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Research Article

Identify Efective factors green supply chain in Automotive Parts Company

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ABSTRACT
Today environmental management emphasizing environmental protection has become one of the most important issues of customers, governments, industry and competitors. International and global pressures have forced organizations to produce environmentally friendly products and services. This study aimed to identify factors affecting green supply chain and provide a framework to implement, evaluate and compare the green automotive part industry. This study was carried out in two different phases; first, by reviewing scientific literature and acquiring experts' opinion, seven green supply chain management criteria were extracted included green supplier and purchase, green design and packaging, green manufacturing, green distribution and marketing, reverse logistics, environmental management, training and research through which Delphi questionnaire was prepared. Then, the criteria were prioritized using fuzzy AHP and experts' opinion. Finally, using fuzzy AHP, three German, Italian and Korean companies were measured by seven influential factors. The results showed that HENKEL, PPG , and KCC acquired the first to third ranks, respectively. It was also tried to provide solutions and analysis of results obtained.

Keywords: Supply Chain, Green Supply Chain, Green Supply Chain Management, GSCM, Environmental Management System, Fuzzy AHP .

INTRODUCTION
Nowadays, ensuring sustainable development of any country depends on the optimal preservation and use of limited and irreplaceable resources and various measures have been taken by governments to deal with this issue, including the use of raw materials compatible with the environment of manufacturing and industrial centers, reduced use of fossil and oil energy resources and the reuse of waste. In recent years, the expedited governmental rules and regulations for obtaining environmental standards and the growing demand of consumers for the supply of green products to the supply chain encompassing all activities related to the flow of goods from raw materials to the delivery of goods to final consumers, as well as the flow of information throughout the chain, have resulted in the emergence of a new concept that

include all phases of green supply chain management (GSCM) and product life cycle from design to recycling. Adopting investment strategy of improving the environmental performance of the supply chain will bring about numerous advantages such as energy resource savings, reduced pollutants, removal or reduced waste, created value for customers, and ultimately, increased productivity for production and service organizations (3).

By economic globalization, increased competition, and IT development, the supply-driven market has become demand-driven one. To survive in a global competitive environment, organizations have realized the importance of customer satisfaction and they have also found that customer satisfaction is done not only by final product but also by all elements contributing to the preparation, manufacturing and delivery of product to the customer; thus, supply chain management (SCM) gains importance. SCM seeks to maximize profits or minimize costs in organizations. However, it overlooked its negative impact on the environment, including the loss of resources, ecosystem degradation and destruction of environment that ensures sustainable development. Ensuring sustainable development of any country depends on the optimal preservation and use of limited and irreplaceable resources and various measures have been taken by governments to deal with this issue, including the use of raw materials compatible with the environment of manufacturing and industrial centers, reduced use of fossil and oil energy resources and the reuse of waste. Expedited governmental rules and regulations for obtaining environmental standards and the growing demand of consumers for the supply of green products to the supply chain encompassing all activities related to the flow of goods from raw materials to the delivery of goods to final consumers, as well as the flow of information throughout the chain, have resulted in the emergence of a new concept called "green supply chain management (GSCM)". In fact, the GSCM model serves as environment protection by which companies can reduce the negative environmental impacts and achieve the optimal use of resources and energy.

Literature

Hamid Abdolmaleki (2014) conducted a study, "identifying and assessing GSCM components in the food industry with a Fuzzy MCDM approach" in three different phases. first, by reviewing scientific literature and acquiring experts' opinion, seven GSCM criteria were extracted included green supplier and purchase, green design and packaging, green manufacturing, green distribution and marketing, reverse logistics, environmental management, training and research through which questionnaire was prepared. Then, the criteria were prioritized using fuzzy AHP and food industry experts' opinion. Finally, using fuzzy TOPSIS, three KALE, PAAK, and LINANIK food industry companies were measured. The results suggested that KALE, LINANIK, and PAAK were in the first to third ranks, respectively.

In a study, "a model for measuring the organizational success in GSCM with a green supplier selection approach" conducted by Mohammadali Afshari (2013), the main objective of this study was to identify the main GSCM indicators and provide a model in this regard, and finally choose the best supplier form the environmental consideration perspective. The study was carried out in two different phases. At the first step, by reviewing scientific literature and acquiring experts' opinion, thirty-four green supply chain criteria were extracted through which questionnaire was prepared. After data collection and factor analysis, the factor model, including indoor management, green purchase, clean production, reprocessing, environmental design, and contaminant, was developed to measure green supply chain. In the second step, according to the extracted components, a hybrid AHP and GRA method was used for the study company's supplier selection.

Problem statement

The GSCM idea is to eliminate or minimize the waste of energy, emissions, hazardous chemicals, and solid wastes along the supply chain. Environmental issues under customer rules and procedures have become a major concern for manufacturers, especially in the

United States, Europe Union and Japan. GSCM as an important innovation helps organizations develop strategies to achieve their common profit and market goals by reducing environmental risks and enhancing their environmental efficiency (5).

If the company uses GSCM, in addition to reduced environmental problems, it will achieve a partial success in the competition, i.e. the GSCM is used as a competitive advantage. Therefore, companies should move towards the GSCM implementation in order to gain opportunities and cope with challenges. Most large companies such as General Motors (GM), Hewlett-Packard (HP), Procter & Gamble (P & G), Nike, and many other companies have earned a good reputation and brand image for green product through GSCM research and implementation (4).

This study seeks to identify the factors affecting green supply chain in the automotive industry. In this study, first the factors affecting GSCM and relevant components were identified in the SAIPA Company. Then, through a pairwise comparison between criteria and sub-criteria using AHP, the weights of factors affecting GSCM were determined.

Objectives

The main goal of this study is to identify the components of supplier selection and reduced environmental pollutants and to determine the importance of each of them in experts' view.

Therefore, the following secondary objectives are considered:

1. To achieve more speed in GSCM
2. To recognize the important factors affecting better GSCM implementation
3. To compare the results obtained from existing methods
4. To identify GSCM criteria and sub-criteria in Saipa Automotive Company
5. To determine the weights of criteria and sub-criteria with FAHP

Questions

Given the nature of this study, any hypothesis isn’t suggested. Instead, some questions are raised that the study seeks to answer them:

1. What are the main criteria of GSCM?
2. What are the prioritization of main criteria of GSCM in Saipa Automotive Spares?
3. How is the prioritization and assessment of these criteria in terms of implementation?
4. Which one of AHP methods does provide a better and more realistic result?
5. How is the status of Saipa Part Manufacturer with regard to the GSCM model?

Method

As this study has been carried out using a cognitive and information context done through basic research on the subject, it IS an applied research because it has used theories, principles and techniques proven AHP evaluation research. One of the characteristics of applied research is to address human needs, improve and optimize tools, methods and models for the human life's welfare and improvement. In addition, since the study investigates data collection for analysis and decision-making, it is also an evaluation research.

Data collection techniques and tools

This field study was conducted by automotive experts' views and documentary method through articles, theses, and magazines at home and abroad.

Since the data collection tool is a questionnaire, the validity and reliability are determined by the inconsistency rate of pairwise comparisons.

The study population consists of academics, scholars and experts of Saipa Company who are familiar with GSCM and environmental issues.

In this study, due to the expertise and job nature of quality assurance, health and environment specialists, it is tried to obtain more surveys from them. The experts had at least a bachelor's degree and three years of related work experience. Due to the limited numbers of them, it is attempted to use all experts' opinions.

Data analysis

This study was performed in two different stages; first, thirty-seven green supply chain sub-criteria of seven criteria were extracted by studying scientific literature and acquiring green supply chain experts' opinions (criteria screening). A seven-factor model with twenty-four indicators (seven criteria and twenty-four sub-criteria) was presented as a conceptual model to identify factors affecting green supply chain (Table 1). Then, the priority of criteria and their weights were determined by Saipa experts through fuzzy AHP. The available alternatives were prioritized in accordance with identified GSCM criteria.

Table 1. Basic model

sub-criteria	**code sub-criteria**	**criteria**	**criteria code**
Supplier selection and evaluation with regard to specific environmental standards	C11	**Green suppliers and purchase**	**C1**
Standards required for the purchase of machinery and equipment from technical and environmental point of view	C12		
Control of certified ISO 1400 series and environmental management system of suppliers	C13		
Avoid buying hazardous and toxic raw materials and considering its compatibility with the environment	C14		
Product design and packaging to reduce material and energy consumption	C21	**green design and packaging**	**C2**
Product and package design in order to avoid the use of toxic and hazardous substances or inappropriate manufacturing process	C22		
The use of materials compatible with nature in material packaging	C23		
The use of appropriate method for the disposal of waste	C31	**green manufacturing**	**C3**
Production planning and process optimization aimed at reduced waste	C32		
Apply advanced and clean technologies leading to savings in energy and water consumption and reduced emissions	C33		
Analytical and ongoing study of the status of machinery in order to reduce waste, contaminants and energy consumption	C34		
Control of ammonia and carbon dioxide emissions	C35		
Selecting distribution, shipping and customer networks with an emphasis on environmental standards	C41	**green distribution and warehousing**	**C4**
Provide rules and guidelines for proper storage, handling and use of chemicals, taking into account environmental aspects	C42		
Marketing products relying on e-commerce	C43		
Support for green supply chain by senior and middle managers	C51	**environmental management**	**C5**
Certificate of ISO 14000 series and environmental management system	C52		
Policies and procedures codified in environment and corporate social responsibility	C53		
Involvement in national and international environmental	C61	**education**	**C6**

associations and environmental research with universities and scientific centers		**and research**	
Hold training seminars on the importance and observance of environmental issues for employees, customers and suppliers**.**	C62		
Provide a context for green research and innovation on environmental issues	C63		
Implementation of waste management system (production management, collection, storage, segregation, transportation, recycling and disposal**(**	C71	**reverse logistics**	**C7**
Clean transport mode selection	C72		
Compliance with environmental aspects	C73		

Fuzzy AHP

To obtain a pairwise comparison matrix from the experts, first a meeting was held in order to educate the concepts of paired comparison matrix and how to create an inconsistency in completing questionnaires. In order to enhance the content validity of questionnaires, the researcher explained all variables for the experts.

At this point of the study, among nine experts respondent to the first stage who participated in completing questionnaires, because of an expert-based AHP, five of them with higher academic education and more practical experience on the research topic were selected as experts and pairwise comparison questionnaires were completed by them. At the next stage, using fuzzy numbers, each one of experts' opinions were converted into triangular fuzzy numbers, and then using geometric mean, an integrated matrix was obtained from the expert's opinions. Gogus and Boucher inconsistency rate was also used to evaluate the reliability of pairwise comparison matrices from the expert's opinions.

The results indicated the consistency of all pairwise comparisons. Because CRm and CRg are less than 0.1 for all tables, so it can be conclude that all pairwise comparisons are reliable.

Weighting coefficients with Chang's extent analysis method

Chang's extent analysis method was used to determine weighting coefficients. Therefore, experts' pair comparison matrix was completed, and then, its elements were converted into triangular numbers. Following due to the longer process of calculations, the weighting coefficients of criteria by goal and alternatives by goal were expressed in detail, and for the rest of calculations, only the weighting coefficients of sub-criteria were offered.

Table2: Fuzzy Expressions

fuzzy numbers	Verbal Expressions
(1,1,1)	Equally important
(1,1.5,1.5)	Equally to poor important
(1,2,2)	Low important
(3,3.5,4)	Poor to strong important
(3,4,4.5)	Strong important
(3,4.5,5)	Strong to very strong important
(5,5.5,6)	Very strong important
(5,6,7)	Very strong to perfectly important
(5,7,9)	Perfect important

Table 3: pairwise comparison matrix of criteria by goal

criteria	c1	c2	c3	c4	c5	c6	c7	total	Si
c1	(1,1,1)	(0.567,0.567,1)	(0.239,0.271,0.333)	(0.213,0.239,0.333)	(1,1.6,1.6)	(0.19,0.211,0.253)	(0.152,0.173,0.2)	(3.361,4.061,4.719)	(0.033,0.045,0.066)
c2	(1,1.8,1.8)	(1,1,1)	(0.3,0.329,0.467)	(0.25,0.286,0.333)	(2.6,3.2,3.6)	(0.222,0.25,0.333)	(0.2,0.222,0.333)	(5.572,7.087,7.866)	(0.055,0.079,0.109)
c3	(3,3.7,4.2)	(2.6,3.2,3.6)	(1,1,1)	(0.667,0.667,1)	(3,4.3,4.8)	(0.533,0.533,1)	(0.229,0.262,0.307)	(11.029,13.662,15.907)	(0.108,0.152,0.221)
c4	(3,4.2,4.7)	(3,3.5,4)	(1,1.5,1.5)	(1,1,1)	(4.6,5.3,5.8)	(0.562,0.567,0.84)	(0.378,0.386,0.707)	(13.54,16.453,18.547)	(0.133,0.183,0.258)
c5	(0.633,0.633,1)	(0.328,0.355,0.467)	(0.209,0.233,0.333)	(0.173,0.19,0.227)	(1,1,1)	(0.352,0.367,0.52)	(0.129,0.155,0.2)	(2.824,2.933,3.747)	(0.028,0.033,0.052)
c6	(4.2,4.9,5.4)	(3,4,4.5)	(1,1.9,1.9)	(1.8,2.4,2.6)	(3.4,4.2,4.8)	(1,1,1)	(0.667,0.667,1)	(15.067,19.067,21.2)	(0.148,0.213,0.294)
c7	(5,5.8,6.6)	(3,4.5,5)	(3.4,4,4.6)	(2.2,3.1,3.3)	(5,6.5,8)	(1,1.5,1.5)	(1,1,1)	(20.6,26.4,30)	(0.202,0.294,0.417)
total								(71.993,89.663,101.986)	

CRm =0.064 CRg =0.0213

According to Chang extent method, the first step is to calculate Si for each row of the pair-wise comparison matrix of main criteria.

Table 4: Si calculations for the prioritization of main criteria

	L	M	U
C1	0.2011	0.3585	0.5907
C2	0.1428	0.2636	0.4714
C3	0.1052	0.1703	0.3170
C4	0.1144	0.2076	0.3955
C5	0.028	0.033	0.052
C6	0.148	0.213	0.294
C7	0.202	0.294	0.417

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1}$$

In the second step of Yang and Chang extent analysis method, Si calculations, their magnitude compared to each other is calculated and the least magnitude of Si will be determined and the resulting numbers will eventually be normalized. The results represent the weighting coefficients of the main criteria in the first level by the goal. This formula is used for magnitude estimations. This equation can also be expressed as follows:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1 & if\ m_2 \geq m_1 \\ 0 & if\ l_1 \geq u_2 \\ \frac{(l_1 - u_2)}{(m_2 - u_2) - (m_1 - l_1)} & otherwise \end{cases}$$

At the third stage, with normalized vector of weights, the normalized weights are obtained.

Table 5: the normalized weights of criteria and final magnitude

factors affecting green supply chain	c1	c2	c3	c4	c5	c6	c7	final magnitude	normalized weights
c1	–	0.244	0	0	1	0	0	0	0.0501
c2	1	–	0.015	0	1	0	0	0	0.0844
c3	1	1	–	0.739	1	0.548	0.118	0.118	0.1644
c4	1	1	1	–	1	0.79	0.334	0.334	0.2002
c5	0.603	0	0	0	–	0	0	0	0.0384
c6	1	1	1	1	1	–	0.531	0.531	0.1974
c7	1	1	1	1	1	1	–	1	0.3074
total								1.982	1

The weights of each sub-criterion with fuzzy AHP are as follows:

Table 6: the weights of criteria and sub-criteria

cod	sub-criteria weights	main criteria code	criteria weights by the goal GOAL	sub-criteria code	final weighting coefficients of sub-criteria
C11	0.3403	C1	0.0501	C11	0.0170
C12	0.1609			C12	0.0080
C13	0.2990			C13	0.1500
C14	0.2006			C14	0.1007
C21	0.4413	C2	0.0844	C21	0.0372
C22	0.2263			C22	0.0191
C23	0.5911			C23	0.0499
C31	0.1858	C3	0.1644	C31	0.0305
C32	0.2877			C32	0.0473
C33	0.1080			C33	0.0177
C34	0.2770			C34	0.0455
C35	0.1488			C35	0.0244
C41	0.1748	C4	0.2002	C41	0.0350
C42	0.3162			C42	0.0633
C43	0.5090			C43	0.1019
C51	0.2758	C5	0.0384	C51	0.0105
C52	0.4475			C52	0.0171
C53	0.2771			C53	0.0106
C61	0.2255	C6	0.1974	C61	0.0445
C62	0.365			C62	0.0720
C63	0.4467			C63	0.0882
C71	0.1406	C7	0.3074	C71	0.04323
C72	0.4567			C72	0.14042
C73	0.4026			C73	0.1237

The pair-wise comparisons of alternatives by criteria are also presented in the following tables.

Table 7: pairwise comparisons of alternatives by criterion C1

C1	A1	A2	A3	total	Si
A1	(1,1,1)	(0.567,0.567,1)	(1,1.6,1.6)	(2.567,3.167,3.6)	(0.204,0.282,0.396)
A2	(1,1.8,1.8)	(1,1,1)	(2.6,3.3,3.7)	(4.6,6.1,6.5)	(0.366,0.544,0.715)
A3	(0.633,0.633,1)	(0.294,0.321,0.467)	(1,1,1)	(1.927,1.954,2.467)	(0.153,0.174,0.271)
total				(9.094,11.221,12.567)	

Table 8: pairwise comparisons of alternatives by criterion C2

C2	A1	A2	A3	total	Si
A1	(1,1,1)	(0.483,0.49,0.867)	(1,1.6,1.6)	(2.483,3.09,3.467)	(0.196,0.274,0.383)
A2	(1.4,2.2,2.3)	(1,1,1)	(2.2,3,3.3)	(4.6,6.2,6.6)	(0.363,0.549,0.728)
A3	(0.633,0.633,1)	(0.344,0.364,0.6)	(1,1,1)	(1.977,1.997,2.6)	(0.156,0.177,0.287)
total				(9.06,11.287,12.667)	

Table 9: pairwise comparisons of alternatives by criterion C3

C3	A1	A2	A3	total	Si
A1	(1,1,1)	(0.6,0.6,1)	(1,1.6,1.6)	(2.6,3.2,3.6)	(0.213,0.294,0.41)
A2	(1,1.7,1.7)	(1,1,1)	(2.2,3,3.3)	(4.2,5.7,6)	(0.344,0.523,0.684)
A3	(0.633,0.633,1)	(0.344,0.364,0.6)	(1,1,1)	(1.977,1.997,2.6)	(0.162,0.183,0.296)
total				(8.777,10.897,12.2)	

Table 10: pairwise comparisons of alternatives by criterion C4

C4	A1	A2	A3	total	Si
A1	(1,1,1)	(0.583,0.59,0.867)	(1,1.6,1.6)	(2.583,3.19,3.467)	(0.209,0.288,0.378)
A2	(1.4,1.9,2)	(1,1,1)	(2.2,3,3.3)	(4.6,5.9,6.3)	(0.372,0.532,0.688)
A3	(0.633,0.633,1)	(0.344,0.364,0.6)	(1,1,1)	(1.977,1.997,2.6)	(0.16,0.18,0.284)
total				(9.16,11.087,12.367)	

Table 11: pairwise comparisons of alternatives by criterion C5

C5	A1	A2	A3	total	Si
A1	(1,1,1)	(0.55,0.557,0.867)	(1,1.6,1.6)	(2.55,3.157,3.467)	(0.205,0.283,0.38)
A2	(1.4,2,2.1)	(1,1,1)	(2.2,3,3.3)	(4.6,6,6.4)	(0.369,0.538,0.701)
A3	(0.633,0.633,1)	(0.344,0.364,0.6)	(1,1,1)	(1.977,1.997,2.6)	(0.159,0.179,0.285)
total				(9.127,11.154,12.467)	

Table 12: pairwise comparisons of alternatives by criterion C6

C6	A1	A2	A3	total	Si
A1	(1,1,1)	(0.517,0.524,0.867)	(1,1.6,1.6)	(2.517,3.124,3.467)	(0.2,0.278,0.381)
A2	(1.4,2.1,2.2)	(1,1,1)	(2.2,3,3.3)	(4.6,6.1,6.5)	(0.366,0.544,0.715)
A3	(0.633,0.633,1)	(0.344,0.364,0.6)	(1,1,1)	(1.977,1.997,2.6)	(0.157,0.178,0.286)
total				(9.094,11.221,12.567)	

Table 13: pairwise comparisons of alternatives by criterion C7

C7	A1	A2	A3	total	Si
A1	(1,1,1)	(0.517,0.524,0.867)	(1,1.6,1.6)	(2.517,3.124,3.467)	(0.2,0.278,0.381)
A2	(1.4,2.1,2.2)	(1,1,1)	(2.2,3,3.3)	(4.6,6.1,6.5)	(0.366,0.544,0.715)
A3	(0.633,0.633,1)	(0.344,0.364,0.6)	(1,1,1)	(1.977,1.997,2.6)	(0.157,0.178,0.286)
total				(9.094,11.221,12.567)	

Table 14: the final weight matrix of alternatives compared to factors affecting green supply chain

prioritization based on definitive weight	the final definitive weights of alternatives	Company
2	0.055	Henkel
1	0.945	PPG
3	0	KCC

RESULTS

By studying a large number of relevant articles and books, the study components were extracted to provide more comprehensive criteria for green supply chain compared to previous studies. The study with its component approach could create a suitable ground for the implementation of green supply chain in the Saipa Automotive Parts. In addition, given the increasing importance of environmental issues, as well as more customers' attention to this issue, and requirements and rules to take into account environmental considerations by industry, it seems very helpful to consider the proposed green supply chain model and its priority for the government and concerned agencies in terms of investment priority. The results (model and its weights) can also be used as the basic data of real environmental issues to assess automotive industrial units and select green industrial units in the environmental protection agency.

After identifying final criteria and forming conceptual model, fuzzy AHP with Chang's approach was used to find the weights of criteria. To enhance the reliability of analyses, an ANP questionnaire was given to experts for fuzzy AHP. Then, through Chang's calculation process, the final weights of sub-criteria were obtained (Table 15).

Table 15: The weighted sub-criteria ranking

Sub-criteria weight	Weighted Rank
Control of certified ISO 1400 series and environmental management system of suppliers	0.150089
Clean transport mode selection	0.140429
Compliance with environmental aspects	0.123784
Marketing products relying on e-commerce	0.101919
Avoid buying hazardous and toxic raw materials and considering its compatibility with the environment	0.100731
Provide a context for green research and innovation on environmental issues	0.088203
Hold training seminars on the importance and observance of environmental issues for employees, customers and suppliers.	0.072057
Provide rules and guidelines for proper storage, handling and use of chemicals, taking into account environmental aspects	0.063326
The use of materials compatible with nature in material packaging	0.049935
Production planning and process optimization aimed at reduced waste	0.047320
Analytical and ongoing study of the status of machinery in order to reduce waste, contaminants and energy consumption	0.045565
Involvement in national and international environmental associations and environmental research with universities and scientific centers	0.044523
Implementation of waste management system (production management, collection, storage, segregation, transportation, recycling and disposal)	0.043230
Product design and packaging to reduce material and energy consumption	0.037276
Selecting distribution, shipping and customer networks with an emphasis on environmental standards	0.035018
The use of appropriate method for the disposal of waste	0.030560
Control of ammonia and carbon dioxide emissions	0.024469
Product and package design in order to avoid the use of toxic and hazardous substances or inappropriate manufacturing process	0.019120
Apply advanced and clean technologies leading to savings in energy and water consumption and reduced emissions	0.017770
Certificate of ISO 14000 series and environmental management system	0.017189
Supplier selection and evaluation with regard to specific environmental standards	0.017084
Policies and procedures codified in environment and corporate social responsibility	0.010645
Support for green supply chain by senior and middle managers	0.010594
Standards required for the purchase of machinery and equipment from technical and environmental point of view	0.008079

According to weights obtained, the maximum weight was associated with "control of certified ISO 1400 series and environmental management system of suppliers" and the lowest weight was related to "standards required for the purchase of machinery and equipment from technical and environmental point of view". In addition, the weights of "control of certified ISO 1400 series and environmental management system of suppliers" and "clean transport mode selection", which were in the first and second ranks, respectively, had a significant difference with other criteria indicating the importance of effective green supply chain factors. Finally, based on a seven-factor model, three Henkel, KCC, PPG companies were measured using Chang's FAHP. PPG gained the most weight and the first rank; Henkel took the second weighting rank; and KCC gained zero weight (Table 14: alternative ranking). Thus, it can be observed that PPG and Henkel are in an acceptable condition, which confirms the results of questionnaire "B" i.e. companies claiming the implementation of GSCM are in an acceptable condition on important criteria from expert's views. When an alternative is zero, this indicates that the alternative isn't important in decision-making; in this method, by assigning zero weight to some alternatives, they are excluded from the decision-making process.

Repeated table 14: The final weights of alternatives

prioritization by definitive weight	**final definitive weights of alternatives**	**Component**
2	0.055	Henkel
1	0.945	PPG
3	0	KCC

1) What are the main criteria of GSCM?

In this study, the GSCM primary and secondary criteria are shown in the study conceptual model (Table 16).

2)What are the prioritization of main criteria of GSCM in Saipa Automotive Spares?

Table 16: main criteria prioritization

prioritization by definitive weight	final definitive weights of alternatives	Component
6	0.0501	C1
5	0.0844	C2
4	0.1644	C3
2	0.2002	C4
7	0.03841	C5
3	0.1974	C6
1	0.3074	C7

3)How is the prioritization and assessment of these criteria in terms of implementation?

The status of each company on green supply chain criteria can be observed in tables.

PPG, Henkel, and KCC gained the first to third ranks, respectively.

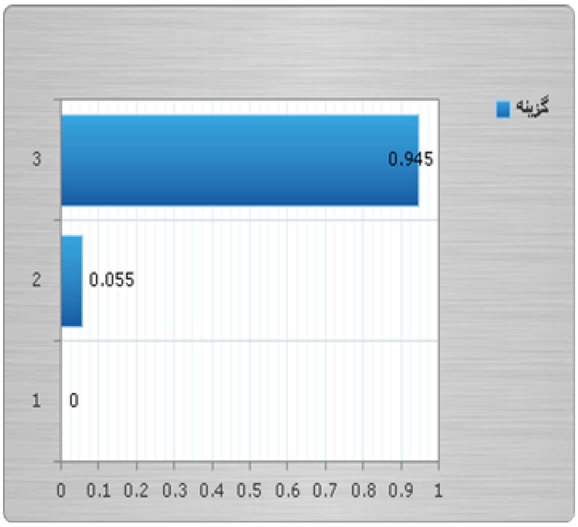

Fig.1. the final weight matrix of alternatives compared to factors affecting green supply chain

4) Which one of AHP methods does provide a better and more realistic result?

In this study, fuzzy AHP with Chang's approach was used, which was much better than Buckley's method. The weights provided by Chang's approach reflects the relative importance of criteria and alternatives, and so, they can be used to determine their priority. In fact, the degree of probability calculated by Chang's approach can not only be a criterion showing the relative importance but also a criterion for comparing two triangular fuzzy numbers.

5)How is the status of Saipa Part Manufacturer with regard to the GSCM model?

In this study, given analyses and weights obtained from the pairwise comparisons of alternatives based on the conceptual model, PPG with higher weight gained the first rank and better place than Henkel in the second rank and KCC in the final rank. Thus, Saipa Automotive Company is more interested in PPG, which has an excellent condition.

Research comparisons with previous studies

This study was performed compared to similar studies that were completely different from the previous literature. Abdolmaleki (2014)'s study was performed in three green supplier evaluation phases using a hybrid Delphi approach, fuzzy AHP, and fuzzy TOPSIS through twenty-nine criteria which was very time-consuming and the company should pay very high cost for the research and working efficiency of experts involved in GSCM. In this study, the green suppliers of automotive parts were evaluated using FAHP and Delphi approach with twenty-four factors affecting Saipa automotive industry. To continue to work with suppliers with high rankings, each one of alternatives was compared and prioritized with seven main criteria. This study is the shortest path and most widely used for evaluating the suppliers of green supply chain, it involves very low cost, and it is also effective for corporate profitability.

Suggestions

Given the prioritization and extracting green supply chain performance areas of automotive parts, to improve GSCM performance, it is recommended to the following areas:

- ❖ Analytical and ongoing study of the status of machinery in order to reduce waste, contaminants and energy consumption
- ❖ Involvement in national and international environmental associations and environmental research with universities and scientific centers
- ❖ Implementation of waste management system (production management, collection, storage, segregation, transportation, recycling and disposal)
- ❖ Selecting distribution, shipping and customer networks with an emphasis on environmental standards
- ❖ Product and package design in order to avoid using toxic and hazardous substances or inappropriate manufacturing process
- ❖ Supplier selection and evaluation with regard to specific environmental standards
- ❖ Policies and procedures codified in environment and corporate social responsibility
- ❖ Support for green supply chain by senior and middle managers
- ❖ Standards required for the purchase of machinery and equipment from technical and environmental point of view

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