,18.718,19.957)⊗(0.016,0.0183,0.019)=(0.289, 0.335, 0.389)
S2=(14.728,16.165,17.614)⊗(0.016,0.0183,0.019)=(0.243, 0.289, 0.343)
S3=(9.690,11.034,12.389)⊗(0.016,0.0183,0.019)=(0.160, 0.197, 0.242)
S4=(7.713,8.276,8.855)⊗(0.016,0.0183,0.019)=(0.127, 0.148, 0.173)
S5=(1.672,1.714,1.793)⊗(0.016,0.0183,0.019)=(0.028, 0.031, 0.035)

The calculation of preference degree (possibility degree) of a convex fuzzy number S greater than K Convex fuzzy number Si;i=1,2,…,k.

V(S1≥S2,S3,S4,S5)=min(V(S1≥S2), V(S1≥S3), V(S1≥S4), V(S1≥S5))=1.000
V(S2≥S1,S3,S4,S5)=min(V(S2≥S1), V(S2≥S3), V(S2≥S4), V(S2≥S5))=0.546
V(S3≥S1,S2,S4,S5)=min(V(S3≥S1), V(S3≥S2), V(S3≥S4), V(S3≥S5))=0.521
V(S4≥S1,S2,S3,S5)=min(V(S4≥S1), V(S4≥S2), V(S4≥S3), V(S4≥S5))=0.237
V(S5≥S1,S2,S3,S4)=min(V(S5≥S1), V(S5≥S2), V(S5≥S3), V(S5≥S4))=0.119

Fourth stage: Normalization of W' vector and obtaining normalized vector W.

$$W' = (1.000, 0.546, 0.521, 0.237, 0.119)$$

$$W_N = (0.413, 0.225, 0.215, 0.098, 0.049)$$

Thus, Eigen vector W21 is as following: Vector W21

$$W_{21} = \begin{pmatrix} 0.413 \\ 0.225 \\ 0.215 \\ 0.098 \\ 0.049 \end{pmatrix}$$

As it can be said, based on fuzzy calculations, business needs criterion is highly preferred and business intelligence system function is in the second

rank of preference. The preference of other criteria is not changed compared to the past.

The result of fuzzy calculations for prioritization of the main criteria based on the goal is shown in Figure 2.

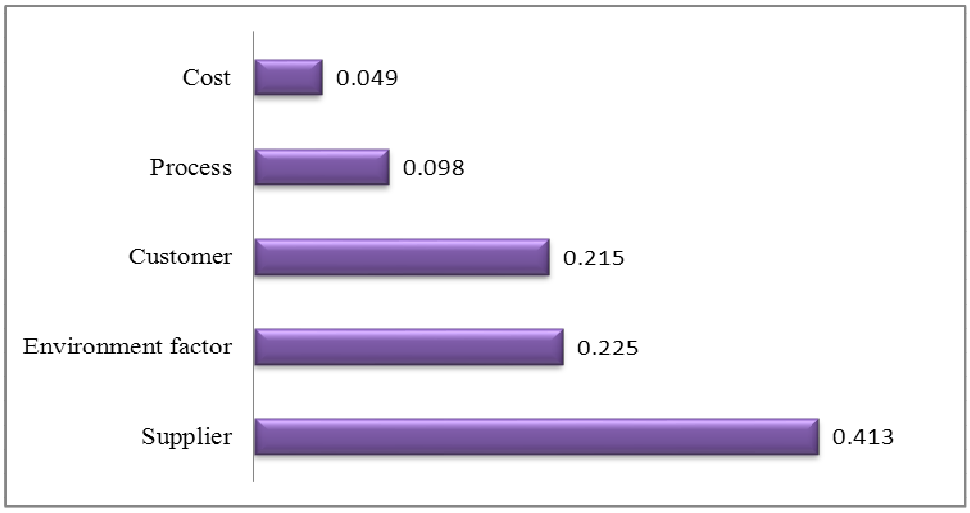

Figure 2. The prioritization of the main criteria based on the study aim

The calculations of internal relations with FDEMATEL technique

Based on the study model, the second step is calculation of the internal relations of the main criteria. Thus, the matrix of main criteria relations W22 is obtained. To reflect the internal relations of the main criteria, fuzzy DEMATEL technique is used and the experts can express their views about the effects (direction and severity of the effects) between the factors. It can be said that the matrix of DEMATEL technique (internal relations matrix) showed the causal relation between the factors and showed also the effect of the variables. The applied fuzzy spectrum is shown in Table 3.

Table 3. Fuzzy spectrum and DEMATEL technique (source: Wang, 2011; Wang and Chang, 1995)

Linguistic variable	Quantity equivalent		Fuzzy quantity equivalent	
		l	**m**	**u**
No effect	0	0.0	0	0.3
Low effect	1	0.1	0	0.5
Effective	2	0.3	0	0.7
Much effect	3	0.5	0	0.9
Very much effect	4	0.7	0	1

In DEMATEL technique, when the views of some experts are used, the simple calculation average of the comments is used and direct relation matrix or M is formed. In this study, first the views of the experts one by one is fuzzificated and by the calculation of fuzzy average of the experts view, the direct relation matrix or M is calculated.

Table 4. The matrix of fuzzificated direct relation (M)

	C1	C2	C3	C4	C5
C1	(0, 0.1, 0.3)	(0.56, 0.76, 0.92)	(0.28, 0.48, 0.68)	(0.42, 0.62, 0.8)	(0.38, 0.58, 0.78)
C2	(0.24, 0.44, 0.64)	(0, 0.1, 0.3)	(0.26, 0.46, 0.66)	(0.26, 0.46, 0.66)	(0.22, 0.42, 0.62)
C3	(0.52, 0.72, 0.88)	(0.52, 0.72, 0.88)	(0, 0.1, 0.3)	(0.46, 0.66, 0.84)	(0.44, 0.64, 0.83)
C4	(0.28, 0.48, 0.68)	(0.34, 0.54, 0.74)	(0.2, 0.4, 0.6)	(0, 0.1, 0.3)	(0.24, 0.44, 0.64)
C5	(0.36, 0.56, 0.76)	(0.3, 0.5, 0.7)	(0.18, 0.38, 0.58)	(0.34, 0.54, 0.74)	(0, 0.1, 0.3)

For defuzzification of direct relation matrix, CFCS technique was used. Defuzzification method of CFCS1 is applied for fuzzy accumulating process and the defuzzificated values are presented better (Opricovic, 20032; Wu, 2007; Chang et al3., 2011). CFCS method is calculated based on Max and Min values of fuzzy number in each range. CFCS method is a 5-stage algorithm:

- Values normalization

$$l_{ij}^{n} = \left(l_{ij}^{d} - min l_{ij}^{d} \right) / \Delta_{min}^{max}$$

- The calculation of crisp values

$$Z_{ij}^{n} = min l_{ij}^{n} + \left(X_{ij}^{n} \times \Delta_{min}^{max} \right)$$

-Based on CFCS algorithm, the crisp values of direct relations matrix are as following:

Table 5. The matrix of direct relation (M) of the crisp main criteria

M	C1	C2	C3	C4	C5
C1	0.126	0.740	0.468	0.605	0.570
C2	0.440	0.126	0.450	0.458	0.420
C3	0.700	0.701	0.128	0.643	0.625
C4	0.478	0.536	0.395	0.127	0.438
C5	0.553	0.498	0.377	0.533	0.127

-The calculation of normal direct relation matrix :N = K*M
At first, the sum of all the rows and columns is calculated. The inverse of the greatest number of k
Row and column is formed. According to Table 5,

$$m_{ij}^{n}=\left(m_{ij}^{d}-minl_{ij}^{d}\right)/\Delta_{min}^{max}$$

$$u_{ij}^{n}=\left(u_{ij}^{d}\text{-}minl_{ij}^{d}\right)/\Delta_{min}^{max}$$

$$where\Delta_{min}^{max}=maxu_{ij}^{d}-min_{ij}^{d}$$

- The calculation of upper and lower limit of normal values

$$ls_{ij}^{n}=m_{ij}^{n}/\left(1+m_{ij}^{n}-l_{ij}^{n}\right)$$

$$us_{ij}^{n}=u_{ij}^{n}/\left(1+u_{ij}^{n}-m_{ij}^{n}\right)$$

- The calculation of total crisp normalized values

$$x_{ij}^{n}=\left[xls_{ij}^{n}\left(1-xls_{ij}^{n}\right)+xrs_{ij}^{n}\times xrs_{ij}^{n}\right]/\left[1-xls_{ij}^{n}+xrs_{ij}^{n}\right]$$

-the greatest number is 2.796 and all the values of this table are multiplied by the inverse of this number to normalize the matrix.

$$\mathbf{k}=\frac{1}{\max\sum_{j=1}^{n}\mathbf{a}_{ij}}=\frac{1}{2.796}=0.357$$

$$\Rightarrow \mathbf{N}=0.357*\mathbf{M}$$

Table 6. Normalized matrix (N) of the main criteria

N	C1	C2	C3	C4	C5
C1	0.0452	0.2646	0.1674	0.2163	0.2036
C2	0.1573	0.0450	0.1609	0.1636	0.1501
C3	0.2503	0.2508	0.0457	0.2299	0.2233
C4	0.1708	0.1915	0.1412	0.0453	0.1568
C5	0.1977	0.1780	0.1347	0.1904	0.0453

To calculate the total relation matrix, at first identity matrix (I) is formed. Then, the identity matrix is minus the normal matrix and the result matrix is inversed and finally normal matrix is multiplied by inverse matrix:

$$T = N \times (I - N)^{-1}$$

Table 7. Total relation matrix (T) of main criteria

T	C1	C2	C3	C4	C5
C1	0.7516	1.0236	0.7372	0.9210	0.8582
C2	0.7060	0.6749	0.6094	0.7285	0.6760
C3	1.0043	1.1038	0.6944	1.0143	0.9507
C4	0.7319	0.8209	0.6076	0.6392	0.6964
C5	0.7821	0.8437	0.6265	0.7966	0.6243

To determine the Network Relations Map (NRM), the threshold value is calculated. By this method, partial relations are ignored and reliable relation network is drawn. The only relations their values are bigger than threshold value in matrix T is shown in NRM. To calculate the threshold value of the relations, it is required to calculate the average Conclusion and Implications values of matrix T. After the determination of threshold value, all the values of matrix T less than threshold is zero, the causal relation is not considered. In this study, threshold value is 0.785. Thus, the model of significant relations is as:

Table 8. The model of significant relations of the main criteria of the model

	C1	C2	C3	C4	C5
C1	×	1.0236	×	0.9210	0.8582
C2	×	×	×	×	×
C3	1.0043	1.1038	×	1.0143	0.9507
C4	×	0.8209	×	×	×
C5	×	0.8437	×	0.7966	×

Based on relations model, the casual chart is drawn as:

Table 9. The model of causal relations of key indicators performance of Green Supply Chain

Critical	D	R	D+R	D-R
Cost	4.292	3.976	8.268	0.316
Process	3.395	4.467	7.862	-1.072
Customer	4.767	3.275	8.042	1.492
Environment factor	3.496	4.100	7.596	-0.604
Supplier	3.673	3.806	7.479	-0.133

In the sum of the elements of each row (D) showed its effect on other system factors. Thus, Customer criterion had the major influence. The Cost criteria were in the second rank. The Supplier and Environment factor with similar effect was in the next position. The Process criterion had the lowest effect.

-The sum of column elements for each factor indicates its effect from other system factors. Thus, Process function has considerable effect. The Customer had the lowest effect from other criteria Horizontal vector (D+R) is the effect of the required model in the system. In other words, the more the value of D+R, the more the interaction of the factor with other factors of the system. Thus, Cost criterion had the major interaction with other study criteria. The Supplier criterion had the lowest interaction with other variables.

-Vertical vector (D-R) showed the power of effect of each factor. Generally, if D-R is positive, the variable is causal and if it is negative, it is effect. In this model, Process and Customer were casual and other variables were effect.

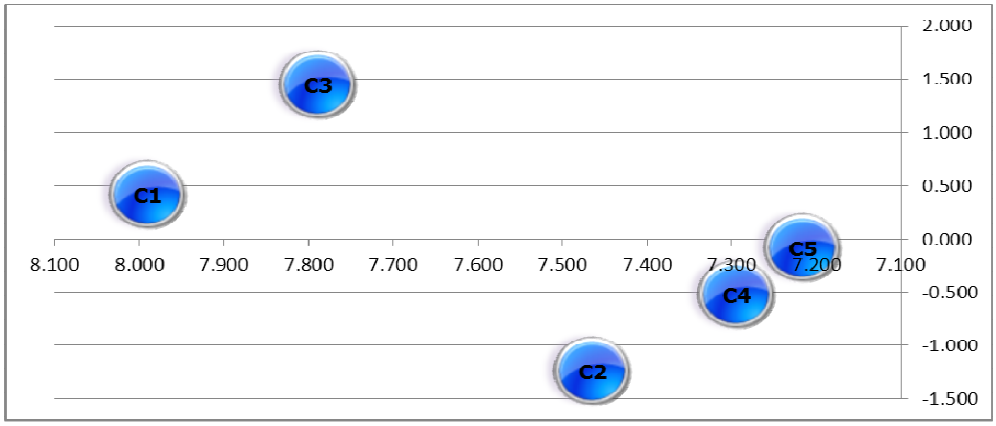

Figure 3. Descartes coordinate system of DEMATEL output for the main criteria

In the third step, the study sub-criteria were compared as paired. In this step, the pair-wise comparisons were done in five stages. In each stage, the sub-criteria of each main criterion of business intelligence evaluation were compared as paired. The defuzzificated prioritization of the indices of five elements of business intelligence evaluation is as:

$W_{32}=$

0.618	0.000	0.000	0.000	0.000
0.382	0.000	0.000	0.000	0.000
0.000	0.134	0.000	0.000	0.000
0.000	0.241	0.000	0.000	0.000
0.000	0.357	0.000	0.000	0.000
0.000	0.268	0.000	0.000	0.000
0.000	0.000	0.390	0.000	0.000
0.000	0.000	0.329	0.000	0.000
0.000	0.000	0.281	0.000	0.000
0.000	0.000	0.000	0.204	0.000
0.000	0.000	0.000	0.430	0.000
0.000	0.000	0.000	0.366	0.000
0.000	0.000	0.000	0.000	0.659
0.000	0.000	0.000	0.000	0.341

Finally, to achieve the general priorities of defuzzificated values are transferred into the super decision software. Based on the study purpose, based on the criteria and sub-criteria, the model of network analysis is designed in super decision software. Thus, based on this model ANP

.After the required calculations, finally the general priorities of the indices with fuzzy ANP techniques are presented. The summary of the results of FANP technique is shown in Table 10.

Table 10. The final priority of the indices of model with ANP, FANP

Inde	I	Initial weight	Normal weight
S11	ROI	0.514	0.1305
S12	Inventory levels of circulating	0.498	0.1265
S21	Effectiveness of distributed scheduling	0.374	0.0949
S22	Ways to order	0.318	0.0806
S23	The accuracy of prediction methods	0.316	0.0801
S24	Level of information sharing	0.307	0.0780
S31	Customer Satisfaction	0.269	0.0682
S32	How to deliver quality	0.262	0.0664
S33	advertisement	0.258	0.0654
S41	Environmental factors (sanctions, war and	0.242	0.0616
S42	Retardation of technological change and	0.182	0.0461
S43	Government support (import, taxes, loans,	0.164	0.0416
S51	Quality Capabilities Supplier	0.146	0.0370
S52	Supplier cooperation	0.091	0.0231

5. Discussion and conclusion

These studies aimed to identify factors affecting supply chain performance influencing variables were green. Using the Delphi technique and literature were identified variables affecting green supply chain performance and then using MCDM approach, they examined Significant based on the conceptual model of factors affecting the performance of green supply chain in the food industry Iran was developed.

In this study, the most comprehensive model to assess the impact of these factors will also be discussed. Results are presented from the perspective of a food factory in Iran experts about the importance of each factor on the performance of green supply chain offers. The accuracy of these results, we discover that the most important factor in this chain are in fact corporate clients in the first category and the companies of the bargaining power of in this industry, it is clear that they have the They measure the performance of these chains is very high. The second factor is the process that it represents the business processes in this industry and

this is a great weakness in the eyes of the industry experts be one of the most important issues to improve the performance supply chain Green be.

Sustainability, green and environmentally issues are significant which has been discussed in recent years and a large number of firms implement green practices to improve their businesses. Food industries are considered one of the major contributors to environmental pollution and the area that requires implementation of more effective sustainability practices. So, it is important to pay attention to environmental requirements in supply chain process in Food companies. In this article, we used the fuzzy DEMATEL method, to study the influence of the most important factors and to find out the ranking of critical factors in green supply chain management in Food corporations and also a model with multi-criteria approach and 14 factors in green supply chain management was presented. Based on our research, we concluded that the top five important critical factors of green supply chain management in Food industries in Iran are as follows: Customer, Cost, Supplier, Environment factor and Process. Researchers can also find this method valuable for other study and this study provides an essential step into further research on greening the supply chain and also, other researchers can develop and use our model, for other green supply chain management researches and our observations may be completed over time with the same case study. This research suggests further researches in order to extend the scope of this study. For example: other criteria can be added to green supply chain or such research can be done in environmental protection, green design, green policy, green purchasing, green sales and marketing, green products, green technology, and green chemistry.

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