

## Identification and ranking of factors effective on performance of green supply chain suppliers : Case study: Iran Khodro Industrial Group

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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.

In this article, we have classified our criteria into four groups each with the following criteria which should be included in suppliers assessment and selection process .TOPSIS method has been used for the selection of the greenest supplier.

**Key words:** supply chain management, green supply chain, suppliers assessment, TOPSIS.

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### 1- INTRODUCTION

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.

Green supply chain (GSCM) requires the investigation of the suppliers on the basis of environmental performance and performance of their activity on the basis of environmental laws and standards (Rao, 2002). The Selection of suppliers in GSCM shall be closely related to purchase management, because sustainable environment and ecological performance can be achieved by the suppliers (Godfrey, 1998). As environmental awareness is being increased- the customers learn how to procure their required goods and services through suppliers who can present their required goods and services in low price, high quality, shorter delivery time, and environmental accountability to them (lee, 2009).

Purchase section plays a more important role in improvement of the environmental performance than other sections of the organization do (Zhu and Geng , 2001). Purchase section can affect some sections such as products design process, suppliers assessment and selection process, and the delivery of stock material (Humphreys, 2003).

Automotive companies had to decrease environmental damages in recent decades with regard to an increase of pressures in environmental fields. An important stage for achieving environmental performance improvement and production quality is establishing special relationship with suppliers (Geffen and Rothenberg, 2000). Before 1980s, relation of automobile manufacturers has been used on the basis of short-term relations with many suppliers for cooperation (Helper, 1991). These relations have been turned into closer and long - term cooperation (Dyer and Ouchi, 1993). Close relations of manufactures with suppliers in Japan's automotive industry can be regarded as the main success factor of Japanese manufacturers at the time of development, a decrease of expenses and an increase of

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products quality (Cusmano and Takeishi, 1991). Nosi (1997) designed a green seller ranking system for assessing environmental performance of a supplier on the basis of environmental criterion, that is ,we can present green competencies and word ‘‘green’’ and pure expense of lifecycle . Walton and Handfield and Melik(1998) designed a simple flowchart for determining suitable methods and criteria in order to assess and select supplier in environmental management. Anarson (1998) used fishbone diagram for assessing suppliers from environmental point of view by adopting quality improvement perspective. Zu and Gong (2001) studied large and medium sized companies owned by LMSOEs in China and studied their environmental progresses such as green purchase in their methods and activities. Hamferiz et al (a2003) identified environmental criteria effective on purchasing decision of a company and classified the criteria into two groups: they combined environmental criteria with suppliers selection processes. Chen (2005) divided the supplier choice into two stages: first, environmental performance as the minimum requirement and second, public purchase trends such as quality delivery performance documents for the suppliers who hold certificate of ISO 14000 can be included in the second stage assessment. Luh and Ku (2007) created multi-purpose decision-making process for green supply chain management to help the managers measure and assess performance of the suppliers. In a comprehensive green supplier choice model, it is necessary to consider all factors to identify the most suitable supplier who acts well in all respects. With regard to environmental awareness, many works have been performed on the selection of green suppliers in recent decades which have considered only environmental dimension. In order for the company to select the most suitable supplier for cooperation, it is necessary to consider environmental protection and suppliers selection specifications. For this purpose, we intend to present the models which have such index.

This article has been written as follows: section 2 refers to suppliers selection criteria; section 3 refers to TOPSIS method; section 4 refers to green suppliers assessment model; section 5 deals with Iran Khodro suppliers assessment; and finally section 6 deals with conclusion and research finding.

## 2- Green suppliers selection criteria

Green suppliers selection criteria should be based on environmental laws, characteristics of the suppliers and, purchasing policies of the company. On this basis, 13 criteria were determined and classified in 4 main groups (table 1).

Table 1-criteria and sub criteria of suppliers selection

criteria	sub criteria	references
design management	process/product changeability ability to design recovery	Chio 2009, Lee,Juang(2009),Zhen(2010), Chio 2009, Lee(2009), Juang(2009), Zhen(2010), Chio 2009,
technology management	technology level ability of R&D clean technology	Lee(2009), Zhen(2010), Lee(2009),Beke(2010), Juang(2009), Chio 2009, Lee(2009), Juang(2009), Zhen(2010),
customer management	controlled use of hazardous material energy consumption green packaging	Lee(2009), Juang(2009), Chio 2009, Lee(2009), Juang(2009), Zhen(2010), Lee(2009), Juang(2009),
strategic management	green image green planning supervision on and following environmental laws social responsibility	Juang(2009), Zhen(2010), Lee(2009), Lee(2009), Beke(2010), Juang(2009), Zhen(2010), Lee(2009),

## 3- Introduction of TOPSIS method

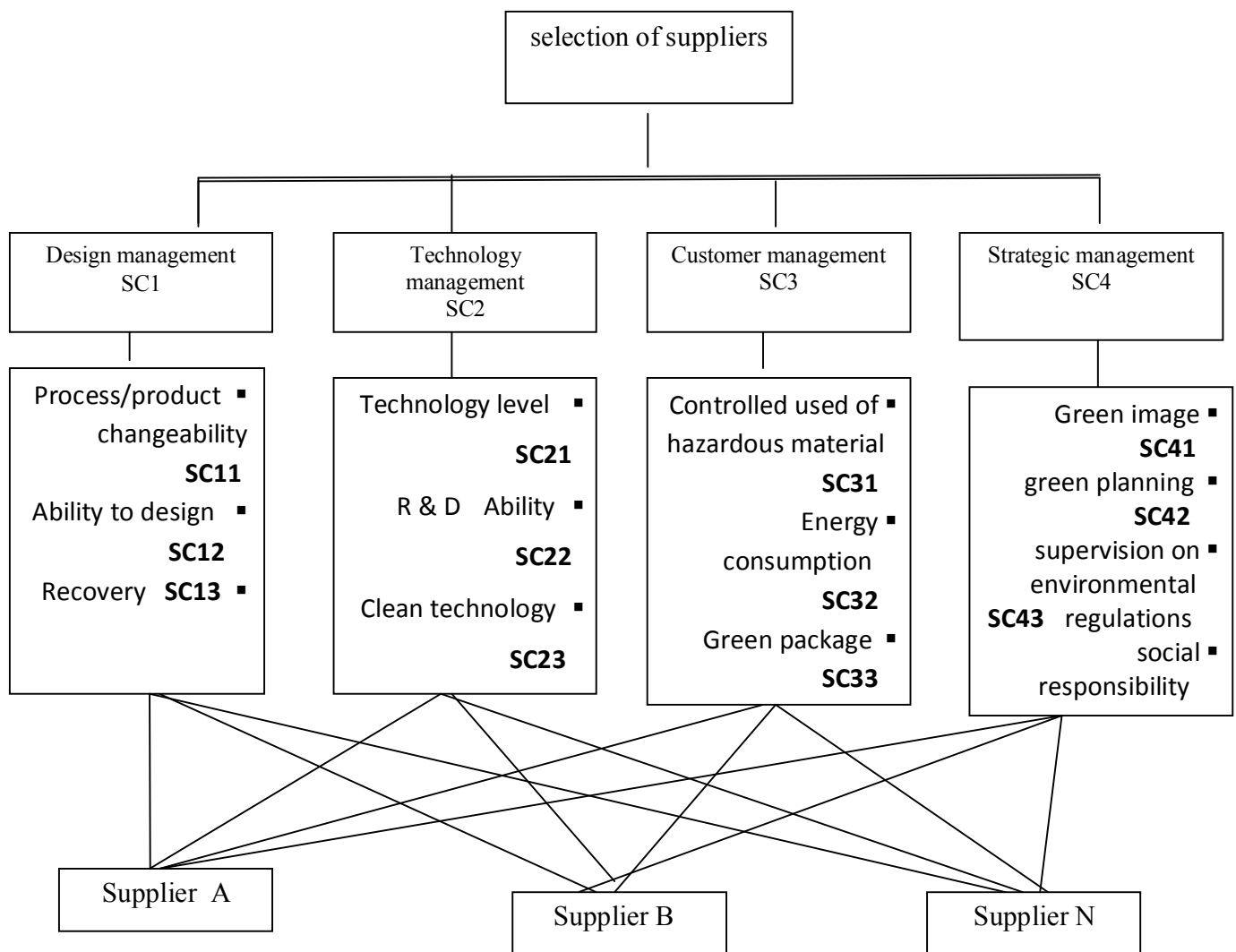
Multipurpose decision making models are the models which have been considered by many researchers recently. These techniques and models are widely used in complex decisions in spite of different and conflicting criteria. High power of these techniques to decrease decision making complexity, concurrent use of quality and quantity structured criteria, decision making issues and finally their easy application caused to use them for decision making in different positions. These techniques formulate decision making problems as a matrix (table 2) and analyze them necessarily.

Table 2- decision making matrix

Index	$X_1$	$X_2$	$X_n$
$A_1$	$r_{11}$	$r_{12}$	$r_{1n}$
$A_2$	$r_{21}$	$r_{22}$	$r_{2n}$
$A_m$	$r_{m1}$	$r_{m2}$	$r_{mn}$

In this matrix,  $A_i$  shows ith option,  $X_j$  shows jth index and  $x_{ij}$  indicates value of jth index (Asghar Poor, 2004). Multipurpose decision making techniques are different, each having special characteristics and application. One of the important applied techniques is TOPSIS technique (Technique for Order Preference by Similarity to Ideal Solution) which will be used in this research for selecting the greenest supplier. This method was presented by Hunag and Yun in 1981. In this method, they assess a group of the decision makers as m factor or option. This technique emphasizes that any selective factor shall have the minimum distance with positive ideal factor (the most important) and the maximum distance with negative ideal factor (the least important). On the other hand, the distance between one factor and ideal positive and negative factor is measured and this is factors ranking and prioritizing criterion.

Figure 3- green suppliers assessment model



##### 5- Green suppliers selection model

Many studies have been done on supply chain and suppliers problems. But there have been limited studies on green supplier and green supply chain in the last two decades. While recent studies have emphasized selection of green supplier, there are limited studies which deal with environmental issues and characteristics of supplier. In this article, green suppliers assessment and selection model is suggested with regard to criteria and sub criteria in different dimensions in order to assess green suppliers. Executive stages of this research are as follows:

- Green suppliers selection problem was defined and general goal of this research was clarified.

- Green suppliers assessment and selection criteria were gathered by review of literature and interviewing automotive industry experts.
- The most important criteria and sub criteria were extracted by the industry experts.
- On the basis of the selected criteria and sub criteria, a hierarchical framework was prepared in order to assess green suppliers.
- On the basis of suggested hierarchy, a questionnaire was prepared, on the basis of which suppliers can be assessed. In this research, a 4-point scale was used in order to score the suppliers.

Global concerns for environmental protection have been regarded as a main challenge in industry. With regard to Iran Khodro Industrial group, which has been regarded as one of the largest automotive group in the Middle East and wants to work in global markets, it shall have some suppliers and help them achieve this important goal. On this basis, the goal of the case study is to create an objective framework for decision making in suitable selection of the supplier. In the first section, the most important factors for assessing green supplier are studied, and totally 17 criteria and 54 sub criteria were identified after review of literature and interview with experts. According to Saati, if there are more than 7 factors in equal cluster, it will be very difficult for the participants to make paired comparison in order to extract green suppliers indices; opinions of the experts were surveyed. The selected criteria and sub criteria are shown in table 1. According to the experts, the most important criteria for assessing suppliers were green planning, green packaging, clean technology, and green packaging. In the second section, a green supplier selection model was suggested and suppliers of Iran Khodro used the criteria selected by the experts and the created framework. The goal of this research is to select the greenest supplier of this manufacturer.

#### Determination of indices comparison matrix

In this stage, a matrix will be drawn which shows suppliers in its row and suppliers selection criteria in its column. Between the row and column, the score which each supplier has given to each one of the factors is included (table 4).

Table 4- green suppliers selection components comparison matrix

CS <sub>1</sub>	CS <sub>2</sub>	CS <sub>3</sub>	CS <sub>4</sub>	CS <sub>5</sub>	CS <sub>6</sub>	CS <sub>7</sub>	CS <sub>8</sub>	CS <sub>9</sub>	CS <sub>10</sub>	CS <sub>11</sub>	CS <sub>12</sub>	CS <sub>13</sub>	CS <sub>14</sub>
1	0	1	1	2	2	2	2	1	2	3	1	2	A
2	1	2	2	3	3	3	2	1	1	1	1	1	B
3	2	0	2	3	3	1	2	0	2	3	2	0	C
2	1	2	1	4	2	1	2	2	1	2	2	1	D
2	1	1	1	4	2	1	2	3	1	2	1	2	E
3	2	1	2	1	3	2	3	2	0	2	1	2	F
2	1	3	2	1	4	3	3	3	1	2	1	2	G
1	1	2	2	3	2	2	3	2	1	3	2	1	H
1	2	1	2	2	0	0	1	3	2	2	1	0	I
3	2	2	3	4	2	2	3	3	2	2	2	2	J

#### - Normalizing decision making matrix

In order to make different measurement scales comparable, decision making matrix has been converted to normalized matrix or balanced matrix without scale.

Table 5: balanced normalized matrix of green suppliers selection components

CS <sub>1</sub>	CS <sub>2</sub>	CS <sub>3</sub>	CS <sub>4</sub>	CS <sub>5</sub>	CS <sub>6</sub>	CS <sub>7</sub>	CS <sub>8</sub>	CS <sub>9</sub>	CS <sub>10</sub>	CS <sub>11</sub>	CS <sub>12</sub>	CS <sub>13</sub>	CS <sub>14</sub>
0.147	0.218	0.186	0.167	0.217	0.252	0.329	0.265	0.141	0.436	0.416	0.213	0.417	A
0.295	0.218	0.371	0.333	0.325	0.378	0.493	0.265	0.141	0.218	0.139	0.213	0.209	B
0.442	0.436	0.000	0.333	0.325	0.378	0.164	0.265	0.000	0.436	0.416	0.426	0.000	C
0.295	0.218	0.371	0.167	0.434	0.252	0.164	0.265	0.283	0.218	0.277	0.426	0.209	D
0.295	0.218	0.186	0.167	0.434	0.252	0.164	0.265	0.424	0.218	0.277	0.213	0.417	E
0.442	0.436	0.186	0.333	0.108	0.378	0.329	0.397	0.283	0.000	0.277	0.213	0.417	F
0.295	0.218	0.557	0.333	0.108	0.504	0.493	0.397	0.424	0.218	0.277	0.213	0.417	G
0.147	0.218	0.371	0.333	0.325	0.252	0.329	0.397	0.283	0.218	0.416	0.426	0.209	H
0.147	0.436	0.186	0.333	0.217	0.000	0.000	0.132	0.424	0.436	0.277	0.213	0.000	I
0.442	0.436	0.371	0.500	0.434	0.252	0.329	0.397	0.424	0.436	0.277	0.426	0.417	J

#### - The determination of positive and negative ideal factor

In this stage, those factors which are the most and least important factors according to respondents are identified (table 6).

Table 6: positive and negative ideal factor of green suppliers selection

	+	-	+	+	+	-	-	+	+	+	-	+	+
The positive ideal	0.047	0.028	0.036	0.035	0.034	0.044	0.029	0.020	0.047	0.015	0.024	0.020	0.021
The negative ideal	0.016	0.000	0.000	0.012	0.009	0.000	0.000	0.007	0.000	0.000	0.008	0.010	0.000

**- calculation of proximity of each criterion to positive and negative**

After identification of positive and negative ideal, proximity of each positive and negative index is measured (table 7).

Table 7: positive and negative ideal

	A	B	C	D	E	F	G	H	I	J
Distance from the negative ideal	0.066	0.057	0.069	0.056	0.052	0.047	0.038	0.050	0.075	0.028
Distance from the positive ideal	0.050	0.062	0.063	0.060	0.068	0.072	0.087	0.061	0.060	0.087

**- calculation of value  $C_j$  on the basis of formula:**

Distance between negative ideal + positive ideal / distance with negative ideal =  $C_j$

**- classification of suppliers on the basis of descending trend  $C_j$**

On the other hand, the higher the  $C_j$ , the higher the degree of supplier (table 8).

Table 8: final ranking of suppliers

	A	B	C	D	E	F	G	H	I	J
Distance from the negative ideal	0.066	0.057	0.069	0.056	0.052	0.047	0.038	0.050	0.075	0.028
Distance from the positive ideal	0.050	0.062	0.063	0.060	0.068	0.072	0.087	0.061	0.060	0.087

As results of the table show, supplier J was identified as the greenest supplier.

## 6- Research finding

Environmental protection and sustainable development are increasingly considered. In order to expand lifecycle of the product and follow durability of the company, it is necessary that the company emphasize on environmental protection and green production as a critical part of its social responsibility. A good green supplier selection model in a dynamic supervisory and competitive environment can help decrease environmental and legal risks and increase competitiveness of a company. This research presents a model for selection of factors for assessing green supplier and assessing performance of the suppliers. Results for the next green supplier are applied for making a framework for assessing suppliers. A framework is made on the basis of this hierarchy so that green suppliers can be assessed for Iran Khodro Industrial group suppliers and the most suitable supplier can be selected. Power of the proposed model is that ambiguity of the experts' process should be considered and the model should be easily applicable. Manufacturers of the related industries can use our proposed method or design a model on the basis of their special needs to assess their green suppliers and select the best supplier for cooperation.

## REFERENCES

- Ahmet Beşkese Adil Şakra, 2010, A Model Proposal for Supplier Selection in automotive Industry, 14th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology
- Amy H.I. LEE, He-Yan Kang, Chang-Fu, A green supplier selection model for high-tech industry, Science Direct, 2009, 36, pp 7917-7927
- Asghar Poor, Mohammad Javad (2004), multivariate decision making, University of Tehran Press, third edition
- Azar Adel, Rajab Zadeh, Ali (2002), applied decision making, Negah Danesh Press
- Chen, C.-C. (2005). Incorporating green purchasing into the frame of ISO 14000. *Journal of Cleaner Production*, 13, 927–933.
- Cheng-Wen Lee, 2008, Green Suppliers with Environmental Performance in the Supply Chain Perspective Asia Pacific Management Review 13(4), 731-745
- Chia-Wei Hsu a,1, Allen H. Hu, 2009, Applying hazardous substance management to supplier selection using analytic network process *Journal of Cleaner Production* 17 255–264
- Cusumano, M.A., Takeishi, A. (1991) Supplier relations and management: A survey of Japanese, Japanese-transplant, and US auto plants. *Strategic Management Journal*, 12(8), 563–589
- Geffen, C.A., Rothenberg, S. (2000) Suppliers and environmental innovation: The automotive paint process. *International Journal of Operations & Production Management*, 20(2), 166–186
- Geng, Q. Z. (Autumn 2001). Integrating Environmental Issues Into Supplier Selection and Management. *Greener Management International*; (35), 27.
- Godfrey R. Ethical purchasing: developing the supply chain beyond the environment. In: Russel T, editor. *Greener purchasing: opportunities and innovations*. Sheffield, England: Greenleaf Publishing; 1998.
- Helper, S. (1991) Strategy and irreversibility in supplier relations: The case of the US automobile industry. *Business History Review*, 65(4), 781–802.
- Humphreys, P. K., Wong, Y. K., & Chan, F. T. S. (2003a). Integrating environmental criteria into the supplier selection process. *Journal of Materials Processing Technology*, 138, 349–356.
- Humphreys, P. K. 2003, Environmental framework for incorporating environmental criteria into the supplier selection process
- Rao P. Greening the supply chain a new initiative in south East Asia. *International Journal of Operations and Production Management* 2002; 22(6): 632–635.
- Yuang A, Kielkiewicz-Yuang A. Sustainable supply network management *Corporate Environmental Management* 2001; 8(3): 260–8
- Lu, L. Y. Y., Wu, C. H., & Kuo, T.-C. (2007). Environmental principles applicable to green supplier evaluation by using multi-objective decision analysis. *International Journal of Production Research*, 45(18–19), 4317–4331
- Noci, G. (1997). Designing green vendor rating systems for the assessment of a supplier's environmental performance. *European Journal of Purchasing and Supply Management*, 2, 103–111
- Saaty, T. L. (1980). *The analytic hierarchy process*. New York: McGraw-Hill.
- Sarkis, J. (1998). Evaluating environmentally conscious business practices. *European Journal of Operational Research*, 107, 159–174
- Verghese, K., & Lewis, H. (2007). Environmental innovation in industrial packaging: A supply chain approach. *International Journal of Production Research*, 45(18–19), 4381–4401.
- Walton, S. V., Handfield, R. B., & Melnyk, S. A. (1998). The green supply chain: Integrating suppliers into environmental management processes. *International Journal of Purchasing and Materials Management*, 34(2), 2–11
- Zhu, Q., & Geng, Y. (2001). Integrating environmental issues into supplier selection and management. *Greener Management International*, 35, 27–40.