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An empirical study of green supply chain management in Indian perspective

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Abstract: This study aims to rank, interactions, and weightage of critical success factors (CSF) of the green supply chain management(GSCM) in Indian manufacturing sector. The approach of the present research includes a literature review, in depth interviews and questionnaire surveys. This study aims to recognize and select appropriate strategy for implementing GSCM in Indian manufacturing industry. Based on an extended literature review, various approaches were identified to determine their reliability and validity and were extracted into studied dimensions. The AHP was applied for determining relative importance and selecting appropriate approach in GSCM practice.

Keywords- Green supply chain management, reliability analysis, AHP methodology

1. Introduction

Green concept has been increasing in consciousness of the environmentalist in the last few decades. More people are aware of the world's environmental problems such as global warming, toxic substance usage, and decrease in non replenish resources. The Government has organised campaigns to make people aware of this concept. Several organizations responded to this by applying green principles, to their company, such as using environmental friendly raw material, reducing the usage of petroleum power, and using the recycle papers for packaging. The green principles were expanded to many departments within organization. Green supply chain management (GSCM) is modern Buzz ward emerging in 21st century. This idea covers every stage in manufacturing from the first to the last stage of product life cycle, i.e. from product design to recycle or retire. GSCM concept has ranged from green purchasing to integrated supply chains starting from supplier, to manufacturer, to customer and reverse logistics. Reverse logistics deals with the activities of the various processes which are necessary for returning waste material and used goods to their producer respectively resulting into the complete economic cycle compared to the traditional unidirectional flow economy. Closed loop economy implies savings of raw materials and energy of the input side and of landfill capacity on the output side, so that economic and ecological efficiency of the enterprises can be improved. This generates on one hand advances towards sustainable development on the other hand considerable cost reduction to some or even all of the enterprises involved.

Thus GSCM is a systematic integrated process, from raw material to finished product, upto customer to disposal, to protect environmental degradation and to improve productivity and profitability. The green productivity see a possibility of producing more environment friendly output from less inputs through clean manufacturing, yet enabling organizations to be free from legal or political restriction, mission of integrating economic development, social progress and ecological balance. Reducing waste and pollution,

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and using less energy and material resources, are obviously good for the environment, and are the best for supply chain because they cut operational costs.

The need of the hour is to analyze the behavior and inter-relations of these critical success factors (CSF) so that GSCM may be executed in business practices. The importance of these CSFs according their weightage makes the effectiveness in implementation of GSCM practices. Therefore, in this study, the CSF of greening the manufacturing supply chain has been analyzed by GSCM model, which helps to understand the interrelationships of the CSF and their levels. These CSFs are also categorized depending on their priority weightage. This study provides a statistical analysis of GSCM critical success factors by using pair wise comparison method of analytical hierarchy process (AHP).

2. Literature review

Literature review takes into consideration the broader concept of sustainable development and outlines how and why companies should be concerned with environmental and social issues in supply chain. The review suggests that this is mainly due to pressure from stakeholders and to enhance the company reputation as well as for competitive advantage reasons. Common benefits of GSCM in achieving sustainability are enhanced value for customers, cost reduction, increased operational efficiency and competitive advantage. The current trend in recent literature also indicates that a more cooperative model of SCM favors the environmental and social dimensions.

Although this environmental issue has been realized very important for business, its introduction to supply chain management has only been developed recently. The literature about environmentally conscious supply chain is very limited. In Earth Summit-1992, 'Sustainable Development' was the key concept and governments and international organizations take action to protect the environment as in integral part of long-term economic development (Bhateja, et al., 2011).

Many researchers (Zhu et al., 2005, 2007; Ninlawan et al., 2010;) studied Green supply chain management: pressures, practices and performance within the Chinese automobile industry and Thailand electronics industry. They observed that increasing pressures from a variety of directions improve both their economic and environmental performance. Zhu et al., (2005, 2007) also focused on different dimensions of practices including green procurement, internal environmental management, eco design, customer cooperation, and investment recovery. Hsu, and Hu (2008) studied the green supply chain management in the electronic industry in which they mentioned various approaches for implementing green supply chain management practices, nevertheless no investigation on reliability and validity of such approaches. Shang et al. (2010) and Walton et al. (1998) conducted a GSCM study based eco design, green manufacturing and packaging, environmental participation, green marketing, stock and suppliers. The results inferred that the firms which were focusing on green marketing had been successful competitors against the rivals. Hsu, and Hu (2008) used the fuzzy analytic hierarchy process method to prioritize the relative importance of dimensions. The findings indicate that enterprises would emphasize on supplier management performance in the crucial role of implementing green supply chain management. Lamming and Hampson (1996) explored the concepts of environmentally sound management and linked them to supply chain management practices such as vendor assessment, collaborative supply strategies, establishing environmental procurement policy and working with suppliers to enable improvements. In another study, researcher (Chien and Shih, 2007; Ninlawan et al., 2010; Kumar et al., 2012) works on the implementation of GSCM practices in electronics industry and provide in-depth study about green

procurement, green manufacturing, green distribution, and reverse logistics and investigate GSCM practices, measure GSCM performance, and explore GSCM pressure/ driver.

The researcher (Mudgal et al., 2009, 2010; Sarode, and Bhaskarwar, 2011) has identified the various variables which help in greening the supply chain of Indian manufacturing sector. They merely focused on top management commitment, societal concern for protection of natural environment, regulations, supplier involvement, customer satisfaction, EMS, employee involvement/empowerment, green product development, green procurement practices, availability of clean technology, green disposal, green transportation, 3R- reduce/ remanufacture/ recycle, lean manufacturing practices, economic interests, eco labelling of products, reverse logistics practices, competitiveness and corporate image. Many studies (Rao, 2002; Zhu and Sarkis, 2004; Zhu et al., 2005, 2007; Chien and Shih, 2007; Darnall et al, 2008; Holt and Ghobadian, 2009) mostly focusing on the same variables in manufacturing firms of China, Taiwan, and South-East Asia. Whilst Bowen et al. (2001) provide a useful summary on the benefits of GSCM practices. The perceived benefits of environmental management are also identified by authors such as Holt (1998) and Rao (2002).

In another aspect, Fengfei Zhu (2009) study on the implementation of GSCM in textile enterprises in which modern management mode consider the environmental influence and resource utilization efficiency and Benjamin et al. (2010) introducing green transportation costs in supply chain modeling. All these previous studies use subtly different constructs to measure or identify the external and internal drivers/benefits of environmental management or some aspects of GSCM.

Literature review shows that various investigations have proposed different approaches to implement GSCM (Lamming and Hampson, 1996; Lippmann, 1999; US-AEP, 1999; Bowen et al., 2001; Yuang and Kielkiewicz-Yuang, 2001; Rao, 2002; Evans and Johnson, 2005; Zhu et al., 2005). There have been far less research on identifying the consistency and priority approaches to GSCM implementation with the systematic analysis, particularly in manufacturing industry. This is because the complexity of GSCM practices, customer and cost pressures and regulation uncertainty. Implementing GSCM is considered as a thankless task that increases overall product cost.

The some researcher (Mudgal et al., 2009, Hsu, and Hu, 2008) has tried to overcome these limitations and provides a useful framework for GSCM study and activity flow required for successful implementation of GSCM practices. It cannot identify the degree to which the various CSF of GSCM present in the organization.

3. Research methodology

3.1 Reliability analysis

Reliability is defined as the extent to which a questionnaire, observation or any measurement procedure produces the same results on repeated trials. In short, it is the stability or consistency of scores over time or across raters (Carmines and Zeller, 1979). Internal consistency analysis was carried out to measure the reliability of the items under each critical factor using Cronbach's alpha. Cronbach alpha was used to estimate the proportion of variance that has been systematic or consistent in a set of test scores. It can range from 00.0 (if no variance is consistent) to 1.00 (if all variance is consistent) with all values between 00.0 and 1.00 also being possible. The acceptable value for Cronbach's alpha is greater than 0.6 (Wee and Quazi, 2005; Sarode and Bhaskarwar, 2011).

According to Allen and Yen (1979) the Cronbach's alpha (α) is compute by following formula.

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\Sigma Vi}{Var(X)}\right)$$

Where,

n = Number of items or Questions

Vi = Variance of scores on each item or question/sum of item variances

$Var(X)$ = Composite variance

High alpha is good and high alpha is caused by high variance.

The standard error of measurement (SEM) is an additional reliability statistic. The SEM's usefulness arises from the fact that it provides an estimate of how much variability in actual test score points you can expect around a particular cut-point due to unreliable variance (Brown, 2002). The standard error of measurement (SEM) is calculated by following formulae:

$$SEM = STDEV(X) * [\sqrt{1-\alpha}]$$

or

$$SEM = \sqrt{Vi}$$

Where,

$STDEV(X)$ = Composite Standard Deviation

α = Cronbach's alpha

Vi=Sum of item variances

3.2 AHP analysis

In this stage, the data collection and analysis was made through the lens of AHP methodology. The CSF prioritization for examination of model was the next step for achieving the research objective. In AHP analysis, comparing the criterions and defining their importance over each other was done using the pair-wise comparison method (PCM). For creating the pair-wise comparison matrix in the PCM, T. L. Saaty has employed a system of numbers i.e. Satty's scale to indicate how much one criterion is more important than the other. The AHP method employs different techniques to determine the final weights; one of the methods is geometric mean. According to Buckley (1985) the weights in pair-wise comparison matrix of attributes are calculated by following formula.

$$r_i = \prod_{j=1}^{n} (a_{ij})^{1/n}$$

Where,

r_i = represents the geometric mean of $_i$th criterion at which a_{ij} (i, j= 1……..n) are the comparison ratios in the pair-wise comparison matrix and

n = is number of alternatives or factors

The relative priority of each criterion or weightage is then calculated by normalizing this column by dividing each value by the total of the column (or the sum of the geometric mean values).

$$w_i = \frac{r_i}{\sum_j r_j}$$

Where,

w_i = represents the relative priority of $_i^{th}$ criterion

A measure of how far a matrix is from consistency is performed by CR. Han and Tsay (1998) explained that having the value of λ_{max} (maximum eigenvector or relative weights) required in calculating the CR. Then, the consistency index (CI) for each matrix order n is computed by using following Equation.

$$CI = \frac{\lambda max - n}{n - 1}$$

Where, λ_{max} = is the biggest eigenvalue at which *n* is the number of criteria
RI is the consistency index of a pair-wise comparison matrix which is generated randomly. The final CR is calculated by comparing the CI with the RI (Malczewski, 1999).

$$CR = \frac{CI}{RI}$$

The CR is designed such a way that shows a reasonable level of consistency in the pair-wise comparisons if CR $\leq$ 0.10 and if C.R. $\geq$ 0.10 indicate inconsistent judgments. If CR more than 0.1 or 10% the inconsistency of judgments within that matrix has occurred and the evaluation process should therefore be reviewed, reconsidered and improved. The final weightages of CSFs were calculated by taking mean of the eight responses. To test the accuracy of the responses, student's *t*-distribution were used, as the sample size is less than thirty.

4. Data analysis and result

The various factors on environmental practices proposed by different authors were organized into a set of fifteen performance measure i.e. critical success factors and 113 sub factors of GSCM, which shown in Table 1. An attempt was made to consolidate these all factors in fifteen critical success factors which affecting GSCM implementation. These CSF's are derived from a review of an existing literature and empirical evidence based on practitioner's reflections.

Table 1: Critical success factors and subfactors

S.N.	GSCM- Critical success factors	
1.	TMC	Top management commitment
	1.1	Top management assumes commitment and responsibilities for GSCM
	1.2	Top management supports long term GSCM process
	1.3	Top management supports prefers GSCM over budget schedule
	1.4	Top management assumes that GSCM is a way to increase profit
	1.5	Top management plays key role for resource allocation for GSCM
	1.6	Top management monitor the process of GSCM
	1.7	Top management ready to accept change to facilitate GSCM process
2.	GPR	Government policies and regulations
	2.1	Regulation are still the most prevalent pressure for GSCM throughout the globe
	2.2	There may be possibility of firm to be thrown out of business if not comply with the regulation or deny it
	2.3	Extent to which regional environmental regulations adopted by firm
	2.4	Extent to which international environmental regulations adopted by firm
	2.5	Properly design environmental regulation can improve firm performance

	2.6	Firms have to constantly strive to meet current and upcoming environmental regulations
3.	EoL	Eco-literacy amongst supply chain partners or team responsibility for GSCM
	3.1	Need and role of employee team responsible for GSCM
	3.1.1	Dedicated GSCM team is required for GSCM implementation
	3.1.2	GSCM implementation is responsibility of all department in organization
	3.1.3	Empowerment and autonomy should be given to GSCM team
	3.1.4	Effectiveness of GSCM awareness measures among employees
	3.2	Supplier involvement
	3.2.1	Supplier assessment/ rating system should be there
	3.2.2	ISO 14000 certified suppliers should be given preference
	3.2.3	Supplier selection based on green practices rather than price or schedule
	3.2.4	Supplier responsiveness/ readiness for changes for green
	3.2.5	Technical assistance to improve the green quality and responsiveness of supplier
	3.2.6	Suppliers involvement in GSCM improvement / development process
	3.2.7	Poor supplier performance may affect the overall GSCM system
	3.2.8	Supplier- Manufacturer relationship are considerable for GSCM success
4.	PWM	Proper workplace, employee involvement management
	4.1	Do work at their allotted workplace
	4.2	Degree of participation in GSCM decisions by non supervisory employee
	4.3	Employee rewards system for innovative ideas to improve GSCM
	4.4	Top management pushes decision making to the lowest practical level
	4.5	Workers encourage to understand housekeeping management
	4.6	Workers are authorized to inspect their own work (self analysis)
5.	GPD	Green product development
	5.1	It involves creating product whose design, composition and usage minimize adverse impact on environment
	5.2	It adopts a preventive approach and integrates environmental concerns into the product life cycle
	5.3	It includes design for disassembly, remanufacturing and recycling
	5.4	It involves details review of product design before product service or marketed
	5.5	It involves analysis of customer requirement in product development
	5.6	Concerning peoples must consider green as saleable attribute
6.	GPP	Green procurement practices
	6.1	Procurement of products and services that have no adverse effect on environment
	6.2	Green procurement improves the organizations environmental performance
	6.3	Green purchasing reduces overall cost, weight, energy
	6.4	Allow an organization to offset financial and environmental risk
	6.5	It improves supplier manufacturers relationship
	6.6	Collect environmental information on product and supplier
	6.7	Analysis of product from mining of raw material to disposal
7.	ACT	Availability of clean technology
	7.1	Development of innovative technology and manufacturing process
	7.2	Adopting automation in production helps GSCM
	7.3	Feedback system for green practices for employee performance
	7.4	Green innovation results in products with environmental neutral attributes
	7.5	Development of environmental friendly product design and packaging
	7.6	Green innovation reduced the resource need and cost and fulfills the fundamental goal of better, cheaper and faster
8.	EIB	Economic interests and benefits from GSCM
	8.1	Financial performance of firm is affected by environmental performance
	8.2	Improved environmental performance of firm leads to improve market share and revenue
	8.3	Waste minimization, better resource utilization, improved efficiency and productivity ultimately reduces operating cost enhance profit

	8.4	New market opportunities due to GSCM led to economic benefits
	8.5	At the end of the day GSCM comes at no cost
9.	ELP	Green packaging or Eco-labelling of products
	9.1	Integrating environmental thinking and innovation in packaging
	9.2	Utilization of packing material which is having minimum or no environmental impact
	9.3	It leads to innovative thinking in eco-labelling of products or packaging
	9.4	Use of recycled material in packaging
	9.5	Elimination of hazardous chemical and toxic material from packaging
	9.6	Reduction in packaging weight
	9.7	Packaging material and its disposal should be environmental friendly
	9.8	Waste or scrap of one product may be used as packaging material for another product
10.	RLP	Reverse logistics practices
	10.1	After end of life, the product should be returned by end user to reverse leg of loop
	10.2	Companies need to realize the hidden value in RL and need to focus this area
	10.3	RL includes recycle and reuse of material along with Green packaging
	10.4	It includes environmental friendly methods of product recovery
	10.5	RL program reduces the consumption of virgin material
11.	LMP	Lean manufacturing practices
	11.1	Company specific GSCM training program should be there
	11.2	Program to develop team spirit and mutual coordination for GSCM
	11.3	Training of advance statistic techniques (Such as LCA,ISM, etc)
	11.4	Availability of resources for employee training in company
	11.5	Problem identification and solving technique training is provided
	11.6	Motivate employee thinking for ideas and innovation
	11.7	Extent to which employee satisfied with training program
	11.8	Participation of employee as trainer
12.	EMS	Environmental management system (EMS)- ISO: 14001 Certification
	12.1	The Certification to ISO: 14001 EMS helps to boost company image
	12.2	EMS Certification is a mechanism for higher profit
	12.3	EMS Certification leads to about good business sense
	12.4	ISO:14001 Certification is legitimate indicator of organizations practices
13.	COM	Competitiveness
	13.1	Companies would like to brand themselves with a green image
	13.2	Growing pressure on manufacturing firm to become more environment responsible
	13.3	Going green should be an integral part of manufacturing process
	13.4	Green image reflects positively over the financial status of firm
	13.5	Consumer awareness for green forced company to adopt green
14.	CSI	Customer satisfaction and involvement through environmental performance
	14.1	Conducting customer meeting for GSCM issue
	14.2	Interaction with customers
	14.3	Feedback on green product, cost, and GSCM
	14.4	Survey on customer requirement for green
	14.5	Response to customer needs
15.	SCP	Societal concern for protection of natural environment
	15.1	Green Disposal
	15.1.1	Green disposal integrates environmental thinking into disposal activity
	15.1.2	It reduces release of toxic substance in product life
	15.1.3	It includes end of life treatment i.e. recycling, reusing, refurbishing etc.
	15.1.4	Problem faces during disposal led to green consciousness
	15.1.5	Source reduction/ pollution prevention strategy led to green design
	15.1.6	Industry should focus alternative efforts to minimize disposal
		Green Transportation
	15.2.1	Mode of transportation should cause minimum environmental impact
	15.2.2	Fuel efficient transportation system must get performance
	15.2.3	Environmental friendly vehicle's (Electric/Solar/Hybrid type) should be used

	15.2.4	Reduction of green house gases through transportation
	15.2.5	Use gravity for wherever possible
		Green Process- Practice
	15.3.1	Industries should practice green processes so as to improve environment outcomes
	15.3.2	Elimination unnecessary steps in production process
	15.3.3	GSCM practices institutes better controls on operating conditions
	15.3.4	Production processes are examined to reduce the amount of waste, energy consumption and emission
	15.3.5	Optimum utilization of available resources through green practices
	15.3.6	Changes in existing operating practices reduce environmental impact
		Reduce/ Remanufacture/ Recycle (3R)
	15.4.1	Reducing the mining and consumption of virgin material
	15.4.2	Reducing the waste at the source will enhance GSCM process
	15.4.3	Recycling activities is carried out to ensure full usage of resources
	15.4.4	Implementation of these activities enhance the profitability of firm
	15.4.5	Recycling should be consider as integral part of processing
	15.4.6	Remanufacturing itself creates a new industry generating employment opportunity

4.1 Reliability analysis result

The sub-factors which were advocated by these studies are scored dichotomously by randomly selected eighteen numbers of experts in the field of GSCM. The score sheet and internal consistency analysis result of each critical factor are calculated. The internal consistency analysis result for the performance measures of GSCM is as shown in Table 2.

Table 4.2: Internal consistency analysis result for the performance measures of GSCM

S.No	Performance Measures of GSCM		Total No. of items	Cronbach's alpha (α)
1.	Top management commitment		07	0.864
2.	Government policies and regulations		06	0.662
3.	Eco-literacy amongst supply chain partners or team responsibility for GSCM			
	3.1	Need and role of employee team responsible for GSCM	04	0.692
	3.2	Supplier involvement	08	0.883
4.	Proper workplace, employee involvement management		06	0.745
5.	Green product development		06	0.776
6.	Green procurement practices		07	0.710
7.	Availability of clean technology		06	0.763
8.	Economic interests and benefits from GSCM		05	0.712
9.	Green packaging or Eco-labelling of products		08	0.785
10.	Reverse logistics practices		05	0.717
11.	Lean manufacturing practices		08	0.750
12.	Environmental management system (EMS)- ISO: 14001		04	0.645
13.	Competitiveness		05	0.677
14.	Customer satisfaction and involvement through envi. performance		05	0.672
15.	Societal concern for protection of natural environment			
	15.1	Green Disposal	06	0.773
	15.2	Green Transportation	05	0.807
	15.3	Green Process- Practice	06	0.659
	15.4	Reduce/ Remanufacture/ Recycle (3R)	06	0.683

4.2 AHP Analysis Result

In this section, the consistencies of the responses were determined by calculating a consistency ratio (CR) for each response. The final weightages of CSFs were calculated by taking mean of the eight responses (eight randomly selected experts). To test the accuracy of the responses, student's *t*-distribution were used, as the sample size is less than thirty. The Saaty's fundamental scale of absolute numbers is used for pair-wise comparison matrix.

The relative priorities for CSFs in the response each respondent and value of CR are calculated. The summary of mean weightage of CSF from the response of Indian manufacturing industry with value of *t*-distribution is shown in Table 3.

Table 3: Weightage of critical success factors of proposed GSCM model

GSCM- Model CSF		Final Weightage	Identified Weightage In the scale of 0-1000	Rank
TMC	Top management commitment	0.200	200	1
SCP	Societal concern for protection of Natural environment	0.181	181	2
GPR	Government policies and regulations	0.134	134	3
EoL	Eco-literacy amongst SCM partners	0.100	100	4
CSI	Customer satisfaction through environmental performance	0.085	85	5
EMS	Environmental Management System (ISO: 14001)	0.065	65	6
PWM	Proper workplace management: housekeeping practices	0.045	45	7
GPD	Green product development	0.036	36	8
GPP	Green procurement practices	0.035	35	9
ACT	Availability of clean technology	0.028	28	10
LMP	Lean manufacturing practices	0.027	27	11
EIB	Economic interests	0.017	17	12
ELP	Eco-labelling of products	0.016	16	13
RLP	Reverse logistics practices	0.016	16	14
COM	Competitiveness	0.015	15	15
Total			**1000**	

5. Conclusion

This study aims to examine the measurement model of GSCM practices implementation focusing on nineteen performance measure factors with 113 underlying dimensions. Statistical tests showed that the identified factors were reliable. The reliability scores i.e. α were quite high for all of the nineteen factors considered under fifteen critical success factors, ranging from 0.645 to 0.883. Hence, it was concluded that all the items had been properly assigned to their respective scales.

The Table 4.3 shows the final weightage and ranks of each critical factor. Top management commitment (TMC) has got highest weightage (0.201) and ranked first. Societal concern for protection of natural environment has got second highest weightage (0.182). Competitiveness (0.015), Eco-labelling of products

(0.016) and Reverse logistics practices (0.016) has got lowest weightage. The index value of each component makes it very clear where the improvement is needed. So this model not only compares the overall GSCM performance, but also guide for the improvement programme.

The central purpose of this study is to establish the consistency and priority approaches for implementing GSCM in response to critical success factors. The analytic hierarchy process (AHP), which is applied to conduct the relative importance of different approaches, is extremely crucial, since the results can be used by managers implementing and adopting their own GSCM practices. This study is limited to Indian manufacturing industries only; nevertheless it can be extended to meet the need of the special category of industries after identification of the key critical success factors.

This developed model is simple to understand and operate and will definitely help to manufacturing industries in their journey of GSCM.

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