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Performance evaluation of the Sustainable supply chain management using a hybrid approach of Fuzzy ANP, Fuzzy TOPSIS and ISM

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Abstract

This study aimed to evaluate the performance of sustainable supply chain management based on the combined approach fuzzy ANP, TOPSIS fuzzy and ISM deals. The purpose of this technique is to identify the supply chain, a combination of hierarchical analysis and fuzzy logic analysis with the grid concept. The technique has been used in a case study and the main factors affecting the supply chain have been identified in this study. Type of research is development. The research library methods, descriptive analysis. The study population consisted of managers and experts Mapna supply chain companies, has. In this study, 95 managers and experts with supply chain companies surveyed using stratified random sampling method, a sample will be selected. In this study, a questionnaire is to collect information. In this study to identify factors affecting the selection of suppliers has been paid, after which the ISM ranking factors and finally FANP and fuzzy TOPSIS method to rank the supplier has been paid.

Keywords: Performance evaluation, sustainable supply chain, AHP, TOPSIS, ISM

Introduction:

SCM is responsible for the materials flow in human society as well as the exchange of material and energy with the environment. Effects of the SCM should be determined in relation to the three main aspects of sustainability: environmental performance, social responsibility and economic contribution. However, today, the main focus is on the economic dimension, through the assessment with some of the best and well-known methods (Sheikhzadeh, 2013).

A supply chain is a system of organizations, people, technology, activities, information and resources involved in moving a product or service from supplier to final customer. Supply chain activities transform natural resources and raw materials into a finished product that should deliver to the final customer (Safarzadeh, 2009). Supply chain is a network that consist all activities associated with the flow and transformation of goods from raw material stage to finished product as well as the information flows related to it. The Materials and information both move up and down in the network, and in order that the supply chain be able to function well and provide customer satisfaction requires a correct management (Znjyrany Farahani, 2005).

Theoretical basis of research:

A comprehensive definition is provided by the global supply chain Association as follow:

Supply chain management is the integration of key business processes from end user to primary supplier that is responsible for supplying products, services and information that add value for customers and stakeholders.

In recent years many organizations have accepted the supply chain operations reference model as a powerful and comprehensive tool to describe, analyze, and improve supply chain: the basis of the model is the supply chain main processes such as resourcing, manufacturing and distribution (Denham et al., 2015).

Most supply chains essentially act as a network, so it is better that the supply network is used as the supply chain structure. A supply chain can contain different levels that include:

- customers or end users
- retailers or intermediate customers
- warehousemen, distributors and wholesalers
- manufacturers
- suppliers of raw materials

According to Handfield (2003), supply chain consists three major processes namely logistics, relationship management and information management.

Money, raw materials, processes and information flows can be gathered in the supply chain management system at the same time, but simultaneously because of pressure from government regulations and increasing public awareness of the environment, the companies cannot ignore environmental issues if they want to be involved in global competition. The green supply chain management or briefly GSCM is replaced with the supply chain management (Buyukuzkan and Shifsy, 2012). Supply chain executives are

looking for faster delivery of goods and services, reducing costs and increasing quality, but improving the environmental performance of the supply chain and the importance of social costs and environmental degradation were not considered. With the pressure of government regulations for obtaining environmental standards on the one hand and the growing customer demand for green products (without harmful effects on the environment), the concept of green supply chain and managing it is appeared (Faith, 2008). In fact, progress in the field of environmental management and the growing acceptance of responsibility for the impact of its production out of the factory by the manufacturers, form the logic of the green supply chain management. Looking back on the general criteria explained in the context of supply chain management three basic assertions can be described: In the late 1970s and early 1980s, the main focus has been on cost; In the early 1990s, main focus was on cycle time and responsiveness to the customer, and finally, in the late 1990s, the focus is shifted to the flexibility (Tian et al., 2014).

Namdarian and moqadam (2010) in a study titled assessing supply chain performance with an process and strategic approach by providing an innovative model through integration of Chan and Cui and score models that eliminates the disadvantages of the two models. These models transform performance data of the various criteria to a significant indicator for a supply chain using fuzzy logic. Ahmadi et al (2010) conducted a study entitled developing a model for measuring the success of an organization in green supply chain management with the green supplier selection approach (Case Study: Iran Alloy Steel Company) with the aim of identifying the main indicators of supply chain management and providing a model and finally selection the best suppliers from the environmental issues view. They extracted 34 indicators from the scientific literature and reviewing the greening issue in Iran Alloy Steel at the corporate level. In this regard, in addition to the aid of the previous research, the experts and industry manufacturers' point of view have also been used and utilized as the basic for preparing a questionnaire. Then they formulated six-factor model include indoor component management, green purchase, clean production, reprocessing, environmental design and emissions to measure the green supply chain management, Which concluded that internal environmental management is a key element in improving the performance of companies that require top management support and it is often considered as a key factor for successful adoption and application of innovation, technologies, programs and green activities and some manufacturers recycle the product to reduce costs, improve the company's image, meet the changing customers' expectations and dominate the market and they believe that many of the environmental impact of products or raw materials can be controlled in the design phase when materials and processes are selected because the profitability of products relates to their design.

Layia Olfat et.al (2010) conducted a study entitled the requirements of realizing green supply chain management in the automotive industry in Iran with the aim of identifying requirements (drivers, obstacles, actions and results) to achieve a green supply chain management. Thus, according to the literature, the necessary actions to achieve a green supply chain management are extracted and the actions are surveyed by providing a questionnaire for the experts to become finalized. In this study, the 5 economic results are obtained include: positive economic, negative economic, environmental, production performance improvement and achieving stakeholder satisfaction, that the MADM method is used to prioritize and determine the importance and TOPSIS method is used in multi-criteria decision-making. According to the results of the research the executive actions of design for environment, environmental collaboration with stakeholders and waste management are in the first to third priorities.

Ganaskaran et al (2014) conducted a research entitled "a framework for measuring supply chain performance" have proposed a framework to measure the performance of the supply chain, a framework for standards and measures of the supply chain performance. These criteria are based on four main processes namely the supply chain planning, sourcing, production and delivery, and they are divided with respect to the three levels of strategic, tactical and operational. Sony and codali (2014) conducted a study entitled "internal benchmarking to assess supply chain performance" have provided a way to reduce the variability in the performance of a supply chains of a single company that operate in different countries. Then, using PVA, the company has evaluated the performance of supply chains, and using the results of PVA, the SWOT analysis is performed on the results to make strategic decisions.

Ohdar and Ray (2014) in their study offer an evolutionary fuzzy system for evaluating the performance of suppliers. They have also made fuzzy rules in their proposed system, and developed a methodology based on genetic algorithm to find optimized fuzzy sets.

Liksin Shen et al (2013) in their study entitled "fuzzy multi-criteria approach for evaluating the performance of green suppliers in the green supply chain with language requirements that aim to reduce energy consumption, emissions and waste within the international organizations" utilized fuzzy multi-criteria approach through combining fuzzy TOPSIS to obtain a total score and achieved 9 criteria include the contaminated products, expendable resources, economic design, green image, environmental management systems, management's commitment to green supply chain management, use of environment-friendly technology, the use of environment-friendly materials and environmental education to employees to assess their suppliers by which they can reduce energy consumption, emissions and waste.

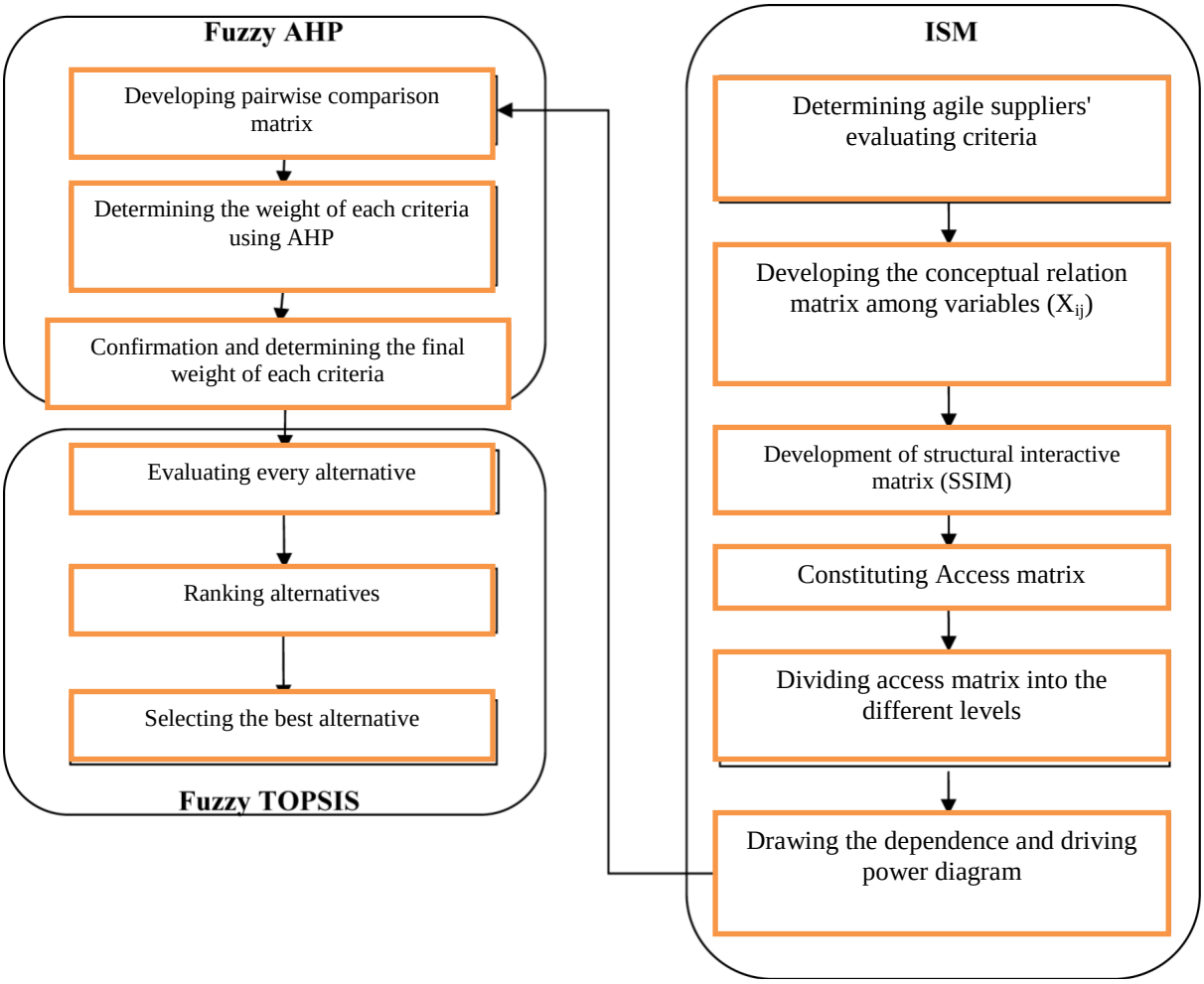


Figure 1. the Research Conceptual Model

Research Methodology

In this study, we have tried to identify obstacles before and during the establishment of sustainable supply chain framework project in the studied organization, investigate the complex relationships between obstacles using fuzzy network analytic model so that by determining the degree of importance as the weights of these barriers with this methods, it will be possible to achieve better understanding and view of

the existing situation so that we can think about and implement proper solutions. So the senior management understanding of barriers to implement sustainable supply chain management in their organizations and based on identified priorities of these obstacles, they plan and fix them according to their abilities and capabilities of their organization. super matrixes view which is well known as the network analysis process, has become an attractive tool to better understand the problem of decision, because it overcomes the limitations of hierarchical structures. Such systems can be directed by a network (diagraphs), in which one or a cluster can directly or indirectly be affected and affect by other features of decision or the elements and levels or the clusters. In this technique, there is the opportunity to consider feedbacks that this is impossible in AHP because of its hierarchical structure. The advantage of this technique compared to traditional statistical methods is to have the power of considering the relations between the criteria and the complexity between criteria and the feedback in order to achieve reliable results that it would help to achieve reliable results. The current study is a development research. The research also utilizes the library, survey, descriptive analysis methods. The study population consists of managers and experts of Mapna companies supply chain. The population can be defined in terms of the study purpose and type of observed unit. According to the definition of population, the territory of the research is the supply chain of the Mapna companies of Karaj. the time period for the study is 2014-2015. In this study, 95 managers and experts related to supply chain of the surveyed companies will be selected using stratified random sampling method. The data collection tool in the study is a questionnaire. In this study, at first we identify factors affecting the selection of suppliers and then we have classified factors using the ISM model and finally we have ranked suppliers using fuzzy TOPSIS and FANP.and the other personnel involved in the project will be able to acquire more and more realistic

Data analysis

- Setting priorities using the ANP model

To Rank the final criteria and sub-criteria the multi-criteria decision-making and ANP models with fuzzy approach are utilized. To determine the relationship between variables the fuzzy DEMATEL technique has been used. Finally the Visual-basic coding and Super-Decision software are used to analyze the data obtained from the Microsoft Excel.

At the first stage, the criteria and sub-criteria for the study were identified and selected. The main criteria include: economic factors, environmental factors, social factors. For each of the main criteria some sub criteria have been identified. 21 sub-criteria have been identified in general. At the first step in order to identify sub-criteria the research literature and expert interviews were used. The analysis stages are as follows:

- prioritizing the main criteria based on purpose using pairwise comparison
- identifying the interrelations among the main criteria using DEMATEL technique
- prioritizing each of the sub criteria in its related cluster using paired comparison
- identifying the interrelations among sub-criteria using DEMATEL technique •
- Calculating the primary, weighted and limited super matrixes

The final priority is specified in this way.

- Determining the main criteria priorities based on the purpose

Three paired comparison is carried out based on the group of experts' point of views. The geometric mean method is used to integrate the expert opinion in fuzzy ANP method. According to the results of the integration of expert opinion, the paired comparison matrix is provided in the following table:

Table 1. paired comparison matrix of the research main criteria

Social factors	Environmental factors	Economic factors	
(2.32 ,1.75 ,1.28)	(1.72 ,1.41 ,1.14)	(1 ,1 ,1)	Economic factors
(1.68 ,1.37 ,1.02)	(1 ,1 ,1)	(0.88 ,0.71 ,0.58)	Environmental factors
(1 ,1 ,1)	(0.98 ,0.73 ,0.59)	(0.78 ,0.57 ,0.43)	Social factors

After formation the pairwise comparisons matrix, the eigenvector is calculated. at first the fuzzy sum of each row is calculated. Fuzzy extension of each criterion will be as follows:
Fuzzy extension of row 1 (5.04 ,4.16 ,3.42)=(2.32 ,1.75 ,1.28)⊕(1.72 ,1.41 ,1.14)⊕(1 ,1 ,1) Fuzzy extension of row 2 (3.56 ,3.09 ,2.6)=(1.68 ,1.37 ,1.02)⊕(1 ,1 ,1)⊕(0.88 ,0.71 ,0.58)
Fuzzy extension of row 3 (2.76 ,2.3 ,2.03)=(1 ,1 ,1)⊕(0.98 ,0.73 ,0.59)⊕(0.78 ,0.57 ,0.43)
The sum of the elements of preferences column will be as follows:

$$\sum_{i=1}^{3}\sum_{j=1}^{3} M_g^j = (8.05, 9.54, 11.36)$$

Each fuzzy weight and normalized values are related to the main criteria. In the final step defuzzification of values and crisp number calculations is performed. The conducted calculations to determine the priority of the main criteria are as follows:

Table 2-defuzzification of calculated normal weights of the study main variables

Normal	Defuzzy	X3max	X2max	X1max	Crisp
0.437	0.454	0.445	0.450	0.454	Economic factors
0.319	0.331	0.327	0.329	0.331	Environmental factors
0.244	0.254	0.248	0.251	0.254	Social factors

The special vector of the main criteria priority will be as W21.

$$W_{21}= \begin{pmatrix} \mathbf{0.437} \\ \mathbf{0.319} \\ \mathbf{0.244} \end{pmatrix}$$

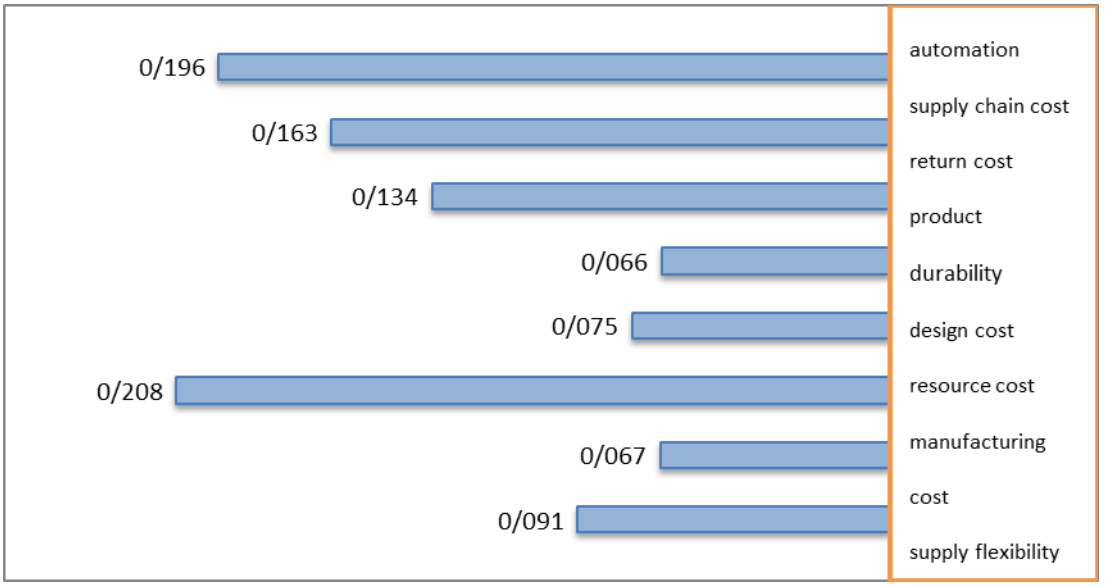
According to the obtained special vector:

- Economic factors with normal weight of o.437 have the highest priority.
- The environmental factors are in the second place with the normal weight of 0.319.
- Social factors with the normal weight of 0.244 have the lowest priority.

- Comparison and determining the priority of sub-criteria

- Prioritizing economic sub-criteria

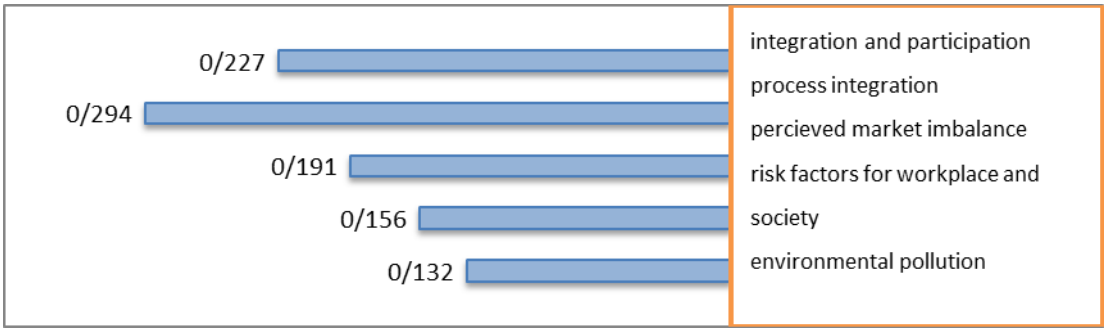
Table 3. defuzzified values of economic sub-criteria weights



- Price index with the normal weight of 0.208 is the most important factor
- Automation index with the weight of 0.196 has the second priority.
- The supply chain cost index with the weight of 0.163 is in the third place.

- determining the environmental sub-criteria priorities

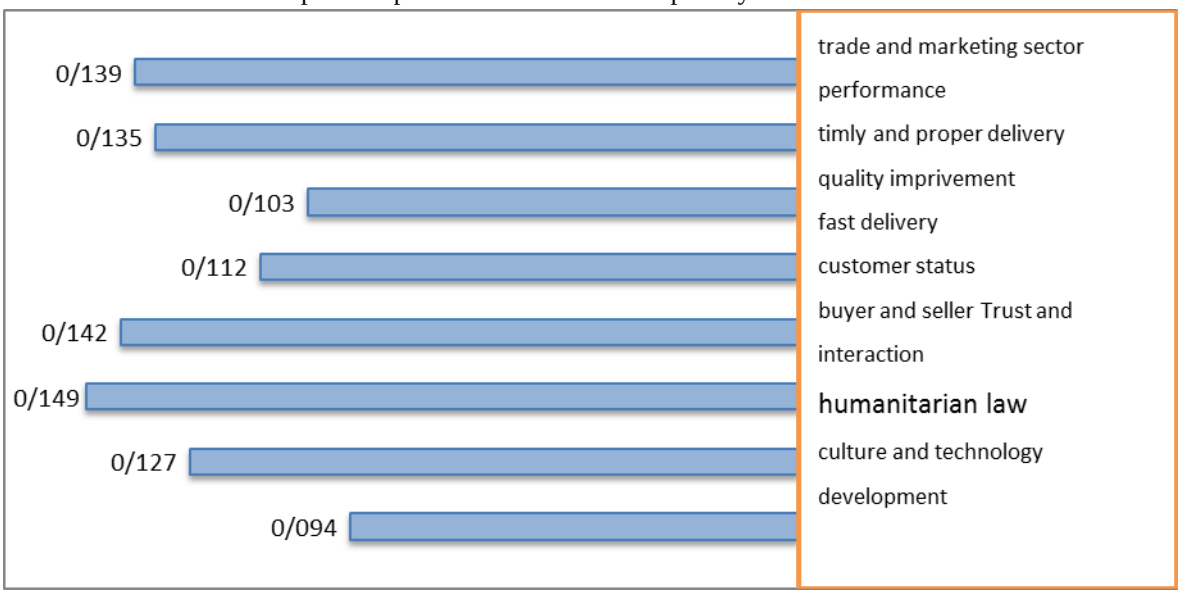
Table 4. Graphical representation of the environmental indicators priorities



- Processes Integration with the normal weight of 0.294 is the most important factor.
- Integration and participation has the second priority by the weight of 0.227.
- Perceived market imbalance with the weight of 0.191 is in the third place.

- Determining the social sub-criteria Priority

Table5. Graphical representation of indicators priority of the social factors



- Trust and interaction between buyer and seller is the most important factor with the normal weight of 0.149.
- The second priority is related to customer position with the weight of 0.142.
- Trade and Marketing performance is in the third place with the weight of 0.139.

Calculation of internal relations with FDEMATEL techniques.

Table6. the causal relationships pattern of the research indicators

D-R	D+R	R	D	

1.02-	6.67	3.84	2.83	automation
0.22	8.09	3.93	4.16	Supply chain costs
0.26	7.42	3.58	3.84	Return cost
0.11	6.88	3.39	3.49	Product durability
0.11	7.19	3.54	3.65	Design cost
0.18-	7.14	3.66	3.48	Resource cost
0.36	6.43	3.03	3.40	Production cost
0.02	7.07	3.52	3.54	Supply flexibility
0.35	6.43	3.04	3.39	Integration and participation
0.10-	6.67	3.39	3.29	Process integration
0.61-	6.82	3.72	3.11	Perceived market imbalance
0.51-	7.49	4.00	3.49	Risk factors for workplace and society
0.29-	7.05	3.67	3.38	Environmental pollution
0.89	7.22	3.17	4.05	trade and marketing sector performance
0.17-	7.61	3.89	3.72	timely and proper delivery
0.38-	7.38	3.88	3.50	quality improvement
0.74	6.94	3.10	3.84	fast delivery
0.27-	7.11	3.69	3.42	customer status
0.26-	7.46	3.86	3.60	buyer and seller Trust and interaction
0.73	7.05	3.16	3.89	humanitarian law
0.35	6.51	3.08	3.43	culture and technology development

The sum of elements of each row (D) indicates the effectiveness of that factor on the other factors of the systems. accordingly the criteria are as follow: Flexibility, security, automation, return cost, supply chain costs, production costs, environmental pollution, integration and participation, timely and proper delivery and perceived market imbalance, customer status, process integration, trust and interaction between buyer and seller , Trading and marketing performance, cost of resources, quality improvement, shelf life, cost of design, fast delivery, risk factors for workplace and society, humanitarian law, development of culture and technology.

- The sum of the elements of each column (R) for each factor indicates the effect of the other factors of the system on that factor. accordingly the criteria are as follow: Trust and interaction between buyer and seller, supply flexibility, environmental pollution, customer status, timely and proper delivery, the development of culture and technology, humanitarian law, quality improvement, fast delivery, Trading and marketing performance, production cost, integration and participation, perceived market imbalance, process integration, risk factors for workplace and society, automation, return cost, supply chain cost, resource costs, design costs, product durability.

- Horizontal vector (D + R), is the impressibility and effectiveness of the given factor in the system. In other words, the greater the amount of D + R of a factor is, the more interacts it has with other elements of the system. accordingly the criteria are as follow: supply flexibility, environmental pollution, trust and interaction between buyer and seller, timely and proper delivery, production cost, customer status, automation, integration and participation, the performance of the trade and Marketing sector, quality

Improvement, perceived imbalance in the market, the cost of return, fast delivery, supply chain cost, process integration, humanitarian law, risk factors for workplace and community, culture and technology development, resource costs, design costs, product durability.

- Vertical vector (D - R), shows the influence of each factor. Generally, if D - R is positive, the variable is a causal variable and if it is negative, it is an effect variable. In this model, the causal variable include: automation, supply chain costs, the cost of return, product durability, designing cost, resources cost, production cost, flexibility, security, integration and participation, process integration, perceived market imbalance.

Effect variables include: risk factors for the environment and society, environmental pollution, trade and marketing sector performance, timely and proper delivery, quality improvement, fast delivery, customer status, trust and interaction between buyer and seller, humanitarian law, culture and technology development. Determining the final priority of indicators using FANP technique.

Table 7. The final weight of indicators based on the limited super matrixes

rank	Ideal weight	Normal weight	General weight	criteria	symbol
4	0.692	0.074	0.037	automation	S11
6	0.575	0.062	0.031	Supply chain costs	S12
8	0.473	0.051	0.025	Return cost	S13
20	0.233	0.025	0.013	Product durability	S14
17	0.265	0.028	0.014	Design cost	S15
3	0.734	0.079	0.039	Resource cost	S16
19	0.237	0.025	0.013	Production cost	S17
14	0.321	0.035	0.017	Supply flexibility	S18
2	0.772	0.083	0.041	Integration and participation	S21
1	1.000	0.107	0.054	Process integration	S22
5	0.650	0.070	0.035	Perceived market imbalance	S23
7	0.531	0.057	0.029	Risk factors for workplace and society	S24
9	0.449	0.048	0.024	Environmental pollution	S25
12	0.332	0.036	0.018	trade and marketing sector performance	S31
13	0.322	0.035	0.017	timely and proper delivery	S32
18	0.246	0.026	0.013	quality improvement	S33
16	0.267	0.029	0.014	fast delivery	S34
11	0.339	0.036	0.018	customer status	S35
10	0.356	0.038	0.019	buyer and seller Trust and interaction	S36
15	0.303	0.033	0.016	humanitarian law	S37
21	0.224	0.024	0.012	culture and technology development	S38

Conclusion:

According to the conducted survey, there can be several factors in successfully and effectively improve supply chain performance. The first factor is the senior management demand and support of the integration process with the suppliers and customers to create the supply chain. The second factor is to educate people (staff and managers) to create a new situation in the organization that provides a platform. The third factor is the proper information system for effective and efficient information flow in the organizations, which help the supply chain member to maintain a constructive interaction. It may be noted that having a proper information flow cause to reach many of the supply chain goals. In the studies carried out on the most successful organizations on the implementation of supply chain management (Toyota, Dell, McDonald's, etc.) It has been found that the management support of staff and those involved in the supply chain and production, as well as their commitment the customer has contributed to the success of these organizations. The role of education in learning new tasks and especially making employees multi-skilled is also important for having the staff appropriate to work for such organizations. And finally an information system that is based on accurate, timely and relevant information helps chain profitability by eliminating most of the waste and delays.

Since in the implementation of the organizational projects, sustainable chain performance improvement is a key element of success, therefore, we propose to Mapna in particular and the other corporate and governmental and nongovernmental organizations in general that exercise the utmost precision in selecting their supply chain management and in this respect use scientific methods. Criteria, the importance of each of them, and the method that is used in this study could be helpful in this regard.

- According to the rating of the main factors, the economic dimension is of utmost importance. Observance of the required standards for the purchase of raw materials is effective from the technical and environmental point of view. In this respect, education and providing energy consumption patterns is critical. Observing the standards in the purchase of machinery, equipment and tools in terms of the technical and environmental point of view is also important. Continues analytical review of the working situation of the machines and checking the status of their exhaustion that causes environmental pollution and high energy consumption should be considered in the agenda of the organization. Analytical review of all the stages of the production process from the point of view of saving is recommended. The organizational culture is very important in this respect and promoting green culture should be at the helm of affairs. The harmony between the organizational interacting elements is very important. Senior management support, effective management and using green working team must be utilized as an umbrella that include all other activities.
- The dimension of focusing on the customers in this study is another important factor. In this regard, the use of new technologies for the efficient use of energy should be on the agenda. Recycling of waste and scrap within the companies can also help supply chain. The product recovered after the end of its useful life can be a step toward a green supply. Long life of the product could be another choice to provide green supply. Providing an environment to study and make recommendations on environmental issues will be a step towards the green supply chain. Evaluation of suppliers in terms of environmental, economic, green packaging and use of the economic labeling for products and services in the market can also promote green supply. Finally, appropriate pricing is required to acquire customers' support for green products.
- The results show that the aspect of the interaction with supply chain suppliers is important. Many organizational projects, especially projects in the automotive industry, due to the lack of accuracy in the selection of supply chain management supplier, have stopped during the execution or completed with

more cost and time that initial estimates. Preventing to enforce the personal and unprofessional opinion in the evaluation of supply chain management results in the creation of a strong system of supply management in the organization, and management and planning for the role of macro management and strengthening it. In this way the entire automotive supply projects are under an Integrated management and it will be prevented the application of different and sometimes contradictory interests in supply chain management.

- Reformation the fittest supply chain selection system considering all factors involved in the final selection of the supply chain
- Modification of the criteria weights based on the obtained weights and priorities. Making decisions based on several criteria and considering their importance when selecting is definitely much better than the decision making based on the price. Therefore, in case of the implementation of the proposed model in the organization and determining the appropriate weight to the decision criteria, the selected supply chain has the right competencies to increase organization revenues at the right time and with the appropriate cost and quality.

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