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Performance Improvement in Indian Manufacturing Industries after Implementing Green Supply Chain Management

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Abstract

Green Supply Chain is used to reduce gas emission, solid waste emission, waste water emission, preserve the natural resources, decrease of consumption of toxic material, decrease the environmental disasters, better product quality and increase not only environmental performance but economic performance also. It reduces negative economic performance. Industries adopt various practices to improve performance. In this paper AHP is used for determining GSCM Practices and Performance with the help of parameters related to these. AHP has been conducted to get the importance of different practices (Internal environmental management system, Green packaging, Green purchasing, Eco designing, Internal recovery, Cooperation with customers) and to get the environmental performance, positive and negative economic performance in Indian manufacturing industries. AHP method has been applied to determine the priorities weightage of different parameters.

Keywords: Green Supply Chain, GSCM Practices, GSCM Performance, AHP

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1. Introduction

Supply chain management is a process to plan, implement, and control the operations of the supply-chain network[1]. It fulfill the requirements of customers as efficiently as possible[1]. The emission of harmful gases and waste are measure source of environmental problems including acid rain and global warming. Green supply chain policies are necessary for proactive strategic, reactive regulatory and competitive advantages[1]. GSCM integrates environmental thinking[2] into the Supply Chain Management (SCM). Researchers find out that Green Supply Chain Management practices consist eight major factors (Rituraj chandraker et.al. 2013). GSCM practices are implemented to improve the GSCM performances. Organization should follow GSCM practices like internal environmental management system, green purchasing, green packaging, internal recovery and eco designing to improve green performances such as environmental performance, positive and negative economic performances. GSCM practices includes mainly six factors as describe above and GSCM performance includes three major factors. Zhu and Sarkis[4] explain positive and negative economic impacts in the industries. Positive economic includes decrease in material purchasing cost, decrease in energy consumption cost, decrease in waste treatment cost, decrease in waste discharge fee and decrease in fine for environmental disaster. Negative economic includes increment in investment, increment in operational cost, increment in training cost and high cost of purchasing. Environmental performance includes reduction of gas emission, waste water emission, solid waste emission, reduction of use of toxic material etc. However, GSCM is considered as a relatively new idea, so with current data and experiences it is very difficult to find if in practice GSCM is providing better results to the industries involved[4]. In today's world scenario of high competition and environmental uncertainty, there should be flexibility in supply chain for the existence of any supply chain business in industry. (Rituraj Chandraker et. al. 2012).

In this paper AHP method is used to find out the importance of different practices and to get the improvement in performance of industries after implementing GSCM practices.

2. Literature Review

The objective of the study is to find out an approach based on the Fuzzy Analytical Hierarchical Process (FAHP) and

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balanced scorecard (BSC) to evaluate an IT department in the manufacturing company in Taiwan. Green et al.[7] construct a GSCM model that focus on green practices implemented by manufacturing industries. They wanted to know whether the GSCM practices would improve the performance of industries. In a study performed by Chien and Shih[9] on implementation of green practices in the electrical and electronic industries and their relation to industries performances, it was concluded that green manufacturing and green procurement can produced favorable environmental performance. ÖmürTosun et al.[8] in this paper, presents the relationship between green supply chain management and the environmental technologies. Wang[10] the authors set up the indicator system of overall performances evaluation on the green supply chain management from the operations, finance and environment of the supply chain using the SCOR model as a framework of GSCM. Chandraker et al.[3] evaluates and measures the performance of GSCM in Chhattisgarh manufacturing industries. In this paper MCDM (Multi Criteria decision making) is conducted to determine the GSCM performance with the help of the parameters related to GSCM performance. Sarkis[15] in this paper, discussed elements and components of the green supply chain management. The decision framework was designed and solved as ANP (analytical network process). This study aims to interactions, rank and weightage of CSF (critical success factors)of the green supply chain management in manufacturing firms. The AHP was applied to determine the relative importance and select the appropriate approach in green supply chain practice. According to Chatterjee et al.[12] increasing competition among the banks and liberalization of policies has motivated many institutions to involve in the banking business. Pang et al.[11] combined with supply chain management practices in Hunan Valin Xiangtan Iron and Steel Limited Corporation, by applying the green supply chain theory, on the basis of demonstrating the implication of environment-friendly green supply chain management, and constructs the corresponding index evaluation model by applying level fuzzy comprehensive appraisal.

3. Proposed Methodology

This paper investigates the GSCM practices adopting by industries i.e. IEMS, green purchasing, green packaging, ecodesigning, internal recovery and cooperation with customers. Now a days manufacturing supply chains are experiencing recycle, reuse of outer packaging, use ecological material for packaging, minimum use of material for packaging, sell excess inventory, sell waste scrape, sell excess equipment, purchase material from ISO 14000 certified supplier, conduct environmental audit, purchase environmental friendly product, make eco labelled product, publish white paper, cooperate with customers for ecodesign, cooperate for clean production etc. Environmental and economic performance improve after adopting these practices. These all factors are considered for implementation. This will definitely improve performance and long term benefits of industries. This will result more environmental friendly practices and enhance company's reputation.

The methodology expresses in following way:

1. Establish GSCM practices and performances factors on the basis of literature review.
2. Design the questionnaires which cover all the factors of GSCM practices and performances.
3. Collect the data from expert interviews.
4. Analyze the collecting data using AHP method.
5. Determine the priority weight of all the factors.
6. Find solution to define problem.

AHP method allows to access the importance of one factor over another factor. Therefore pairwise comparisons are appealing to users.

Table 1. Saaty's 9 point scale

N	1	2	3	4	5	6	7	8	9	10
RCI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

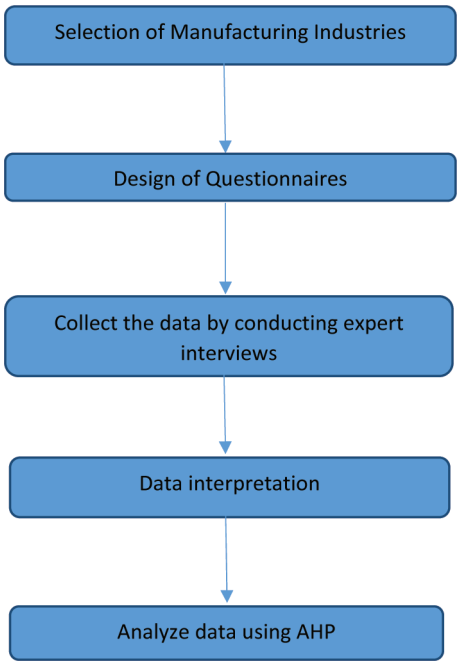

Figure 1. Detailed Methodology.

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AHP formulation:

Calculate the product of every line of judgment matrix element $M\,i$:

$$Mi = \prod_{j=1}^{n} xij, i, j = 1,2,\ldots n$$

$$W\,i = \sqrt[n]{Mi}$$

$$\overline{W}\,i = \overline{W}\,i / \sum_{j=1}^{n} \overline{W}\,j$$

Now perform the consistency test, if the test is not qualified, we need to revise the matrix. Then find out maximum Eigen value λmax i.e. approximately equal to Eigen value. Now determine consistency index CI = (λmax - M)/(M-1). The deviation from the consistency is smaller for small value of CI. Then obtain the Random Index (RI) for number of attributes used in decision making. Refer Table 3.1 in which the upper row is the order of the random matrix and the lower row is corresponding index of consistency for random judgments.

Finally calculate consistency ratio CR = CI/RI. If the value of CR is 0.1 or less, the result would be acceptable.

4. AHP Model

5. Result

In this section, using AHP method, as a frame work of GSCM, establish the overall performance evaluation on Green supply chain from environmental, positive and negative economic after implementing Green practices. Using the implementation of Green supply chain in Indian industries, we analyze that Green practices can improve overall performance of an industries.

5.1 AHP Method is used to Determine the Normalized Priorities Weight of Green Practices Factors

The weight of parameters are;

W1 = (0.07, 0.039, 0.189, 0.109, 0.45, 0.14), λmax = 6.6048, C.I = 0.1207, C.R = 0.097

C.R value is less than 10%, the matrix is acceptable. The priorities weightage is higher for cooperation with customers. It means it is most important factor for industries followed by green packaging, internal recovery, eco designing, IEMS and green purchasing.

5.1.1 AHP method is used to Determine the Normalized Priorities Weight of Cofactors of Internal Environmental Management System

W2 = (0.158, 0.317, 0.041, 0.317, 0.039, 0.125) , λmax = 6.205, C.I = 0.0411, C.R = 0.033

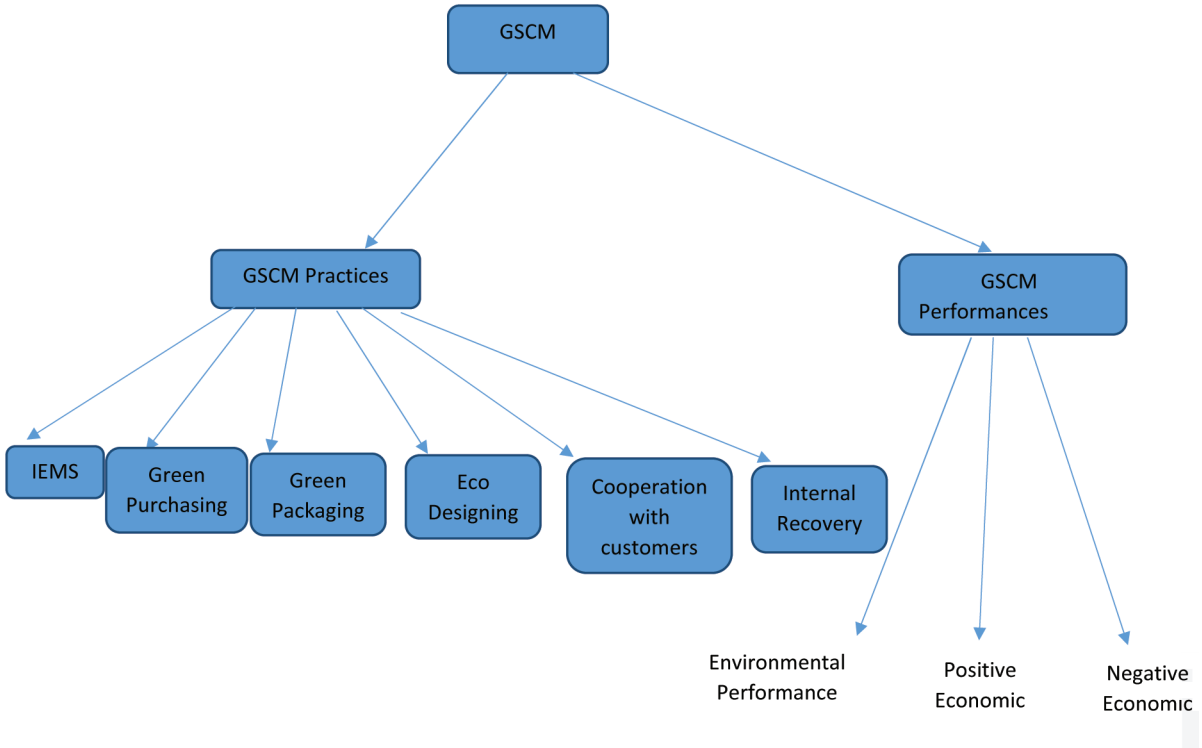

Figure 2. GSCM Practices and Performances AHP model.

	IEMS Purchasing	Green Packaging	Green Designing	Eco With Customers	Cooperation Recovery	Internal
IEMS	1	4	0.25	0.5	0.2	0.333
Gr. Pur.	0.25	1	0.2	0.25	0.2	0.333
Gr. Pack.	4	5	1	20.5	1	
Eco.Des.	2	4	0.5	10.333	0.5	
Coop. Cust.	5	5	2	3	1	2
Int. Rec.	3	3	1	2	0.5	1

	Support of Managers	ISO14001 Certified company	Makes Eco labelled products	Team to solve Environmental issues	Publish white paper	Training for Environmental Management
Support of managers	1	0.333	4	0.333	5	2
ISO14001 cert.. comp.	3	1	6	1	6	3
Makes eco labelled prod.	0.25	0.166	1	0.166	1	0.25
Team to solve env.issues	3	1	6	1	6	3
Publish white paper	0.2	0.166	1	0.166	1	0.2
Training for env. management	0.5	0.333	4	0.333	5	1

According to priorities weightage, companies focus more on two factors i.e. companies must be certified by ISO14001 and companies should have team to solve environmental issues. Industries are adopting these factors seriously.

5.1.2 AHP Method is used to Determine the Normalized Priorities Weight of Cofactors of Green Purchasing

W3 = (0.061, 0.362, 0.085, 0.316, 0.174), λmax = 5.11, C.I = 0.027, C.R = 0.024

According to obtained result, the industries focus more on cooperation with suppliers on environmental issues followed by purchasing environmental friendly product, consider environmental criteria for supplier selection, environmental audit for internal environmental management system and last one purchase of raw material from ISO14000 certified suppliers.

5.1.3 AHP Method is used to Determine the Normalized Priorities Weight of Cofactors of Green packaging

W4 = (0.209, 0.240, 0.549), λmax = 3.018, C.I = 0.009, C.R = 0.015

The most important cofactor of green packaging is minimum use of material for packaging with highest weightage. Industries focus on minimum use of material for packaging to adopt green practices.

5.1.4 AHP Method is used to Determine the Normalized Priorities Weight of Cofactors of Eco Designing/ Manufacturing

W5 = (0.158, 0.103, 0.377, 0.158, 0.158, 0.042), λmax = 6.169, C.I = 0.033, C.R = 0.026

The most important criteria with highest weightage is designing of product to reduce the use of hazardous material. The other important sub criteria are reduction of consumption of material for manufacturing, less energy consumption and minimum use of natural resources with almost same weightage.

5.1.5 AHP Method is used to Determine the Normalized Priorities Weight of Cofactors of Cooperation with Customers

W6 = (0.191, 0.355, 0.191, 0.191, 0.069), λmax = 5.019, C.I = 0.004, C.R = 0.004

	Purchase raw material from ISO14000 Certified suppliers	Cooperate with supplier for Environmental issues	Environmental audit for internal management of suppliers	Purchase Environmental Friendly product	Consider Environmental Criteria for suppliers selection
Purchase raw material from ISO14000 Certified suppliers	1	0.2	0.5	0.25	0.333
Cooperate with suppliers for Env. Issues	5	1	4	1	3
Env. audit for internal management of suppliers	2	0.25	1	0.25	0.333
Purchase Env. friendly product	4	1	4	1	2
Consider Env. Criteria For suppliers selection	3	0.333	3	0.5	1

	Recycle & Reuse of outer packaging	Use ecological material for packaging	Minimum use of material for packaging
Recycle & Reuse of outer packaging	1	1	0.333
Use ecological material for packaging	1	1	0.5
Minimum use of material for packaging	3	2	1

	Reduction of consumption of material for Manufacturing	Reuse, recycle, recover the components parts material	Design product to reduce use of hazardous material	Minimum use of natural resources	Less energy consumption use during manufacturing	Use renewableenergy resources for manufacturing
Reduction of consumption of material	1	2	0.333	1	1	4
Reuse, recycle the components parts material	0.5	1	0.333	0.5	0.5	4
Design product to reduce use of hazardous material	3	3	1	3	3	5
Min.use of natural resources	1	2	0.333	1	1	4
Less energy consumption in manufacturing	1	2	0.333	1	1	4
Use of renewableenergy resources for manufacturing	0.25	0.25	0.2	0. 25	0.25	1

	Cooperation with customers for Eco designing	Cooperation with customers for clean production	Cooperation with customers for green packaging	Cooperation with customers for green logistics	Cooperation with customers for reverse logistics
For eco design	1	0.5	1	1	3
For clean prod.	2	1	2	2	4
For green pack.	1	0.5	1	1	3
For green log.	1	0.5	1	1	3
For reverse log.	0.333	0.25	0.333	0.333	1

Industries focus more on cooperation with customers for clean production with 0.355 weightage. Industries focus least on reverse logistics.

5.1.6 AHP Method is used to Determine the Normalized Priorities Weight of Cofactors of Internal Recovery

W7 = (0.1, 0.673, 0.225), λmax = 3.085, C.I = 0.042, C.R= 0.073

According to the obtained result, manufacturing industries focus more on selling the waste scrape followed by selling excess equipment and excess inventory.

5.2 AHP Method is used to Determine the Normalized Priorities Weight of Green Performance Factors

W8 = (0.647, 0.122, 0.229), λmax = 3.003, C.I = 0.001, C.R = 0.003

Results show that the industries' performance is improving after implementing Green practices. The effect of Green practices is highest on environmental performance with highest weightage of 0.647. Economic performance is also improved.

5.2.1 AHP Method is used to Determine the Normalized Priorities Weight of Cofactors of Environmental Performance

W9 = (0.129, 0.24, 0.09, 0.281, 0.258), λmax = 5.076, C.I = 0.017, C.R = 0.017

According to normalized priority weight, there is reduction of use of toxic material, decrement in environmental disaster and reduction of waste water emission. Weightage are high for these factors.

	Sell excess inventory	Sell waste scrape	Sell excess equipment
Sell excess inventory	1	0.2	0.333
Sell waste scrape	5	1	4
Sell excess equipment	3	0.25	1

	Environmental	Negative economic	Positive economic
Environmental	1	5	3
Positive economic	0.2	1	0.5
Negative economic	0.333	2	1

5.2.2 AHP Method is used to Determine the Normalized Priorities Weight of Cofactors of Positive Economic Performance

W10 = (0.081, 0.457, 0.122, 0.092, 0.246), λmax = 5.044, C.I = 0.011, C.R = 0.009

There is a large decrement of energy consumption cost with highest weightage of 0.457 after adopting green practices. There is a decrement of fine for environmental disaster in industries. There is also small decrement in other cofactors like waste treatment cost, waste discharge fee and material purchasing cost.

5.2.3 AHP Method is used to Determine the Normalized Priorities Weight of Cofactors of Negative Economic Performance

W11 = (0.494, 0.072, 0.157, 0.275), λmax = 4.097, C.I = 0.025, C.R = 0.028

	Reduction of gas emission	Reduction of waste water emission	Reduction of solid waste emission	Reduction of use of toxic material	Decrease in environmental disaster
Reduction of gas emission	1	0.5	2	0.333	0.5
Reduction of waste water emission	2	1	2	1	1
Reduction of solid waste emission	0.5	0.5	1	0.333	0.333
Reduction of use of toxic material	3	1	3	1	1
Decrease in env. disaster	2	1	3	1	1

	Decrease in material Purchasing cost	Decrease in energy consumption cost	Decrease in waste treatment cost	Decrease in waste discharge fee	Decrease in fine for environmental disaster
Decrease in material Purchasing cost	1	0.2	0.5	1	0.333
Decrease in energy consumption cost	5	1	4	5	2
Decrease in waste treatment cost	2	0.25	1	1	0.5
Decrease in waste discharge fee	1	0.2	1	1	0.333
Decrease in fine for environmental disaster	3	0.5	2	3	1

	Increase in Investment	Increase in operational cost	Increase in training cost	Increase in cost of purchasing
Increase in investment	1	5	4	2
Increase in operational cost	0.2	1	0.333	0.25
Increase in training cost	0.25	3	1	0.5
Increase in cost of purchasing	0.5	4	2	1

Investments are increasing little bit after adopting green supply chain but profits are much more than investments. Overall the performance is improving and industries are getting more profit.

6. Conclusion

The evaluation of environmental performance and economic performance show all the current level of internal control. The performance of industries has been improved after adopting Green practices. There is a reduction of use of toxic materials, reduction of emission of solid waste and liquid waste. There is a decrement of energy consumption cost, waste treatment cost and material purchasing cost after implementing green supply chain. Fine for environmental disasters has been reduced. There is a little increment in investment but the overall performance improvement is more than negative economicafter implementing Green practices in manufacturing industries.

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