Journal of Scientific & Industrial Research
Vol. 78, June 2019, pp. 368-372

Studies on Sustainable Supply Chain Barriers of Suppliers to the Thermal Power Heavy Industry

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Received 7 July 2018; revised 19 December 2018; accepted 12 April 2019

The paper proposes a method to identify and rank the small and medium scale industries which are a supplier to the thermal power heavy industry, following the sustainable supply chain. A large and growing number of manufacturers are realizing substantial and financial benefits from sustainable business practices. Sustainable manufacturing also enhances employee, community and product safety. Awareness about these benefits is not much wider in the Indian Subcontinent, particularly amongst the small and medium scale industries (MSMEs). Literature papers used to identify Barriers of Sustainable Supply chain. It is fundamental to understand the drivers, barriers, and benefits influencing sustainable manufacturing initiatives. All barriers do not have the same degree of influence on the sustainable supply chain. It is, therefore, necessary to rate these barriers. These barriers can be weighed and can be ranked by using one of the Multi-Criteria Decision Making (MCDM) tools that are the Analytical Hierarchy Process (AHP). Based on the ranking, important barriers are shortlisted from the present list. A survey is floated to small and medium scale industries related to thermal power where the respondent companies will be asked to rate their level of agreement on the drivers, barriers, and benefits of sustainable manufacturing initiatives**.** In this study three broad area of sustainable supply chain, barriers are involved those are Economic, social and Environmental barriers. This three broad area of SSCM is called Triple bottom line concept of Sustainable supply chains. Here those are analyzed and ranked.

Keywords: Analytic Hierarchy Process, Medium and Small Scale Industries, Sustainable Supply chain, Thermal power industry, Small and medium scale enterprises, Barriers, Multi-criteria decision making (MCDM), BHEL

Introduction

In recent years, sustainability has become a buzzword in today's business marketplace. There are a number of drivers to promote the development of sustainability, for instance, increased consciousness relating to climate change, supply and demand characteristics in energy consumption, and greater transparency concerning both the environmental and social Perspectives of actions in organizations[7.] The execution of sustainable supply chain management is a multifaceted and tough sensation, due to its dependence and several factors. These factors are unified and interdependency needs to be understood for effective SSCM implementation[1]. The priority approaches of SSCM implementation in MSME show the respondents' perception about the importance of SSCM and assisted organizations recognize their strengths move towards continuous improvement[2]. The term of sustainability, which refers to the integration of social, environmental, and economic responsibilities, has involved both the management and operations of companies. In addition, the topic of Supply Chain Management (SCM) has attracted many practitioners and scholars to research and investigate[8].The SSCM concept integrating the element of Environmental criteria and corporate social responsibility with supply chain management being pursued as one single interference has gradually caught the attention of the experts in India[4]. Approaching to implement the SSCM in Micro, small, & medium scale industries should be transformed to accompany changes in environmental regulations and customer in future research. Also, the supplier management plays a vital role in implementing SSCM[2, 5]. Supplier related barriers, such as associated costs, ease of use, suppliers' credibility, and their offerings' creativity and execution, and intra-administrative barriers, such as organizational structure and culture, inhibit adoption. The refinement and alignment of suppliers' actions, communications, and offerings were suggested to assistance in disabling the barriers[3]. Business managers to develop their sustainable

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practices are more effective and also facilities organization in India to renovate their existing practices and conclude new strategies accordingly[6].

Sustainable supply chain

Supply chain sustainability is a business issue affecting an organization's supply chain or logistics network in terms of environmental, risk, and waste costs. There is a growing need for integrating environmentally sound choices into supply-chain management. Sustainability in the supply chain is increasingly seen among high-level executives as essential to delivering long-term profitability and has replaced monetary cost, value, and speed as the dominant topic of discussion among purchasing and supply professionals. A sustainable supply chain seizes value creation opportunities and offers significant competitive advantages for early adopters and process innovators. Supply chains are critical links that connect an organization's inputs to its outputs. Traditional challenges have included lowering costs, ensuring just-in-time delivery, and shrinking transportation times to allow the better reaction to business challenges. However, the increasing environmental costs of these networks and growing consumer pressure for eco-friendly products has led many organizations to look at supply chain sustainability as a new measure of profitable logistics management. This shift is reflected by an understanding that sustainable supply chains frequently mean profitable supply chains. Many companies are limited to measuring the sustainability of their own business Operations and are unable to extend this evaluation to their suppliers and customers. This makes determining their true environmental costs highly challenging and reduces their ability to remove waste from the supply chains. However, much progress has been made its defining supply chain sustainability and benchmarking tools are now available that enable sustainability action plans to be developed and implemented. In supply chain management Multi-criteria decision-making process is a very important tool for decision makers. Since Bernoulli (1738) proposed the concept of utility function to reflect human pursuit, such as maximum satisfaction, and von Neumann and Morgenstern (1947) presented the theory of game and economic behavior model, which expanded the studies on human economic behavior for multiple attribute decision making (MADM) problems, an increasing amount of literature has been engaged in this field. Roughly speaking, the procedures of MADM can be summarized in five main steps as follows:

Step 1: Define the nature of the problem;

Step 2: Construct a hierarchy system for its evaluation

Step 3: Select the appropriate evaluation model;

Step 4: Obtain the relative weights and performance score of each attribute with respect to each alternative.

Step 5: Determine the best alternative according to the synthetic utility values, which are the aggregation value of relative weights, and performance scores corresponding to alternatives. If the overall scores of the alternatives are fuzzy, we can add Step 6 to rank the alternatives for choosing the best one.

Step 6: Outrank the alternatives referring to their synthetic fuzzy utility values from Step 5.

It should be highlighted that Keeney and Raiffa by 1976, suggest that five principles must be followed when criteria are being formulated: (1) completeness, (2) operationally, (3) Decomposability, (4) non-redundancy, and (5) minimum size. On the basis of dealing with MADM problems, the analytic hierarchy process (AHP) was proposed to derive the relative weights according to the appropriate hierarchical system. In this chapter, four methods, including the eigenvalue method, the geometric mean method, the linear programming method, and the lambda-max method, are proposed to derive the weights using the AHP. Among these methods, only the eigenvalue method is employed to deal with crisp numbers and the other methods are adapted to handle the AHP under fuzzy numbers

Analytic Hierarchy Process (AHP)

The analytic hierarchy process (AHP) is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. The elements of the hierarchy can relate to any aspect of the decision problem—tangible or intangible, carefully measured or roughly estimated, well or poorly understood—anything at all that applies to the decision at hand.
Generally, AHP has the following four steps:

1. Define an unstructured problem and determine its goal.

2. Structure the hierarchy from the top (objectives from a decision maker's viewpoint) through intermediate levels (criteria on which subsequent levels depend) to the lowest level, which typically contains a list of alternatives. Employ a pair-wise comparison approach. Fundamental scale for pair-wise comparisons developed to solve this problem.
3. The pair-wise comparison matrix A, in which the element a_{ij} of the matrix is the relative importance of the i^{th} factor with respect to the j^{th} factor, could be calculated as

$$A = [A_{ij}] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{12} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{12}} & \cdots & 1 \end{bmatrix}$$

4. There are n (n-1)/judgments required for developing the set of matrices in step 3. Reciprocals are automatically assigned to each pair-wise comparison, where n is the matrix size.

Methodology

Problem Statement

Bharat Heavy Electrical Limited (BHEL), Tiruchirappalli, is the major thermal power Heavy Industry in India. The BHEL is itself established 70% of the thermal power plant equipment in the country. Hence BHEL outsources some non-pressure parts material from Micro, Small and Medium Scale enterprises around the BHEL, Tiruchirappalli complex. These MSMEs are contributed to BHEL is considerable. It is nearly 400 MSMEs are living and adopted by BHEL, Tiruchirappalli. But still, this sector is facing a number of problems and challenges like environmental legislation, inefficiency in supply chain networking, increasing competition in the home as well as global market, uncertainty in domestic market conditions, fund shortage and growth sustainability. A Detailed study on the internal & external barriers and drivers (Triple Bottom Line) for Sustainable manufacturing is to be conducted to find the impact of different factors and feasibility of implementation of the same in suppliers of the thermal power industry in Manufacturer's perspective. And based on the data, important factors can be selected and it can be used to rank the industries based on their implementation of these Sustainable Barriers.

Solution Methodology

Barriers

The factors affecting Sustainable Supply chain is divided into two those are Drivers and Barriers. Drivers are those factors which encourage the adoption of Sustainable Supply chain. Barriers are those factors which pose a problem from adopting the same.

These barriers are classifying into the following three categories in Table 1: -

1. Economical
2. Social
3. Environmental.

The MCDM Tool used

Analytic Hierarchy Process (AHP)

The analytic hierarchy process (AHP) is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology.

Pairwise comparison data

The Table2 gives pair wise comparison data for AHP and Fuzzy AHP tools. The Table gives pairwise comparison data between three broad classifications of barriers are Economic, social and environmental.

Observation and calculation

Step 1. The pair wise comparison was calculated between the three broad classifications of barriers Economic, Social, Environmental.

Step 2. By using AHP the broad classifications of the barriers are Ranked, That is defined in Table2.

Step 3.Again there are thirteen economic barriers are compared with the remaining twelve barriers and pair wise comparison matrix formed.

Step 4. AHP is used to rank the Economic barriers based on its own weight calculated as on.

Step 5. The same will be repeated for the total Ten Environmental and twenty-one social barriers are compared with Pairwise comparison and ranked by AHP.

Finally, Table 3 gives the top ranks of the Economic, social and Environmental Barriers.

Results and discussions

More than 70 BHEL suppliers have participated in this study, in which all were small and medium scale enterprises. The study is resulting in that 20 influential factors of SSCM are found and ranked at Table3.

The identified critical barriers are:

Economic - Cost of Implementation, Limited access to finance, Lack of Infrastructure, Lack of potential to save money and remain competitive, Lack of IT infrastructure, uncertain benefits, and Absence of Economic Incentive policies, Economies of scale and market share.

Social - Lack of preparation, lack of understanding and knowledge, Organizational Culture, Lack of Vision, Lack of data and standardization, Resistance to change.

Table 1 — Listed the Economical social and Environmental barriers

Economical	Social	Environmental
Lack of Tools	Lack of preparation	Environment
Cost of Implementation	Lack of understanding and knowledge	Environmental Issues
Lack of Infrastructure	Lack of data and Standardization	Lack of awareness of existing Environmental regulations
Uncertain benefits	Resistance to change	Low level of understanding of the principles of environment
Lack of IT infrastructure	Lack of vision	Being compliance – driven and reactive to environmental issues
Technology	Incorrect Implementation	Practices
Limited Access to Finance	Credibility and Ease of use	Lack of effective evaluation measures of CP
Size of the Company	Creativity and execution	Supply chain routes that are long and energy intensive
Competitive	Organizational Structure	Waste management
Economies of Scale and Market share	Organizational Culture	Lack of environmental awareness
Absence of Economic incentive policies	Technological Risk	
Too high cost for disposal of hazardous waste	Low Customer Demand	
Cost for environmentally friendly packaging	Uncertain future legislation	
	Weak Legislation	
	Law enforcement	
	Supplier Commitment	
	Ethics and policies	
	Market competition	
	Audits and Industry Standards	

Table 2 — Ranking the main Criteria using AHP

CriteriaVsCriteria	QDP	CC	RSST	Total	Root	WT	Rank
Eco	1	2	2	5	1.71	0.37	1
So	0.5	1	0.33	1.83	1.22	0.27	3
En	0.5	3	1	4.5	1.65	0.36	2
Total:		4.58					

Table 3 — Ranking the main Criteria using AHP

Economic	Social	Environmental	Ranking the Criteria
Cost of Implementation	Lack of preparation	Lack of Expertise and understanding of strategies to address environmental issues.	1
Limited access to Finance	Lack of understanding and knowledge	Lack of awareness of existing environmental regulations.	2
Lack of Infrastructure	Organizational culture	Lack of environmental awareness	3
Lack of potential to save money and remain competitive	Lack of vision		4
Lack of IT infrastructure	Lack of data and standardization		5
Uncertain Benefits	Resistance to change		6
The absence of Economic Incentive policies			7
Economies of scale and market share			8

Environmental - Lack of expertise and understanding of strategies to address environmental issues, Lack of awareness of existing environmental regulations, SME's perception that they have little individual impact on the environment, Lack of environmental awareness, being compliance - driven and reactive to environmental issues, SME's challenge to influence suppliers to improve environmental practices.

Conclusion

From the result, it has been calculated that the economic barriers are more significant than the social and environmental barriers. Using the above results, the critical barriers from each category are identified and included in a questionnaire. This questionnaire was sent to industries to rate them according to the amount of implementation of sustainability and supplier assortment will be the future research. Rankings and comparison of factors will be shared with the BHEL suppliers which in turn lead to a clear understanding of which factors to concentrate on while implementing Sustainable Supply chain. Furthermore, a study on the factors influencing Sustainable Supply chain will help in implementing Sustainable Supply chain even more efficiently. Also, the outcome of the study will help suppliers of BHEL in enhancing their understanding of sustainable supply chain practices.

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