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Identification and Assessment of Managerial and Logistical Factors to Evaluate a Green Supplier Using the DEMATEL Method

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ABSTRACT

Increasing pressures and challenges to improve economic and environmental performance have caused the countries in particular to consider and start implementing GSCM. supplier selection and evaluation in supplier management is important because of the increasingly critical role in a firm success that is played by suppliers. Hence, the purpose of GSCM implementation into business activitiesis to concurrently improve environment and economic performance. One objective of the present study was to assist firms in understanding the criteria and implementation involving management aspects and logistics. And in this regard , by using DEMATEL method, tries to evaluate the influential of factors among ten criteria such as: Strategic Management, Supplier Management, Production Management, Financial Management, Customer Management, Procurement Logistics, Production Logistics, Distribution Logistics, Reverse Logistics, Disposal Logistics of two main factors included : management aspects and logistics for the selection of suitable suppliers and proponents of environment. Results show that Strategic Management (one of management factors) and Disposal Logistics (one of logistics factors) are more influential among other factors.
KEY WORDS: Green supply chain management, Supplier selection, Logistics Factors, Management Factors, Decision Making Trial and Evaluation Laboratory (DEMATEL)

1. INTRODUCTION

Many firms have realised that customers and other stake-holders do not always distinguish between a single company and its partners in the supply chain. Also, the lead company in a particular supply chain is often held responsible for the adverse environmental impacts of all organizations within its supply chain (Rao and Holt, 2005; Kova´ cs, 2008). Managers of a focal firm select and govern business partners through out the supply network. Therefore, they are responsible for the environmental performance of the entire supply chain(Seuring and Muller, 2008). For this reason, Green Supply Chain Management (GSCM) is a concept that is gaining popularity. Green Supply Chain Management is defined as a buying firm's plans and activities that integrate environmental issues into SCM inorder to improve the environmental performance of suppliers and customers (Bowen etal., 2001). Greening the supply chain is one of the three major issues of sustainable SCM besides the economicand social dimensions (Seuring and Muller, 2008; Large and Thomson, 2011). The optimal supplier plays an important role in the implementation of GSCM practices. Suppliers often have long-term contracts with the firm and provide multiple services. The involvement and performance of the supplier have been discussed in various studies (Tseng, 2009; Stanley and Wisner, 2001; Shang et al., 2010; Choi and Hartley, 1996; Li et al., 2007). In the past decade, many studies have focused on the development of a selection model for green suppliers (Tseng, 2011). In recent years, green supply chain management (GSCM) initiatives have gained considerable prominence. However, how much value it brings to organizations is still being investigated. While an Aberdeen research study indicates companies implementing successful GSCM initiatives may benefit from reduction in energy and logistics costs, and enhanced competitive advantage, the study also mentions a majority of the corporate respondents (55%) who identified green initiatives as a top focus reported that the key pressure for these initiatives were overwhelmingly related to corporate social responsibility (Shecterlea and Senxian, 2008). one of the important goals of supply chain management is improving supply chain performance (Cai et al., 2009; Bose and Raktim, 2012). Business environment is continuously changing due to diversification of customer demands. This diversification of demand leads to increase in operating cost and followed by the decrease in profit. Therefore, purchasing decision from a particular supplier is a crucialstrategic decision to ensure profitability and long term survival of the company. Most of the companies are trying to reduce their operating costs while satisfying customer needs by increasing their core competencies and outsourcing other functions (Lee, 2009). A careful assessment is needed to select right supplier who can maintain a continuous replacement of product in proper time. Most of the times supplier strength and weakness are varied,

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which leads to complex decision making of supplier selection. Many researches in supplier selection area used mathematical programming (Shaw et al., 2012). Many methods have been proposed to solve the supplier selection problem. Carr and Smeltzer (Carr and Smeltzer, 1999) documented the process competitive priority is closely related to top management support that requires strategic purchasing. As such, the present study will view GSCM a complex, interactive process of many different resources with multidimensional, interdependent criteria (Sarkis, 1998; Sarkis, 2003). Recently, supplier selection studies based on multiple criteria have employed fuzzy analytical systems. For instance, Humphreys et al. (Humphreys et al., 2006) proposed a hierarchical fuzzy system with scalable fuzzy membership functions to facilitate the supplier selection process by incorporating environmental criteria. Lu et al. (Lu et al., 2007) constructed a MCDM process to assist managers in evaluating supplier's performance (Tseng, 2011). The objective of this study is to investigate main logistics factors and main management factors and evaluate them in GSCM and study the influence of these most important criteria for supplier selection using the DEMATEL method. The structure of this study is as follows: Section 1 introduces the background and motivation. The review of literature related to GSCM is mentioned in Section 2. The DEMATEL is described in Section 3. The results are presented in Section 4. Section 5 discusses the results. Finally, conclusion and implications are presented in Section

2. LITERATURE REVIEW

In order to provide sufficient understanding of the relationships among proposed GSCM criteria, this chapter clearly presents the literature related to green supply chain management , logistics and management criteria. green supply chain management is the process of incorporating environmental concerns into business activities. There are various factors in GSCM as following: and These are summarized in Table 1.

2.1.1. Financial management

Financial management is typically the most important driver for companies that wish to implement environmental management performance. Alvarez Gil et al. (2001) indicated that environmental management such as GSCM has a positive relationship with a corporation's financial management. Green supply chain management not only increases environmental profit but also can be of some benefit to financial performance (Lippmann, 1999). Good environmental performance not only has a positive effect on good financial performance but also on environmental exposure (Al-Tuwaijri et al. 2004).

2.1.2. Production Management

Green production management refers to the products or services with certain environmental consciousness (Fiksel, 1996). Green production management measurements include tracking all material and reverse flow of a product from the retrieval of raw materials out of the environment to the disposal of the product back into the environment (Gungor and Gupta, 1999; Tibben-Lembke, 2002; Arena et al., 2003). Environmentally-responsible consumption and production management is seen as an essential part of the strategy to improve environmental quality, reduce poverty and bring about economic growth, with resultant improvements in health, working conditions, and sustainability, and is today's highlighted Agenda. Production management influences the green supply chain with the design and the production process.

2.1.3. Customer management

Due to customer demands for green products which are manufactured using environmental friendly raw materials and green production processes, firms have to integrate its environmental goals with long-term customer management. Customers collaboration plays an important role in a successful environmental management programs (Vachon and Klassen, 2006).

2.1.4. Supplier management

The supplier plays an important role in the whole chain, and good suppliers directly affect the product quality, cost and reputation of the company. The supplier becomes the major factor in the whole supply chain performance, and a bad quality supplier can affect the performance of the whole supply chain (Sarkar and Mohapatra,2006). Managers and consultants believe that a good relationship with the supplier determines the competitive advantage of the factory (Sheth and Sharma, 1997). The environmental performance of the supplier is now thought to be a key decisive factor in many companies (Clark, 1999).

2.1.5. Strategic management

Due to customer demands for green products which are manufactured using environmental friendly raw materials and green production processes, firms have to integrate its environmental goals with long-term strategic

management (Sarkis, 2006).GSCM practices can be considered as an outcome of strategic management through coordination with suppliers (Olugu et al., 2010).

2.2.1. Procurement logistics

In an environmental friendly chain the first step is procurement and vendor selection.The integration of suppliers functioning begin with Green purchasing of raw material (Srivastava, 2007; Zhu and Geng, 2001; Zhu et al., 2010). this Green purchasing can leads to Environment friendly raw material, Substitution of environmentally questionable raw materials, (Rao, 2002; Hervani et al., 2005)

2.2.2. Production logistics

Production influences the green supply chain with the design and the production process. Within this function, environmental issues such as total quality environmental management make some form of value-adding contribution (Sarkis et al., 2004)

2.2.3. Distribution logistics

Distribution is another operation that effect green supply chain. Distribution Logistics has, as main tasks, the delivery of the finished products to the customer. It consists of order processing, warehousing, and transportation. Distribution logistics is necessary because the time, place, and quantity of production differs with the time, place, and quantity of consumption (Srivastava, 2007).

2.2.4. Reverse logistics

A significant trend in GSCM has been the recognition of the strategic importance of reverse logistics. The definition of reverse logistics from an environmental perspective focuses primarily on the return of recyclable or reusable products and materials into the forward supply chain. (Srivastava, 2007). Reverse Logistics is a ‘‘closing the loop’’ of supply Chain. the company can achieve both cost and competitive advantage of Recycling, Refurbishing, Re- manufacturing (Hervani et al., 2005; Rao and Holt, 2005; Tsaia and Hung, 2009; Zhu et al., 2010 .

2.2.5. Disposal logistics

Recycling is the process by which products otherwise destined for disposal are processed to recover base materials, for example, precious metals from computer chips. For minimization of environmental impact the ideal scenario would be maximum possible reuse and disposal in a landfill only when it cannot be reused or recycled (Awasthi et al., 2010; Humphreys, Wong,& Chan, 2003).

Table 1: criteria and sub criteria of supplier selection

Purpose	Criteria	Sub-criteria	Refrences
Green Supply Chain Management	Management aspects	Strategic Management (C1)	Iiraj pour et al . (2012), Pratali, P. (2003), Hu and Hsu (2010), Oliveira et al. (2010), Holt and Ghobadian (2009), Bechtel and Jayaram (1997), Hong et al. (2009)
		Supplier Management (C2)	Hu and Hsu (2010), Hsu and Hu (2008), Zhu et al. (2005), Choudhary and Seth (2011), Holt and Ghobadian (2009)
		Production Management (C3)	Narasimhan and Kim (2001), Tseng et al. (2011), Büyüközkan and Çifçi (2012)
		Financial Management (C4)	Büyüközkan and Çifçi (2012), Zhu et al. (2010)
		Customer Management (C5)	Tseng et al. (2011), Narasimhan and Kim (2001), Azevedo et al. (2011), Iiraj pour et al . (2012)
	Logistics	Procurement Logistics (C6)	Büyüközkan and Çifçi (2012), Choudhary and Seth (2011), Zhu,et al. (2010)
		Production Logistics (C7)	Büyüközkan and Cifçi (2012), Choudhary and Seth (2011), Wan Mahmood et al. (2010)
		Distribution Logistics (C8)	Byüközkan and Çifçi (2012), Diabat and Govindan (2011), CHOUDHARY and SETH (2011)
		Reverse Logistics (C9)	Byüközkan and Çifçi (2012), Wu et al. (2012), Choudhary and Seth (2011)
		Disposal Logistics (C10)	Büyüközkan and Çifçi (2012), Diabat and Govindan (2011)

3. Approaches for supplier selection

3.1. Methods to supplier selection

Supplier selection is a multi-criteria decision problem (Akarte et al., 2001; Liaoa and Rittscherb, 2007; Huang and Keskar, 2007), for which the related literature has proposed several supplier selection methodologies. Some familiar examples of systematic analysis for supplier selection include analytic hierarchy process (AHP) (Tam and Tummala, 2001; Chan, 2003), analytic network process (ANP) (Gencer and Gürpinar, 2007; Hsu and Hu, 2009) and

etc. However, those approaches to supplier selection in the supply chain require additional data and scarcely consider the relationship between criteria. The DEMATEL technique does not need large amounts of data and is capable of revealing the relationship among these factors influencing other factors in the supplier selection (Chang et al., 2011). DEMATEL modeling thus better fits the problem examined in this study, and offers the advantage of providing a systematic approach to supplier selection for GSCM practice.(Hsu et al., 2011)

3.2. The DEMATEL method

DEMATEL is a comprehensive tool for building and analyzing a structural model involving causal relationships between complex factors (Wu and Lee, 2007). Developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976. The DEMATEL method is based on digraphs, which separate involved factors into cause group and effect group. Directed graphs, known as digraphs, are more useful than directionless graphs because digraphs demonstrate the directed relationships of sub-systems. The digraph may portray a basic concept of contextual relation among elements of a system, in which the values represent the strength of influence. Hence, The DEMATEL can convert the relationship between cause and effect factors into an intelligible structural model of the system. The DEMATEL can propose the most important criteria which affects other criteria. (Fontela, 1976). This structural modeling approach adopts the form of a directed graph, a causal effect diagram, to present the interdependence relationships and the values of influential effect between factors (Wu and Lee, 2007). Hence, the DEMATEL method can Through analysis of visual relationship of levels among system factors, all elements are divided into causal group and effected group And the relationship between the causes and effects of criteria into an intelligible structural model of the system. this can provides researchers a better understand of the structural relationship between system elements, and find ways to solve complicate system problems (Gabus and Fontela, 1972, 1973; Herrera et al., 2000; Chiu, 2006; Wang and Chuu, 2004).

The essentials of the DEMATEL method suppose that a system contains a set of criteria $C=\{C_1,C_2\ldots,C_n\}$, and the particular pairwise relations are determined for modeling with respect to a mathematical relation.
The DEMATEL process can be summarized by the following steps:

1. Generating the direct relation matrix. Measuring the relationship between criteria requires that the comparison scale be designed into four levels: 0 (no influence), 1 (very low influence), 2 (low influence), 3 (high influence), and 4 (very high influence). An initial direct relation matrix A is a n × n matrix obtained by pair-wise comparisons, in which T_{ij} is denoted as the degree to which the criterion i affects the criterion j, i.e., $T = [t_{ij}]_{n\times n}$
2. Normalizing the direct relation matrix. On the base of the direct relation matrix A, the normalized direct relation matrix I can be obtained through the equation.

(1) $$S = K \times A$$

(2) $$K = \frac{1}{\max\limits_{1\le i\le n} \sum_{j=1}^{n} a_{ij}}$$

3. Attaining the total relation matrix. Once the normalized direct relation matrix S is obtained, the total relation matrix I is denoted as the identity matrix.

(3) $$T = S\,(I - S)^{-1}$$

4. Producing a causal diagram. The sum of rows and the sum of columns are separately denotes as vectors D and R within the total relation matrix M. A causal and effect graph can be acquired by mapping the dataset of (D + R, D - R). The horizontal axis vector (D + R) named “Prominence” is made by adding D to R, which reveals how much importance the criterion has. Similarly, the vertical axis (D - R) named “Relation” is made by subtracting D from R, which may group criteria into a cause group. Or, if the (D - R) is negative, the criterion is grouped into the effect group.

(4) $$T = [t_{ij}]_{n\times n},\ i,j = 1,2,\ldots,n$$

(5) $$D = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} = \left[t_j\right]_{1\times n}$$

(6) $$R = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} = \left[t_i\right]_{n\times 1}$$

5. Obtaining the inner dependence matrix. In this step, the sum of each column in total relation matrix is equal to 1 by the normalization method, and then the inner dependence matrix can be acquired. (Tzeng et al., 2007; Liou et al., 2007).

4. RESULTS

This section operationalized the evaluation methodology for firm's GSCM at a case firm. There are reasons for firms' GSCM evaluation. The firm continues to face challenges with how they manage the competitive advantages of GSCM practices and the firm has to follow the green aspects to develop their criteria from a competitive market. This study attempts to apply the DEMATEL to build up a cause and effect model for GSCM aspects. Following is four proposed steps:

Step 1: Identifying decision goal - gathering the relevant information and defined the goals for further developing the eight GSCM criteria in order to examine the interrelationships of criteria in uncertainty.

Step 2: Ten criteria are evaluated including: (C1), (C2), (C3),(C4), (C5), (C6), (C7), (C8), (C9), (C10). The DEMATEL method is also used to test the influence of each criterion. Then, the respondents were asked to evaluate the interrelationship of each criterion using four scores in linguistic term: 0 (no influence), 1 (very low influence), 3 (high influence), and 4 (very high influence). To ensure the relationships among the evaluation criteria, it is necessary to consult the experts to confirm reliable information of the criteria influences and directions using a survey instrument (Table 2 and Table 3).

Table 2- The linguistic scale.

Linguistic variable	Influence score
No influence	0
Very low influence	1
Low influence	2
High influence	3
Very high influence	4

Table 3- Direct relation matrix T.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	3	3	3	3	3	3	3	3	2	2
C2	1	1	3	2	3	4	2	3	2	1
C3	3	3	3	4	3	3	3	2	3	2
C4	2	2	2	3	3	4	3	3	3	3
C5	3	3	4	3	3	4	4	2	2	2
C6	2	3	3	3	3	3	3	1	2	2
C7	2	3	3	2	3	2	2	2	3	1
C8	2	3	1	3	3	1	1	2	1	1
C9	1	2	3	3	2	3	3	1	3	4
C10	3	3	3	3	3	3	3	1	3	1

We utilized the DEMATEL to construct the influence map in accordance with the real situation in which criteria should be interdependent. Ten senior managers were invited to fill out expert questionnaires using a five-point scale (i.e., 0 = no influence, 1 = low influence, 2= moderate influence, 3 = high influence, and 4 = extreme influence), indicating the influence of each criterion on other criterion. Using the 10 * 10 pairwise comparisons, the averages of their opinions were. The normalized initial direct-relation matrix was then generated by using Eqs. (1) and (2). The total relation matrix was computed by using Eqs. (3) as shown in Table 3. Final results of computations are given in Table 4. Obtained results made it possible to present the influence map of considered, mutually interdependent criteria. The influence map of these 10 mutually interdependent criteria is depicted in Fig. 1.

Considering the significance of management and logistics criteria in supplier selection, as presented in Table 4, the importance is identified as C5 > C3 > C4 > C6 > C1 > C9 > C7 > C2 > C10 > C8 according to the degree of importance (Di+Ri).

Table 4- Final results of the analysis.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
D	0.699	0.421	0.756	0.698	0.809	0.599	0.479	0.323	0.593	0.575
R	0.479	0.550	0.718	0.746	0.737	0.816	0.650	0.377	0.551	0.328
D+R	1.177	0.970	1.474	1.443	1.547	1.415	1.129	0.700	1.144	0.903
D-R	0.220	-0.129	0.037	-0.048	0.072	1.129	-0.171	-0.054	0.043	0.247

Incorporating the analysis of the DEMATEL evidence, Customer Management (C5), Production Management (C3) are two of most important criteria with the values of 1.547 and 1.474, respectively. Distribution Logistics (C8) and Disposal Logistics (C10) are the least important criteria with the values of 0.700 and 0.903, respectively. Contrary to the importance of criteria, Strategic Management (C1), Production Management (C3), Customer Management (C5), Reverse Logistics (C9) and Disposal Logistics (C10) are net causer and can be improved,

whereas Supplier Management (C2), Financial Management (C4), Procurement Logistics (C6), Production Logistics (C7), and Distribution Logistics (C8) are net receivers and can arrive the effect criteria in accordance with the value of difference (Di-Ri). Causal relationships shown in Fig. 1 confirm that Strategic Management (C1) and Disposal Logistics (C10) are the most influential criteria. They are the real sources which affect the other criteria directly. Although they are not considered priority criteria with the highest value of evaluation of significance, they can offer insights for managers to understand the cause-effort relationship, and to select appropriate suppliers with management and logistics competence. This shows that enterprises should prefer suppliers with competence and information capability with regard to management and logistics at most.

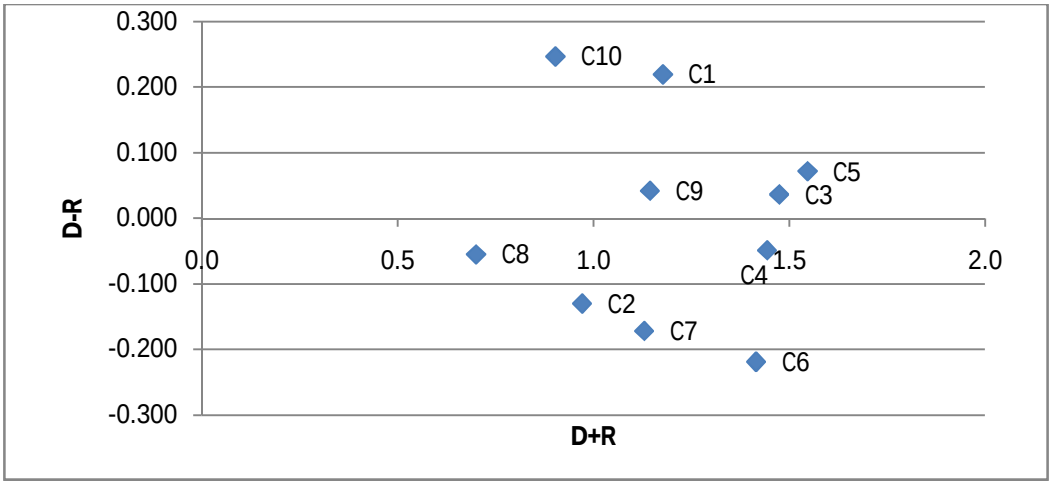

Fig. 1. The causal diagram.

5. Conclusions and future research

The GSCM-based conceptual framework and operational model for the incorporation of management and logistics into supplier selection have been presented. After identifying the criteria related to management and logistics criteria for the proposed framework, the DEMATEL was applied in the case of analysis devoted to firms. Application of the DEMATEL revealed not only the structure and interrelationships between the criteria, but also allowed to identify the key criteria influencing the supplier selection with regard to management and logistics competencies. Results of the analysis indicate that training related to management and logistics of GSCM criteria are the most significant criteria. They influence results of selection of green suppliers. Issues which pertain to these two main criteria can therefore have a great impact on the continuous improvement of the suppliers' overall performance with regard to management and logistics. The significance of mitigating climate change risks coming from the green supply chain operation causes that supplier selection should not only consider the importance of criteria as in conventional evaluation model. It ought to observe the causal relationships of evaluation criteria with regard to the potential influence as well. Firms choosing their suppliers should observe which suppliers possess characteristic training related to management and logistics of GSMS criteria.also this study find these information as follow:

Strategic Management, Production Management, Customer Management, Reverse Logistics and Disposal Logistics are net causer and can be improved, whereas Supplier Management, Financial Management, Procurement Logistics, Production Logistics, and Distribution Logistics are net receivers and can arrive the effect, also Strategic Management (C1) and Disposal Logistics are the most influential criteria. They are the real sources which affect the other criteria directly.

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