Selection of Best Sustainable Supplier for "Green Supply Chain Management" in an Automotive Manufacturer- Fuzzy TOPSIS Approach

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ABSTRACT

Supply chain is an essential part of any company wishing to maintain aa competitive edge over its rival companies. It takes a leading role in deciding the business continuity of any company. Recently making this supply chain more environmentally sustainable is gaining importance among companies. Choosing the best vendor in terms of their sustainability enforcement for any company is the first step in leading this transformation of making the supply chain more greener. In this research we are taking the effort to choose the best sustainable vendor for a leading automotive manufacturing company. The data is collected by interviewing various officers belonging to middle level management and involved in procurement activities within the organization . We chose attributes such as waste management , green manufacturing, green design, green logistics & percentage rejection. We applied fuzzy TOPSIS to arrive at the optimal solution of choosing the best supplier in terms of sustainability approach

Keywords
"Green Supply Chain Management"(GSCM),Fuzzy TOPSIS, "Waste Management" , "Green Manufacturing", "Green Design", "Green Logistics"

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Introduction

"Supply chain management" is now plays and important role for any company and is also a pivotal part of company's strategy in order to provide the customer with the most customized and flexible solution at a much cheaper price in order to maintain the competitive edge of company in market. "Green supply chain management" integrates the concern of the environment into providing seamless solution to the customers . To enhance the sustainability of the entire supply chain operation of a company , many factors are be considered while selecting the supplier of a business [1] and [2]. Nowadays sustainable concepts of "green supply chain management" (GSCM) has become very important and pivotal for companies as they are becoming very concerned about meeting the governmental regulation, less use of toxic materials ,global warming , pollution and use of non renewable sources of energies [3,4]. A green supply chain management involves two major criterions; Green operation and green design . Within green operation there are "waste management", "network design" and "reverse logistics" &"green manufacturing". Evaluating and selecting the best vendor is a very key aspect for the preservation of the environment and also maintaining the company's image as customers are getting very acquainted with the rising environmental challenges what the world is facing today[5].The green supplier selection or assessing the suppliers according to their efforts in maintaining the greenness of the supply chain of the nucleus firm is a multi-criterion decision making problem having few criterion and few major suppliers of the company . The major criterion for assessing the greenness of the supply chain of the vendors are green operations like waste management, green manufacturing , reverse logistics and network design , etc. Leaving beside these criterions there are others as well like green design, life cycle analysis ,etc [6].

Literature Review

There are numerous research works that were done about selection of the best supplier or vendor performance evaluation.But the research paers on "green supply chain management" are very rare. Recently, the concepts of "green supply chain management" has gained impetus in industry and academia .People are gaining knowledge on various important sectors and areas such as "environmental competencies", "environmental performance", "waste management" [7–12].

Handfield et al. [13] used AHP to evaluate various factors affecting the environmental impact of a supplier in "green supply chain management". Lu et al.

Chiou et al. [14] used Fuzzy AHP to select the most green supplier in the context of the Taiwan, US and Japanese electronics industry . They used a ranking system and applied different weightage to different criterion used in the study.

Lee et al. [15] used "fuzzy AHP" to select the best supplier in terms of sustainability enforcement. This study included 11 criterion and 43 sub criterion.

Grisi et al. [16]also used the method of "Fuzzy AHP" method for clustering the best sustainable vendors in a nucleus firm. They used the seven step approach to do so. They took resort to the fuzzy approach because they wanted to relegate the error caused by the human judgement.

Mollenkopt, Stolze, Tate, and Ueltschy (2010) conducted an extensive research to ease out the important dimensions corresponding to the "green supply chain management" of the supply chain of any nucleus firm. They understood four criterion are important for maintain the greenness of the supply chain. They are as follows:

a. Cost reduction

b. Meeting customers demands;

c. Improvement in the risk management methodology

d. ISO14001 certification

Perotti, Zorzini, Cagno, and Micheli (2012) conducted research on Italian 3PL logistics companies on their GSCM practices which are being implemented to improve the sustainability of the supply chain.The result of the study was that they found more than 15 firms reaped benefits on the introduction of these green supply chain initiatives .

Koh, Gunasekaran, and Tseng (2012) in their research stressed on the negative effects of the use of radioactive material in the supply chain

Research Gap

After extensive review of past studies and researches , following research gaps were found

a. Only few studies were made in the assessing the greenness of the supply chain of the vendors

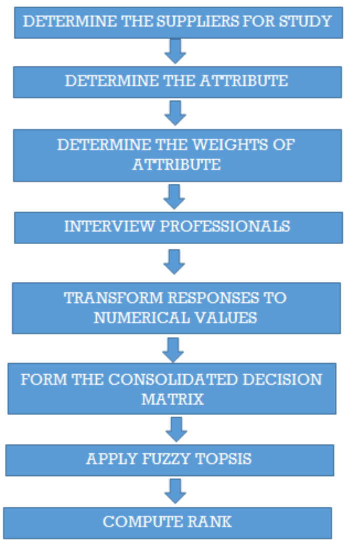
b. Past researches are mainly concentrated on the apparel industries and no study was done taking an automotive company as nucleus firm

c. Majority of the past studies used Fuzzy AHP as their tool of assessment but no other studies have used the tool of Fuzzy TOPSIS

d. Previous assessment of greenness of the operation of the vendor was mainly concentrated on the factors related to the manufacturing process and techniques of the vendor. Nobody looked into factors related to design of the material or logistics

Method

The nucleus firm in our study is a leading automotive manufacturer having its mother plant in Tatanagar . We have designed a questionnaire and interviewed several middle level officers in the purchase department. We designed a five point fuzzy scale to rate their responses for 5 suppliers in various attributes. The flow of the process is given below



Fuzzy TOPSIS proposed by Hwang and Yoon in 1981 is a popular and widely used method for multi-criteria decision making (MCDM) used to rank the alternative in a fuzzy environment

Analysis

The steps for fuzzy TOPSIS is given below

Step 1: Creation of the "Decision Matrix"

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Table 1: Segregation and weightage of criterion

	name	Beneficial/Non Beneficial	Weightage
1	WASTE MANAGEMENT	+	(0.200,0.200,0.200)
2	GREEN MANUFACTURING	+	(0.200,0.200,0.200)
3	GREEN DESIGN	+	(0.200,0.200,0.200)
4	GREEN LOGISTICS	+	(0.200,0.200,0.200)
5	PERCENTAGE REJECTION	+	(0.200,0.200,0.200)

The following table shows the fuzzy scale used in the model.

Table 2: Scale(Fuzzy)

Code	Scale Nomenclature	Low	Mid	Upper
1	"Very Low"	1	1	3
2	"Low"	1	3	5
3	"Medium"	3	5	7
4	"High"	5	7	9
5	"Very High"	7	9	9

Table 3: Consolidated Decision Matrix

	WASTE MANAGEMENT	GREEN MANUFACTURING	GREEN DESIGN	GREEN LOGISTICS	PERCENTAGE REJECTION
SUPPLIER 1	(5.000,7.000,9.000)	(1.000,1.000,3.000)	(7.000,9.000,9.000)	(3.000,5.000,7.000)	(5.000,7.000,9.000)
SUPPLIER 2	(1.000,3.000,5.000)	(5.000,7.000,9.000)	(1.000,3.000,5.000)	(1.000,3.000,5.000)	(1.000,3.000,5.000)
SUPPLIER 3	(7.000,9.000,9.000)	(3.000,5.000,7.000)	(3.000,5.000,7.000)	(1.000,3.000,5.000)	(1.000,3.000,5.000)
SUPPLIER 4	(1.000,1.000,3.000)	(7.000,9.000,9.000)	(3.000,5.000,7.000)	(5.000,7.000,9.000)	(7.000,9.000,9.000)
SUPPLIER 5	(5.000,7.000,9.000)	(1.000,3.000,5.000)	(1.000,1.000,3.000)	(3.000,5.000,7.000)	(7.000,9.000,9.000)

Step 2: Creation of the "normalized decision matrix"

$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right)$; $c_j^* = max_i\, c_{ij}$; *Positive ideal solution*

$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right)$; $a_j^- = min_i\, a_{ij}$; *Negative ideal solution*

Table 4 : A Normalized Decision Matrix Table

	WASTE MANAGEMENT	GREEN MANUFACTURING	GREEN DESIGN	GREEN LOGISTICS	PERCENTAGE REJECTION
SUPPLIER 1	(0.556,0.778,1.000)	(0.111,0.111,0.333)	(0.778,1.000,1.000)	(0.333,0.556,0.778)	(0.556,0.778,1.000)
SUPPLIER 2	(0.111,0.333,0.556)	(0.556,0.778,1.000)	(0.111,0.333,0.556)	(0.111,0.333,0.556)	(0.111,0.333,0.556)
SUPPLIER 3	(0.778,1.000,1.000)	(0.333,0.556,0.778)	(0.333,0.556,0.778)	(0.111,0.333,0.556)	(0.111,0.333,0.556)
SUPPLIER 4	(0.111,0.111,0.333)	(0.778,1.000,1.000)	(0.333,0.556,0.778)	(0.556,0.778,1.000)	(0.778,1.000,1.000)
SUPPLIER 5	(0.556,0.778,1.000)	(0.111,0.333,0.556)	(0.111,0.111,0.333)	(0.333,0.556,0.778)	(0.778,1.000,1.000)

Step 3: Creation of the "weighted normalized decision matrix"

We are taking different weightages of each criterion, the "weighted normalized decision matrix" is evaluated by multiplication of the weightage of individual criterion to the " normalized fuzzy decision matrix".

$\tilde{v}_{ij} = \tilde{r}_{ij}.\tilde{w}_{ij}$

Where $\tilde{w}_{ij}$ represents weight of criterion c_j

Table 5 : The "weighted normalized decision matrix"

	WASTE MANAGEMENT	GREEN MANUFACTURING	GREEN DESIGN	GREEN LOGISTICS	PERCENTAGE REJECTION
SUPPLIER 1	) 0.111,0.156,0. (200	) 0.022,0.022,0.0 (67	) 0.156,0.200,0. (200	) 0.067,0.111,0. (156	) 0.111,0.156,0. (200
SUPPLIER 2	) 0.022,0.067,0. (111	) 0.111,0.156,0.2 (00	) 0.022,0.067,0. (111	) 0.022,0.067,0. (111	) 0.022,0.067,0. (111
SUPPLIER 3	) 0.156,0.200,0. (200	) 0.067,0.111,0.1 (56	) 0.067,0.111,0. (156	) 0.022,0.067,0. (111	) 0.022,0.067,0. (111
SUPPLIER 4	) 0.022,0.022,0. (067	) 0.156,0.200,0.2 (00	) 0.067,0.111,0. (156	) 0.111,0.156,0. (200	) 0.156,0.200,0. (200
SUPPLIER 5	) 0.111,0.156,0. (200	) 0.022,0.067,0.1 (11	) 0.022,0.022,0. (067	) 0.067,0.111,0. (156	) 0.156,0.200,0. (200

Step 4: Determination of the "fuzzy positive ideal solution" and the "fuzzy negative ideal solution"

Table 6 : The "positive and negative ideal solutions"

	"Positive ideal solution"	"Negative ideal solution"
WASTE MANAGEMENT	(0.156,0.200,0.200)	(0.022,0.022,0.067)
GREEN MANUFACTURING	(0.156,0.200,0.200)	(0.022,0.022,0.067)
GREEN DESIGN	(0.156,0.200,0.200)	(0.022,0.022,0.067)
GREEN LOGISTICS	(0.111,0.156,0.200)	(0.022,0.067,0.111)
PERCENTAGE REJECTION	(0.156,0.200,0.200)	(0.022,0.067,0.111)

Step 5: Calculation of distance in between all the data points and positive ideal solution and negative ideal solution

Table 7 : Distance matrix

	Distance from positive ideal	Distance from negative ideal
"SUPPLIER1"	0.267	0.403
"SUPPLIER2"	0.486	0.193
"SUPPLIER3"	0.363	0.304
"SUPPLIER4"	0.227	0.436
"SUPPLIER5"	0.351	0.321

Step 6: Calculation of the "closeness coefficient" alternatives rank

Table 8 : Closeness coefficient

	Ci	rank
"SUPPLIER1"	0.602	2
"SUPPLIER2"	0.284	5
"SUPPLIER3"	0.455	4
"SUPPLIER4"	0.658	1
"SUPPLIER5"	0.478	3

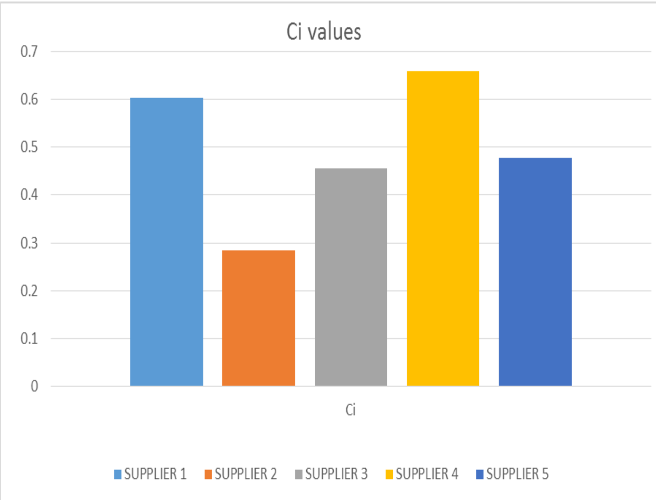

Figure 1

Limitation and scope of further research:

This study mainly focused on the green parameters of a supplier involved in business with the nucleus firm . We took 5 criterion for our analysis. There are many other parameters which can be taken in order to increase the authenticity of the study.

Here we have taken 5 alternatives in form of suppliers which can be further increased to make this study an ubiquitous one.

We have used fuzzy TOPSIS methodology for choosing the best alternative but other optimization techniques like ANP can also be used.

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