Identification of Green Supply Chain Pressures For Business Implementation

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Abstract: - Consumer environmental awareness together with government regulations are recognized as crucial factors that impact the success of organizations. Hence, development and implementation of strategies to advance the business in the green era is a major managerial subject. Green Supply Chain Management (GSCM) is identified as an organizational philosophy that facilitates companies in enhancing their market share by improving ecological efficiency and reducing environmental negative impacts. However, several pressures are reported to jeopardize the implementation of GSCM concept. The necessity to clearly identify and promptly answer to these pressures has been recognized by organizations. Yet, the limitation of current quantitative methods, that analyze the business and market information, remains a challenge. This paper proposes a Fuzzy Analytical Hierarchy Process (FAHP) to evaluate the barriers of GSCM implementation. The proposed model in this paper is further investigated by studying a real case from the pipe manufacturing industry.

Keywords: - Pressure, Green Supply Chain Management, Evaluation, Environmental issues, Fuzzy Analytical Hierarchy Process, Multi Criteria Decision Making

1 Introduction

To ensure the success of businesses in today’s competitive market adapting strategies to cope with the changing market issues is critical [1]. The rising demand for environmental protection and green manufacturing is a major issue. Green Supply Chain Management (GSCM) is a modern philosophy in theory of organizations with the goal to create a competitive economical and market advantage by improving the ecological efficiency and minimizing the negative environmental impact [2]. The environmental research is receiving greater attention due to the growing green regulations, green institutions pressure, competition to create a green business image, customer preferences, media, and etc.

Moreover, the fast depletion of natural resources, growing concerns on distribution of wealth and corporate social responsibility emphasize the significance of research in environmental issues. Hence, adopting GSCM practices is recognized as an important factor for successful industry. In fact, there are pressures to adopt GSCM practices in industries. Yet, evaluating the pressures that threaten the implementation of GSCM is a challenge for industries that are seeking to improve their environmental friendly image [3, 4, 5]. Although several factors that pressure the industries are identified, simultaneously responding to all the factors is not possible for industries with limited resources. Therefore, there is a demand for a detailed analysis to find the most critical pressure factors that influence the GSCM implementation.

In this regard, there are several studies, for example: Muduli et al. [6] studied the impact of behavioural variables in mining industry that challenge the implementation of GSCM. They recognized the key issues by applying Interpretive Structural Modeling (ISM). Fonseca et al. [7] also studied the mining industry and summarized the key issues that sustainability initiatives face by using constructive critique of the GRI approach. Gomes et al. [8] studied the mining industry in Brazil with the goal to improve the business performance through sustainability practices. The gap in the research remains due to the scarcity of studies that analyse the impact of indirect pressures on GSCM. There is no evidence of research that evaluates and prioritises the indirect GSCM adaptation pressures.

This Paper proposed research is critical due to its focus on analysing and prioritizing the GSCM adaption initiatives in pipe industries. The purpose of this work is to inspire and support the industry practitioners to identify and implement strategies to cope with the most critical pressures that risk the GSCM adaptation efforts. The approach of this study contributes to fill the gap in this field of research.

Bearing in mind those pressures on GSCM adaption; the pressures can be categorized and classified under several criteria. This paper defines a multi criteria decision making (MCDM) problem and provides an appropriate solution approach to find the answers. Analytical Hierarchy Process is a common approach to solve MCDM problems [9]. This approach provides a systematic framework and structure for solving MCDM problems [10]. One of the biggest advantages of AHP is its capability to incorporate both qualitative and quantitative variables. However it needs crisp values for the process of pair-wise comparisons. This issue comes as a shortage since decision making experts express their preferences linguistically. Due to the uncertainty involved with the linguistic expressions and human judgments [11, 12] there is a quest in research to implement suitable methods to deal with this ambiguity. The approach of Chang [13] involves the concept of fuzzy set theory in AHP; for this reason it is called Fuzzy AHP.

In this paper, an integrated framework is proposed for evaluating the GSCM pressures to support and help supply chain managers. To resolve the conventional AHP shortcomings, a Fuzzy AHP (FAHP) is proposed here.

2 Fuzzy AHP

Several methods have been proposed for Fuzzy AHP by researchers [14]. This study applies the approach introduced by Chang [13,15]; called extent analysis, since the steps of this approach are easier than the other fuzzy AHP approaches. The steps of Chang [13,15] extent analysis approach are as follows: let X = $\{x_1, x_2, \ldots, x_n\}$ be an object set, and U = $\{u_1, u_2, \ldots, u_m\}$ be a goal set. According to the method of Chang [13] extent analysis, each objective is taken and extent analysis for each goal, g_i, is performed, respectively. Therefore, *m* extent analysis values for each object can be obtained, with the following elements:

$$M_{gi}^1, M_{gi}^2, \ldots\ldots M_{gi}^m, \quad i = 1,2,\ldots\ldots,n \tag{8}$$

Where all the M_{gi}^j (j = 1,2,…..,m) are TFNs.

The steps of Chang's extent analysis can be given as in the following:

Step 1: The value of fuzzy synthetic extent with respect to the *i*th object is defined as:

$$S_i = \sum_{j=1}^{m} M_{gi}^j * \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1} \tag{9}$$

To obtain $\sum_{j=1}^{m} M_{gi}^j$, perform the fuzzy addition operation of m extent analysis values for a particular matrix such that:

$$\sum_{j=1}^{m} M_{gi}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \tag{10}$$

And to obtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1}$, perform the fuzzy addition operation of M_{gi}^j (j = 1,2,…..,m) values such that:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j = \left(\sum_{j=1}^{m} l_i, \sum_{j=1}^{m} m_i, \sum_{j=1}^{m} u_i\right) \tag{11}$$

and then compute the inverse of the vector in Eq. (11) such that

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1} = \left(\frac{1}{\sum_{j=1}^{m} u_i}, \frac{1}{\sum_{j=1}^{m} m_i}, \frac{1}{\sum_{j=1}^{m} l_i}\right) \tag{12}$$

Step 2: The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq (l_1, m_1, u_1)$ is defined as:

$$V(M_2 \geq M_1) = \sup\left[\min(\mu_{M1}(x), \mu_{M2}(y))\right] \tag{13}$$

and can be equivalently expressed as follows:

$$V(M_2 \geq M_1) = \text{hgt}(M_1 \cap M_2) = \mu_{M2}(d) = \begin{cases} 1, & if\ m_2 \geq m_1 \\ 0, & if\ \ l_1 \geq m_2 \\ \frac{u_2 - l_1}{(m_2 - m_1) - (u_2 - l_1)}, & otherwise \end{cases} \quad (14)$$

Where d is the ordinate of the highest intersection point D between μ_{M1} and μ_{M2} (see Fig. 2). To compare M_1 and M_2, we need both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$.

Step 3: The degree possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i ($i = 1,2,...,k$) can be defined by:

$$V(M \geq M_1, M_2, \ldots M_k) = V[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and } \ldots (M \geq M_k)] = \min V(M \geq M_i),\ i=1,2,\ldots,k. \quad (15)$$

Assume that:

$$d'(A_i) = \min (S_i \geq S_k) \quad (16)$$

For k = 1,2,. . . ,n; k ≠ i. Then the weight vector is given by:

$$W' = \left(d'(A_1),\ d'(A_2), \ldots \ldots \ldots d'(A_n)\right)^T \quad (17)$$

Where A_i ($i = 1,2,. . . ,n$) are n elements.

Step 4: Via normalization, the normalized weight vectors are:

$$W = \left(d(A_1),\ d(A_2), \ldots \ldots \ldots d(A_n)\right)^T \quad (18)$$

Where W is a non-fuzzy number.

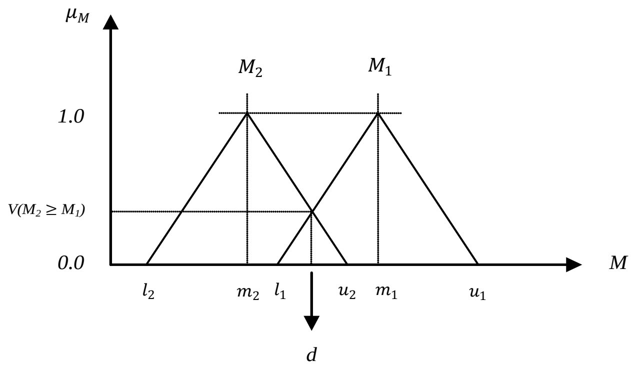

Fig. 2. The intersection of M_1 and M_2

3 Proposed approach

This study develops a solution approach based on Fuzzy AHP method to rank the GSCM pressures. The approach is examined for a real case industrial company called Kooshan Etesal Co., A pipe and fitting manufacturer located in the centre of Iran. The purpose of the case study is to demonstrate the capability of the proposed approach to prioritize the factors and to provide an example for industry practitioners on how to implement the approach. The steps of this approach are as follow:

3.1 Criteria and alternatives identification

One of the most important aspects of using MCDM techniques is choosing appropriate criteria to compare and evaluate alternatives. Results of these techniques are strictly dependant on criteria. The first step of the proposed model is finding appropriate criteria to evaluate the project complexity. Regarding to this point that main aim of this paper is evaluating and prioritizing GSCM pressures, nine pressures are taken into account as alternatives. These pressures are divided in 3 categories, Regulations, Social, and Commercial and operational. These categories are defined as criteria of this model. In fact, nine pressures are evaluated based on these three categories. It should be noted, case study mangers determine dimensions and alternatives. Table 1 shows the dimensions and pressures of this study.

Table 1, Model dimensions and alternatives

Dimensions	Pressures
Regulations (D1)	Environmental regulations of foreign countries (P1) Internal environmental regulations (P2) High penalty for environmental pollutions (P3)
Social (D2)	Pressures from Non-governmental organizations (NGOs) (P4) Customer demand for green product (P5) Firm’s competitiveness (P6)
Commercial and operational (D3)	Scarcity of raw material (P7) Social responsibility (P8) Financial incentives of energy savings (P9)

3.2 Structuring the model

Modelling the problem in a hierarchical structure is one of the major issues in AHP approach. For this purpose the objective of the model should be defined and the dimensions to achieve the goal should be laid out in a horizontal position. The higher dimension elements then are decomposed into sub-dimensions that create another horizontal layer and called attribute-enablers. Once the hierarchical layers are defined the relationship between the dimensions and pressures should be defined. Via brain storming process the problem structure and relationships are defined in this research with respect to the literature.

3.3 Building pair-wise comparison matrices between components/attributes

Determining the local weight that represents the importance of dimensions and factors is the second step in this approach. Assigning the weights is based on pair-wise comparisons. Section 2 illustrates the technique to execute the comparisons. This technique to compare the dimensions is based on the Fuzzy AHP [13. 15]. It applies triangular fuzzy numbers (TFNs) (Table 2). The linguistic expression of two SCM experts and supply chain managers is the source of judgments.

Table 2. Linguistic scales for importance

Linguistic scale for importance	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
Absolutely equal	(1, 1, 1)	(1, 1, 1)
Equally Important (EI)	(1/2, 1, 3/2)	(2/3, 1, 2)
slightly more Important (WMI)	(1, 3/2, 2)	(1/2, 2/3, 1)
moderately more Important (SMI)	(3/2, 2, 5/2)	(2/5,1/2, 2/3)
strongly more Important (VSMI)	(2, 5/2, 3)	(1/3, 2/5, 1/2)
extremely more Important (AMI)	(5/2, 3, 7/2)	(2/7, 1/3, 2/5)

3.4 Calculate the global pressures' weights

To calculate the global weights, it is necessary to consider the interdependent weights for criteria and the local weights calculated by the Fuzzy AHP. By multiplying the local weights of pressures with the interdependent weights of the belonging criteria, the global pressures' weights are produced. The pressures are ranked based on the final global weights. Table 3 shows the computed values.

Table 3. Global weights of pressures

Dimensions	Local weight	Pressures	Local weight	Global weight
D1	0.31	P1	0.41	0.127
		P2	0.21	0.065
		P3	0.38	0.118
D2	0.39	P4	0.18	0.070
		P5	0.52	0.203
		P6	0.30	0.117
D3	0.30	P7	0.47	0.141
		P8	0.22	0.066
		P9	0.31	0.093

4 Conclusions & Future research

This paper presented a Fuzzy AHP (FAHP) approach to evaluate GSCM pressures. Three dimensions are identified to classify the pressures. To examine the effectiveness of proposed approach a real case from piping industry is studied. The social dimension obtained the highest rank among pressures for the studied case. That result shows the highest level of significance in GSCM adoption belongs to social pressures. The other two dimensions pressure for GSCM were recognized to have the same level of importance. These equally important dimensions are: regulations, commercial/operational. A more detailed analysis revealed the significance of factors within every individual dimension. Among social pressures the most important factor is the customer demand for green products. This result proves that the recent consumption trend and tendency toward green products is vivid in the studied industry. The result also shows the importance of social awareness and the level of impact that this factor has on GSCM. The customer oriented approach of the studied industry contributes to the high significance of the customer demand factor. Next, among the regulation factors, the environmental regulations of foreign countries factor is ranked the highest. The results show that international trade and requirements by international trade regulatory laws are contributing significantly to GSCM implementation. This suggests that the impact of domestic environmental regulations is highly significant for the industry in international extent as well as domestic market. Finally, among the commercial and operational factors, the scarcity of raw material is recognized as the most important factor. The consistency of the obtained results with the concerns raised by the experts of industry proves the practicality of the approach. Highlighting the most significant issues can balance the efforts of organizations to focus on what matters the most. Planning and implementing green strategies is possible via conducting this approach.

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