Exploring Green supply chain performance measures framework for Indian Manufacturing Practices

Sadia Samar Ali, Associate Professor : OM& QT
New Delhi Institute of Management, Tughlakabad Institutional Area
New Delhi 110062, India
Ph: (Off.) +91 11-40111000 (Mob.) +91 9650691133

Abstract:

The world has come a long way from the time of abundant and affordable energy to a time of limited and expensive energy. It is the need of the hour to preserve the lead resources and in the wake of the need for environmental protection, logistics and supply chain managers are required to reduce costs while maintaining good environmental performance standards.

Manufacturing firms around the globe are opting for cradle to cradle products that are more energy efficient and environmental friendly. Henceforth, it is now essential that all processes in the supply chain rely on resources that are cost effective and incur minimum cost possible.

Researchers started on focusing on the green supply chain management (GrSCM), reverse logistics, in particular, closed-loop logistics in the wake of the growing concerns about global warming and alarming consistent increase in amount of e-waste (comprising majorly of end-of-life ,EoL) electronic and electrical products. Green supply chain management GrSCM ensures the optimal use of resources by integrating the concept of disposal, recycling, reusing or remanufacturing of the product or its parts (Lund 1984).

Here researcher has done literature review to derive research objectives to further develop a theoretical framework on identified constructs that are under-going for Green Supply Chain Management practices with the effect of environmental aspects on supply chain management. The purpose of this paper is to explore the antecedents of Indian firms practicing green supply chain management on firm performance in terms of tangible performance measures (i.e. Business performance) and intangible performance measure (i.e. environmental performance).

Keywords-Green supply chain management, Indian manufacturing industries, practices

1. Introduction: Indian Manufacturing Sector

The majority of the Indian work forces are earning their livelihood through low-wage agriculture. The 'Indian Manufacturing' sector has the potential to raise much of the Indian population above poverty.Manufacturing sector fuels growth, productivity, employment, and also strengthens service sectors and agriculture. So the backbone of the economy is manufacturing sector. Considering the contrast to trends in emerging economies worldwide with a strong manufacturing bias, stagnation has been noted in the contribution of Indian manufacturing to the national GDP over the last few years by around 15 per cent in-spite of the growth in the manufacturing sector per se. The comparable economics of countries such as China (39.3 per cent), Thailand (35.2 per cent), Malaysia (31.1 per cent), Indonesia (24.7 per cent) and Vietnam (20.8 per cent) is much higher when benchmarked with current contribution level of India. The manufacturing capacities of these countries have been boosted because of needed leveraging of infrastructure and

competitive advantages (Mc Kinsey Report 2012). Thus a great impetus has been provided to their GDP growth. **Services sector** in case of India has made contribution and impetus towards growth of GDP. It has been a cause of concern how to increase the Indian manufacturing sector contribution to the national GDP. For this a strong manufacturing base in both the *commodity* and *high value goods* is required to sustain economic growth trajectory together with employment. It means that 'Manufacturing sector is required to sustain economic growth trajectory together with employment. Manufacturing sector is required to grow at a faster rate than the national GDP. In this regard it is mentioned GDP's share of manufacturing industry has grown from *25.38% in 1991 to 27% in 2004* increasing the exports from 52% in 1970 to 59% in 1980 and *71% in 1990, 77% in 2000-01*. The value of output accounted for a little over 5% of the output of the manufacturing sector in 1990 and is now estimated close to 10% with a worth of about $50 billion. The forecast is growth of 17% crossing the $300 billion mark by 2015(Planning Commission Report 2012). Auto components, pharmaceutical, apparel, specialty chemicals, and electrical and electronic equipment sectors would constitute most of this off-shoring business.

There are approximately *53 lakhs unit* in the manufacturing sector of India comprising of micro, small and medium enterprises, *spread across 2,000 manufacturing clusters* across India. An important component of *foundation layer of entrepreneurial activities in India is Small Scale Industrial (SSI).* These firms have 4.6 employees on average per unit employment and play a key role in employment generation.

About *75 per cent of total number of units* in the manufacturing sector are engaged in *Food & beverages, textiles, non-metallic mineral products, chemical products and machinery & equipment* and are top 5 verticals in terms of number of units.

There have been significant success stories in various pockets of the manufacturing sector, in the recent past. Few of the verticals of the *Indian manufacturing sector* have been able to make a global impact. Auto industry is one such example. The industry is becoming globally competitive but India is getting recognized as an *innovation hub* [19] for small cars for many of the global and Indian auto majors. For India to enter and sustain a strong growth trajectory it is important to be replicated by other verticals.

It is unfortunate that a majority of the firms in the Indian manufacturing sector still continue to go along in a cycle of *low productivity* and *low value-add* products in comparison to countries which are comparable when we compare manufacturing value added per capita in India, it is only *USD 83 compared to USD 496 in **China**, USD 749 in **Brazil** and USD 1,001 in **Mexico*** (Mc Kinsey Report 2012

Manufacturing has been identified as area of focus in most 5 year plans. However in the last couple of decades, the industry has witnessed a phase of stagnation and showing marginal increase in its contribution to the GDP. Over the last couple of decades the annual growth rate varies between 2.5 per cent to 12 per cent (Planning Commission Report 2012).

Stupendous growth of global manufacturing networks has shown astronomical growth in worldwide distribution systems and IT together with opening of trade barriers. The Central Pollution Control Board has identified seventeen highly polluting industries, the majority of which are manufacturing industries(National Productivity Council 2006) .The MSMEs in India, can have a significant impact on the environment as they are generally liable to be equipped with

obsolete, inefficient and polluting technologies and processes. More than70% of the total industrial pollution load of India is attributed to MSMEs. New technologies leading to cleaner processes and operations are not being developed at a fast enough pace to address the urgent need for environmental protection. The current ecosystem does not encourage and facilitate the mainstreaming and scaling up of new technologies for widespread use mainly due to a lack of financial support, resources and government assistance. The waste management and recycling industry in India is currently vast but largely unorganized (Min and Galle 2001). In this space, it is necessary to mainstream the industry and ensure that the livelihoods of all people dependent on this industry are supported and upgraded (Porter and Linde 1995; Raghavendran , Xavier and Israel 2012; Sarkis 2003; Seuring and Muller 2008, Carter and Rogers 2008, Zhu , Sarkis and Lai 2007 Lammings *et al* 1999).

2. Green Supply Chain Management

Manufacturing sector is associated with intensive use of resources and with time the rate of material use is increasing which leads to diverse impact on environment (Giovann 2012). The contribution of the manufacturing sector to environmental degradation basically occurs during the following stages: procurement, industrial operations, product use and disposal (Giovann 2012, Singh *et al* 2011) . According to (Porter and Linde 1995); investing in greening can actually help the organizations in resource saving, waste eliminating and productivity improving (Krikke *et al* 2003). Green Supply Chain Management, GrSCM has emerged in the last few years as a result of firm wanting to make their businesses environmentally sustainable (Jackson 2010), hence, it is mandatory to design GrSCM in such a way so that it can take care of ecological burden [8]. To ease this burden it becomes necessary to use appropriate material and requisite technologies. The industrial process which converts and restores worn-out products to like new condition is part of industrial products (Scfoenherr 2012). A company must decide to adopt environmental management system to improve its environmental performance. Performance measurement is the process of quantifying the effectiveness and efficiency of action (Wong *et al* 2011, Zhu, Sarkis and Lai 2007). The trade-off can be achieved between the economic growth and the sustainability of the environment with the company. Research has indicated a positive outcome of measuring the performance of supply chain as it leads to better understanding of the supply chain and the factors which have positive influence on it [99]. A range of focus and purpose from reactive monitoring to proactive practice aspects on green supply chain management has been covered, including GrSCM drivers and/or pressures and GrSCM practice in [Zhu *et al* 2008; Zhu and Sarkis 2007, Wong *et al* 2012) . There are various explanations given by (Solvang *et al* 2007) as to why firms should engage in GrSCM activities. Besides overall environmental improvement, (; suggests that large firms have to meet stakeholder pressure beyond legal environmental responsibilities and many suppliers are under considerable pressures from their customers (Hart 1995). According to (Yang and Sheu 2011), there are five critical environmental stakeholder groups:

- Regulatory stakeholders, which set regulations or can, convince government to set standards;
- Organizational stakeholders, who are directly related to an organization and can affect the company financially;

- Community groups, environmental organizations and other lobbies who can change public opinion for or against a firm's environmental policies;
- The media, which can influence the public perception of a specific firm; and
- Customers, which are the most vital stakeholders of any companies.

The pressure faced by organizations differs, and not being the same (Zhu and Sarkis 2007) and varies according to industry, sectors and country (Zhu *et al* 2008). According to (Zhu and Sarkis 2007) ,five GSCM practices can be used to improve their performance, including internal environmental management, green purchasing, and cooperation with customers, investment recovery, and eco-design practices. These GrSCM practices are integrated into each other and need cross-functional cooperation. Internal environmental management is most significant for the improvement of enterprises' performance (Melnyk et al., 2002). Large customers can impose pressures on their suppliers with requirements of better environmental performance (Lenox *et al* 2000). For environmental objectives, the companies and enterprises need to cooperate with customers [99]. Early stages of a product's supply chain are related to green purchasing (Yang and Sheu2011) and eco-design focus on the inbound(Jackson 2010; Gangela and Verma 2011; Porter and Linde 1995). The critical impact for GrSCM practices in United States and Europe is investment recovery. But in India investment recovery is not considered important compared to developed countries (Zhu 2009).Organizations need to ensure their green operations throughout. Increasingly environmentally selectively consumers are looking for organizations to make sweeping changes to cut carbon emission now [Zhu and Sarkis 2007; Hoffman 2007, Li *et al* 2006].

3. Literature Review

Green supply chain management (GSCM) has emerged as an important new innovation that gives organizations a 'wining' strategy to lowers environmental risks and impacts, at time ecological efficiency (Shrivastava 1995); is raised. The supply chain in India does not have rigorous investigation of environmental sustainability issues (Ish and Datta 2011). The overview of drivers, GSCM practices and performances issues have been provided in this study. The topic itself encompasses many sources including procurement, marketing, distribution and operational management. It also includes customer supplier relationship, delivery times, inventory management, product life cycle assessment etc. The main purpose of the literature review is to understand the pressures and practices prevalent in Indian system, the roadblocks to GrSCM and ultimately how green supply chain practices within an organization can be the source of competitive advantage in general and particularly in Indian manufacturing sector and how in the past various researcher(s) have carried out study to understand the secret behind GrSCM practices by which organizations has been benefited and what are the studies carried out in this direction so far. Thus, the author brings forward a proposed research direction on GrSCM adoption and implementation in Indian firms.

In order to understand the evolution of research related to GrSCM practices, researcher has reviewed latest papers published in *Journal of Cleaner Production, International Journal of Production Economics, Supply Chain Management: An International Journal, International Journal of Logistics, International Journal of Logistics Management, International Journal of Production Research, Production Planning and Control, International Journal*

of Operations and Production Management, Benchmarking: An International Journal, International Journal of Physical Distribution and Logistics Management, Journal of Operations Management, Transportation Research-A, International Journal of Services and Operations Management and other referred Scopus indexed publications.

To begin with researcher in the initial stage identified 116 papers between 2001 to 2013.Out of which relevant papers related to present research researcher has presented in tabular form so that research findings can be concluded from each research objectives in Table 2.1.

Table1: Research in Green Supply Chain Management

Author(s),Year	Research Objective	Research findings
Seman. et al (2012)	To review the recent literatures of GSCM and determine the new research direction of this emerging field.	Authors bring forward a proposed research direction on GSCM adoption and implementation
Kumar and Chandrakar (2012)	To study the correlation of two major factors, i.e. organizational learning and management support in GSCM adoption in Indian manufacturing industries.	Significant positive relationships exists between organizational learning and management support with respect to GSCM adoption
Luthra, et.al, (2012)	To identify the important factors to implement GSCM relevant to Indian manufacturing industry.	1. Innovative green practices, 2.Awareness level of customers 3. Supplier Motivation 4. Technology advancement and organization adoption, Organization encouragement, Quality of human resources 5. IT enablement 6. Top management commitment 7. Government support policies 8. International Environmental agreements
Bhateja, et.al, (2012)	To identify the critical factors related to evaluation of GSCM performance measurement in Indian manufacturing industry.	A. Green Purchasing 1. Substitute for hazardous material 2. Improved quality of raw material

		3. Minimal usage of raw material 4. Supplier Development 5. Reduced Resource B. Green Manufacturing 1. Process Design 2. Product Design 3. Higher Efficiency 4. Employee Satisfaction
Pandya,et al., (2012)	To explore external factors affecting GSCM and understand the relationship between the GSCM practices and environmental performance and operational performance as well as financial performance in the context of Indian pharmaceutical industry.	**Pressures/Drivers:** Environmental regulations, suppliers, consumers and community stakeholders GSCM practices can enhance the environmental, operational and financial performance of firms.
Bhateja, et.al, (2011)	To study the activities of the supply chain process of various Indian manufacturing industries and evaluate their degree of greenness for the purpose of measuring performance.	51% of manufacturing industries feels that lack of awareness of environmental issues is the biggest issue facing manufacturing sectors. 36% of manufacturing industries have plans to implement GCSM initiatives within two years. 40% of companies use electronic processes to create efficiencies in procurement. 32% of companies are having active discussions regarding collaborating to reduce impact on environment. 64% of companies are not using e-tools extensively to support their supply chain operations. The biggest perceived barrier to adopting GSCM is that it is not cost effective.
Duarte, et al. (2011)	To develop a conceptual model incorporating lean and green supply	Linking performance measurement system to

	chain into performance measurement system using BSC approach.	green/lean practices can benefit firms for better positioning to succeed in their supply chain initiatives.
Dües CM.,et al., (2011)	To explore and evaluate previous work focusing on the relationship and links between Lean and Green supply chain management practices.	Lean is beneficial for Green practices and the implementation of Green practices in turn also has a positive influence on existing Lean business practices
Gangele and Verma (2011)	To survey current green practices in Indian pharmaceutical manufacturers and GSCM evaluation.	Environmental management systems are given top attention than Green Purchasing, Customer Cooperation, Investment Recovery and Eco-Design is given low priority. Influence of GSCM on Performance factors such as Environmental and positive economic are relatively significant. Top two GSCM drivers are Pressure from environmental regulations and export pressure.
Luthra, et.al, (2011)	To develop a structural model using Interpretive Structural Modeling of the barriers to GSCM implementation in Indian automobile industry.	Eleven variables were identified from literature review and expert opinions **Top Level Barriers:** Market competition and uncertainty; Lack of implementing green practices; Cost implications; Unawareness of customers **Bottom Level Barriers:** Lack of government support systems
Singh, et al., (2011)	To assess the role of logistics & transportation in GSCM in the context of Indian retail industry.	Technological integration with primary suppliers and with major customers was positively linked to environmental

		monitoring and environmental collaboration. However logistical integration only has an impact on GSCM with primary suppliers but not with the major customers.
Shukla, A.C, et al., (2009)	To identify implementation level, major drivers, various practices and performance of environmentally and socially conscious SCM in the context of Indian automobile industry	Environmentally and socially responsive supply chains are in the early adoption stages in India. Actual implementation lacks a holistic approach
Soler et al., (2010)	To describe the use of environmental information at different stages of the Swedish food supply chain	Consumer must be perceived as close to supply chain actors, enabling a correct transaction of consumer preferences into relevant green supply chain practice to avoid distortion of information.
Yung, et al., (2011)	To examine the impact of environmental regulations on green supply chain management.	1. EU directives foster green partnerships among manufacturing firms of all sizes located at different positions in international supply chains 2. Firms environmental management strategy affects its regulation compliance practices
Darnall et al., (2008)	To empirically evaluate the relationship between EMS and GSCM practices	Environmental management systems are more likely to adopt GSCM practices.
Simpson and Samson (2008)	To develop strategies for GSCM	Described four GSCM strategies: A. Risk -based Strategies B. Efficiency-based Strategies C. Innovation-based Strategies D. Closed-loop Strategies

Seuring and Muller (2008)	To develop a conceptual framework for sustainable SCM	Identified dimensions are 1. Suppliers management for risks and performance 2. SCM for sustainable products
Zhu e.al, (2008)	To evaluate perceived GSCM practices in four different Chinese manufacturing firms and relate them to closing the supply chain loop	Adoption of GSCM varies in different industry context. GSCM can be used as an environmental tool to improve the environmental image and gain competitiveness within the international business arena.
Zhu,Q., et al, (2008)	To investigate whether organization size plays a role in GSCM adoption	Large and medium sized organizations are more advanced than their small sized counterparts on most aspects, but not necessary all of these GSCM practices
Field and Sroufe (2007)	To examine the implications of using recycled materials on operations strategy with a focus on the corrugated cardboard industry.	The benefits of the changes in the supply chain and supplier relationships accrue primarily to non-integrated firms and managers should expect the use of recycled material inputs to be dominated by non-integrated firms with decreasing capital costs over time.
Vachon, S., (2007)	To determine if there is a link between green supply chain practices (environmental collaboration and environmental monitoring) and environmental technologies selection.	The results suggest that environmental collaboration with suppliers is positively associated with greater investment in pollution prevention technologies while such collaborations with customers has no impact on the adoption and the implementation of pollution prevention technologies

Zhu et al, (2007)	To examine the relationships between GSCM practices, environmental and economic performance in Chinese manufacturing firms, incorporating three moderating factors i.e. market, regulatory and competitive institutional pressures	1. Chinese firms have experienced increasing environmental pressure to implement GSCM practices. 2. The existence of market and regulatory pressures influences organizations to have improved environmental pressures especially in case of eco design and green purchasing 3. Manufacturers facing higher regulatory pressure tend to implement green purchasing and investment recovery 4. Competitive pressure significantly improves the economic benefits from adoption of different GSCM practices 5. None of the institutional pressures contribute to or lessen possible "win-win" situations for organizations.
Srivastava (2007)	To present a comprehensive integrated view of the published literature on all dimensions of GSCM, primarily taking a reverse logistics perspective for facilitating future research directions	GSCM can reduce the ecological impact on industrial activity without sacrificing quality, cost, reliability, performance or energy utilization efficiency.
Raoand Holt(2005)	To identify potential linkages between GCSM and environmental performance, economic performance and competitiveness	Greening the different phases leads to an integrated supply chain which ultimately leads to competitiveness and economic performance
Zhu, et.al, (2005)	To evaluate and describe GSCM drivers, practices and performance among various Chinese manufacturing firms	Chinese firms have increased their environmental awareness due to regulatory, competitive, and marketing pressures and drivers. Chinese firms have implemented a variety of GSCM practices to improve their environmental performance and

		directly helped in enhancing export sales. Commitment from top level managers and support from mid -level managers is necessary for any GSCM program development.
Sarkis (2003)	To present a strategic decision framework that will aid managerial decision making	Strategic & Operational elements were structured for evaluating green supply chain alternatives

From above table researcher can draw conclusions:

- GSCM practices are source of competitive advantage;
- GSCM practices are source of sustainability;
- The companies practicing GSCM, enjoy high market share and superior business performance;

3.1 GSCM and its impact on organizational performance

The GSCM practices has helped firm to achieve superior performance is supported by literatures (e.g. Pauli,1997;Farish, 2009; Franchetti et al., 2009; Deif, 2011; Murovec et al.,2012;Prajogo et al.,2012; Pereira-Moliner et al.,2012;Dues et al., 2013; Gavronski et al.,2013).The literature defines performance as combination of environmental performance (e.g. reduction in CO_2,SO_2,NOx..,converting waste into more useful product, reuse or recycling after use, increase in product quality, increase in customer satisfaction) and business performance (e.g., increase in market share, increase in profitability, increase in ROI, increase in ROA, improvement in Inventory Turnover etc.,).

However in present study we would like to confine our research to firm performance which includes environmental performance and business performance. Researcher has prepared literatures which have supported Green Supply Chain Management practices and its positive impact on "environmental performance" and "firm performance" (e.g., i.e,Zhu et al.,2005; Zhu., 2007;Zhu et al.,2008; Dues et al., 2011; Olugu and Wong,2011; Bhateja,et al., 2012, Seman et al., 2012, Gangele et al., 2012;Whitelock,2012;Kim et al.,2012).

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4. Research Methodology:

This section deals with the framework or design used to carry out research study as a systematic and scientific investigation. In order to further validate the theoretical concepts, an empirical research is undertaken.

Literature review has reflected some important and related issues which not only lay down the foundation for the present research but also raise "Research Questions" for the present study. These research questions were identified and explained through secondary literature survey. It paved the way for primary survey to be carried out for the purpose of conceptualization, development and further validation of framework for present study.
The research questions needs to be explored and solved. Each of the identified questions and the research strategies for each is presented below in a tabulated form in Table 2 as:

Table 2: Research questions and research tools

Research Questions	**Research Tool**
RQ 1: What are the factors/dimensions that constitute Green Supply Chain Practices?	Thorough literature review
RQ 2: Can these factors/dimensions be further categorized?	Exploratory Factor Analysis
RQ 2.1.1: What are the variables and sub variables of Green Supply Chain Practices in Implementation?	Through Literature review and expert opinion
RQ 2.1.2: Can a research model be developed & tested empirically?	Primary survey
RQ 2.2: What is the relationship between Green Supply Chain Practices and firm performance?	Literature review and primary survey.

4.1 Research Objectives

The central problem of the study is how we can make GSCM implementation effective in an organization. Literature review has given a direction to identify the research gaps and to develop the research objectives for the present study is as follows:

- To study the role of various driver that lead to Green Supply Chain implementation in a firm and its relationship with firm performance.
- To propose and validate a research model showing relationship between Green Supply Chain Management and firm performance.

4.2 Proposed Theoretical Framework

On the basis of the preceding discussion and the synthesis of the existing literature, conceptual framework is proposed as shown in Figure 1. The two main components that constitute the conceptual framework include the drivers for Green Supply Chain implementation which will be measured in terms of firm performance variables.

Green supply chain management has its roots both in environmental management and supply chain management literature. Developed countries are those countries where we find high level development based on certain characteristics-consisting of economic, industrialization and human development index. Countries such as Japan, South Korea, Australia , Germany, Portugal, Italy, Sweden and Canada(Min and Galle 2001) fall in this category and

GCSM has been so far practiced majorly in these countries(Lenox, King and Ehrenfeld 2000). In developing countries especially in Asian region (India, China, Philippines, Indonesia, Malaysia, Thailand, and Singapore);

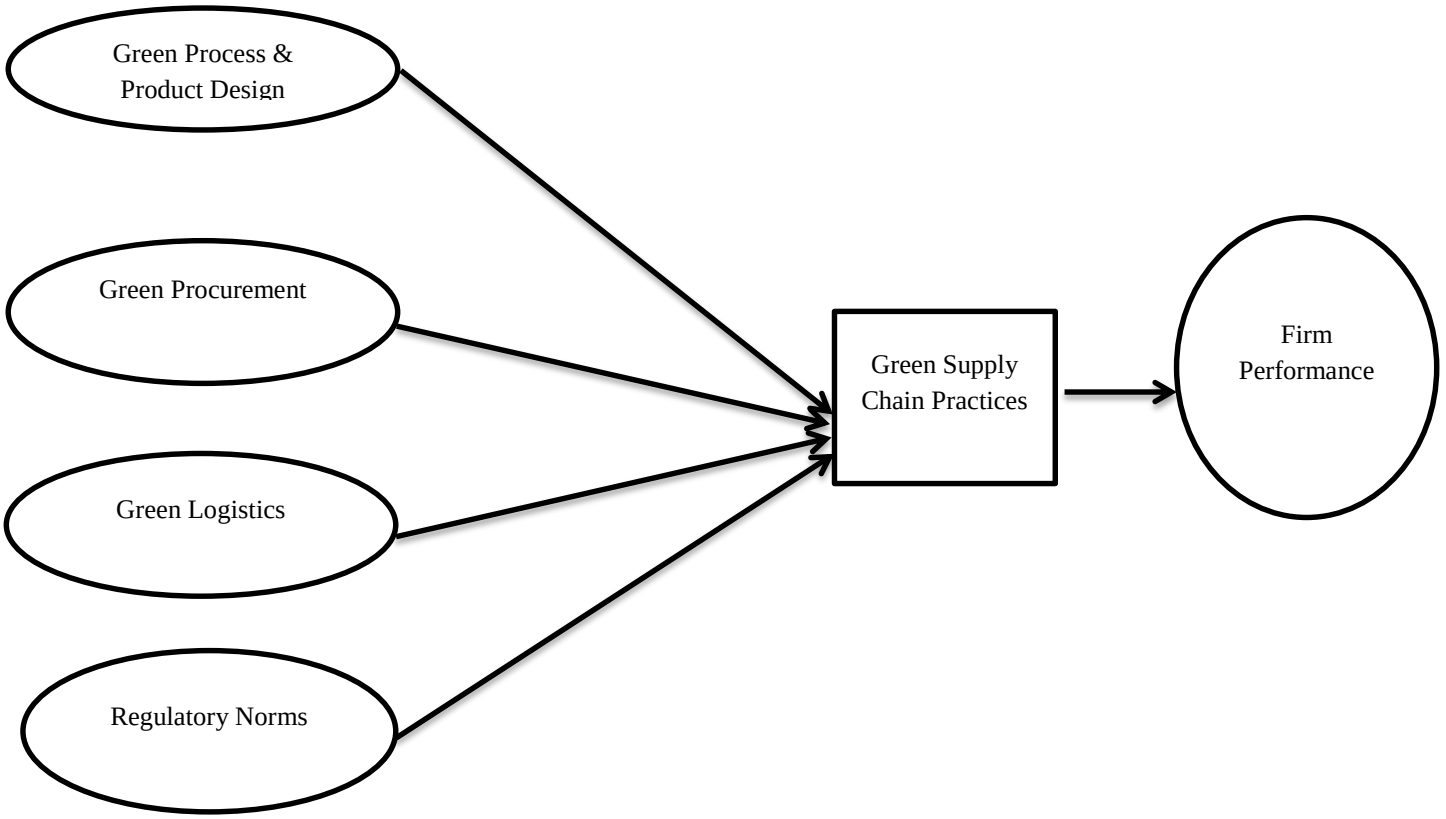


Fig 1: A conceptual model showing the relationship between green supply chain practices drivers and firm performance

GCSM practices are in a very nascent stage in Indian Industries (Singh *et al* 2011). Most firms in developing countries adopt GCSM to reduce the environmental impact of various business activities (Angel and Junquera 2003) rather than a proactive attitude to reduce the source of wastage or pollution.

Drivers of GCSM identified in Malaysian context are *Regulations, Customer requirements, expected business gains and social responsibility* (Zhu and Sarkis 2007) ; GSCM awareness is high and is perceived as a competitive advantage for companies in India. Adoption of GSCM practices is highest in areas where there is a correlation to efficiency and cost savings and vice versa (Bhateja *et al* 2012).

The dimensions of GSCM are identified through literature review which has been discussed critically as:

Table 2: Dimensions of Green Supply Chain Practices

Green Supply Chain Management drivers/Variables	**Authors(Year)**	**Dimensions/Sub-Variables**
Green Process & Product Design	Yang and Zhang(2012); Wahid *et al.*(2011); Bjorklund (2011);Zhu *et al.*(2007) Rao, 2002, 2004; Green *et al.*, 2012a, 2012b; Giovanni, 2012; Hollos *et al.*, 2012; Narasimhan and Schoenherr, 2012; Shi *et al.*, 2012; Zhu *et al.*, 2012	• Supplier pressure; • Consumer pressure; • CSR activity; • reducing energy usage and resource consumption during production; • Green management cost; • Pollution prevention, or source reduction • environment-friendly, renewable sources
Green Purchasing	Bierma and Waterstraat,1999;Vachon and Klassen,2006;Hsu and Hu,2009;Bai and Sarkis,2010;Ku *et al.*,2010;Testa and Iraldo,2010; Green *et al*., 2012b; Zhu *et al*., 2005, 2012 ; Carter and Easton, 2011; Hollos *et al*., 2012; Shi *et al.*, 2012; Wong *et al.*, 2012; Kumar *et al*., 2012; Shi *et al*., 2012; Zailani *et al.*, 2012 Hoof and Lyon,2013.	• Bringing Suppliers together; • Guiding Suppliers to implement their environmental programs; • Holding awareness seminars for suppliers/contractor; • Sending in-house company's auditor to appraise environmental performance of the suppliers
Green Logistics	Yang and Zhang(2012); Wahid *et al.*(2011); Bjorklund (2011);Zhu *et al.*(2007) ; Hollos *et al*, (2012); Wong *et al*., (2012); Zailani *et al*., (2012); Zhu *et*	• Recovery of the company's end of life products; • Taking back of material;

	al., (2012); Green *et al*., (2012b); Kumar *et al.*, (2012); Shi *et al.*, (2012);	• Green fuels; • Eco product lifecycle approach for distribution; • Change for more environment friendly transportation;
Regulatory Norms	Yang and Zhang(2012); Wahid *et al*.(2011); Bjorklund (2011);Zhu *et al*.(2007); EPP (2011); ACC sustainability report(2010)Green Purchasing Australia report(2009);European Communities(2004); Zailani, *et al.*, 2012; Giovanni *et al.*, 2012; Shi *et al*., 2012; Wong *et al*., 2012	• Green Labeling; • Disposal norms; • Waste water treatment and recycling; • Green mining; • Carbon emission norms; • Sox, NOx emission norms;
Firm performance	Raghavendran *et al.*(2012); Schoenherr (2012); Zailani *et al.* (2012); Hart, (1995); Shrivastava, (1995) Dess and Robinson (1984); Porter and van der Linde, (1995); Carter and Rogers, (2008)	• customer satisfaction; • profitability; • market-share;

By discussing with industry experts and literature review the following variables are used to define the construct and capture the drivers of green supply chain management: (1) Green Process & Product Design (2) Green Procurement (3) Green logistics (4) Regulatory pressure;

The above dimensions will be used in developing a structured questionnaire for conducting survey among firms which are practicing Green Supply Chain practice for testing following hypothesis

4.3 Hypotheses of study

Based on the literature review conducted, research gaps and research objectives identified, following hypotheses are proposed for the present study:

Hypothesis 1: There is a positive relationship between Green Process and Product Design and firm performance.
Hypothesis 2: There is a positive relationship between Green Procurement and firm performance.
Hypothesis 3: There is a positive relationship between Green Logistics and firm performance.
Hypothesis 4: There is a positive relationship between Regulatory norms and firm performance.

The above model could be used to carry out survey for Indian manufacturing industries. An instrument for testing these hypotheses will be developed scientifically using Literature review. To carry out survey, an instrument for this study was developed scientifically using two approaches namely:

- Literature review;
- Pretest of questionnaire consisted of expert opinion and pilot survey;

To begin with an exhaustive literature survey has been conducted to identify key issues. The various critical factors are identified from various sources which are important for successful GSCM adoptions. The various critical success factors, CSFs are identified. A pragmatic and grouping of dimensions is done. The various questionnaire instruments in the area are also identified. These included (e.g., Sarkis,2003;Zhu *et al*.,2005;Vachon,2007;Bhateja *et al*.,2012;Luthra *et al*.,2012).All of these researchers have developed their questionnaires differed from each other. However, the questionnaires developed by these researchers gave some useful insights into developing the questionnaire required for the identified research objectives.

4.3.1 Questionnaire Design

To design questionnaire researcher reviewed latest work (e.g., Zhu *et al.*,2008;Wu *et al.*,2009;Wahid *et al*.,2011;Carbone and Moatti ,2011;Yang and Zhang,2012;Raghavendran,2012;Luthra *et al*.,2012;Dubey *et al*.,2013).The items of questionnaire were selected from these studies and some items were also included based upon opinion of practitioners. The questionnaire started focusing questions related to general information of the organization. Further consists of close ended questionnaire, on five point Likert scale. Initially this part consists of 32 items related to objectives of the study.

Includes questions on dimensions of GSCM in terms of 7 items of Green Purchasing, 8 items of Green Logistics, 9 items of Green Process Design,8 items of Regulatory Frameworks and 12 items of Organizational performance. The constructs of green product and process design (Yang and Zhang 2012; Zhu et al. 2007 Green et al., 2012a, 2012b) are found. The green purchasing constructs has been adopted from(Zhu et al., 2005, 2012 ; Kumar et al., 2012; Shi et al., 2012; Zailani et al., 2012 Hoof and Lyon,2013.),green logistics has been adopted from Zhu et al., (2012); Green et al., (2012b) , for regulatory framework constructs were identified from recent studies(e.g. Zhu et al.(2007); EPP (2011); ACC

sustainability report(2010) ; Green Purchasing from Australia report(2009);European Communities(2004); Zailani, et al., 2012; Giovanni et al., 2012) and firm performance constructs are identified from Raghavendran et al.(2012); Schoenherr (2012) and Zailani et al. (2012).The scales will be further developed on the basis of exploratory factor analysis on survey.

(1) Pretesting;

(2) Pilot survey to check the validity and construct reliability of instrument;

Expert interviews, is performed to develop valid survey instrument for research. Total five experts were invited to refine and validate measures for each concept, two experts from academics and three from industry. Experts were asked to provide their opinion on initial 32 items of GSCM constructs and 12 items of organizational performance. The major comments were related to adjusting the details of wording (reworded or shortened) in some questionnaire items, to make it clearer and more concise. Suggestions were received to eliminate some overlap items.

Expert opinion suggested that labelling such as 'green process and product design'; 'green purchasing' ; 'green logistics' and 'regulatory framework' should be removed that resulted in 22 mixed items for GSCM constructs and 8 items for organizational performance.

4.3.2 Sampling Design

It is a well-established fact that '**Industry**' is the Central Point to the economies of the modern societies and an indispensable motor of growth. At the same time, the industrial growth adversely affects the environment through its inherent quality of emitting pollutants viz. hazardous emissions, air and water pollutants etc. In Maharashtra State, the environmental regulations are more stringent in comparison to that in the Uttar Pradesh State. Especially in the industrial areas, Maharashtra Pollution Control Board **(MPCB)** has laid down very strict parameters for meticulous compliance related to Emission, Noise, Water & Air Pollution level, and has made it mandatory for the Industrial Units to:

- Ensure to establish waste treatment plants for treatment of the released effluents.

- Use Solar Energy Panels in the industrial as per the requirement and keeping in view the viability cost.
- Maintain a particular defined decibel level to have control on the noise pollution.
- Compulsorily adopt Water Harvesting System.
- Compulsory plantation of trees/plants/flower beds where deforestation has taken place for setting up of the industrial unit.

Implementation of such regulations has paid rich dividends by having better forest area coverage in Pune & Nasik. In fact, despite of industrial growth and rise in population levels in Pune & Nasik[5], the forest coverage is 11.7% and 17.26% respectively. Adoption of these stated various environmental practices, has given a boost to the industrial growth in Pune-Nasik Industrial belt, resultantly it has become the most sought over area for the National and Multi-National Companies to set up their industries/companies.According to project's objectives, in the present scenario the Pune-Nasik industrial belt is more favourable for the research, this can be attributed mainly to the environment-friendly practiced (i.e. implemented by the state), hence sustainable over the long run as compared to Greater Noida.

There are over 2500 manufacturing companies however researcher initially aimed at 175 companies who are either practicing Green Supply Chain, based on initial information provided[2,3,7] .

4.3.3 Sample Firm Identification

In order to study researcher has identified manufacturing companies who have implemented GSCM. Researcher has identified manufacturing companies who have implemented GSCM. These companies are identified as per information provided by the experts and with the help of CII database[2,3,5,]. After having discussion with Experts, these companies have been selected. Companies that "included" are the ones that are using CSR (or sustainability) as a way of 'innovation, cost savings, **Brand differentiation, Long-term thinking, Customer engagement, Employee engagement** for their business processes into the organization.

5. Data Collection

The structured questionnaire was targeted to over 175 companies. Out of 175 questionnaires only 54 questionnaires were filled after several follow up with respective companies. This represents 31% total

targeted sample.

5.1 Non Response bias tes*t*

It is advisable that whatever may be the response rate, the non-response bias test is very important. Non-response bias is one of the serious limitations of survey based research. Though researcher took utmost care during data collection, but no one can deny the implications of non-response bias.

Statisticians and other experts in the survey method (e.g. Armstrong and Overton, 1977; Barriball and While, 1999) recommend that researcher should conduct non-response bias analysis.There are various non-response bias methods or techniques available, as each approach has its own strengths and limitations. However, researcher use *Wave Analysis* technique because it is (1) a widely used method; (2) inexpensive; (3) less time consuming; (4) low in data requirements, and (5) reasonable and coherent within our paper context. Wave analysis technique is also known as Linear Extrapolation Method (Armstrong and Overton, 1977).The differences in the waves (wave1=initial respondents and wave2=late respondents) were analyzed. Statistical difference was estimated using non-parametric test which is most suitable to research data collected (one-sample-Kolmogorov-Smirnov test).In this case researcher found that there was not statistically significantly different from each other. Researcher therefore can conclude that non-response bias was not any issue in the present stud

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Wave 1 Mean is normal with mean 3.01 and standard deviation 0.39.	One-Sample Kolmogorov-Smirnov Test	.614	Retain the null hypothesis.
2	The distribution of Wave 2 Mean is normal with mean 3.14 and standard deviation 0.42.	One-Sample Kolmogorov-Smirnov Test	.678	Retain the null hypothesis.
3	The distribution of Wave 1 SD is normal with mean 1.05 and standard deviation 0.20.	One-Sample Kolmogorov-Smirnov Test	.494	Retain the null hypothesis.
4	The distribution of Wave 2 SD is normal with mean 1.06 and standard deviation 0.19.	One-Sample Kolmogorov-Smirnov Test	.852	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

5.2 Research Tool for Data Analysis

To begin with analysis, researcher used exploratory factor analysis to validate scale and constructs used in questionnaire. The exploratory factor analysis output was used as an input for regression analysis. Here the sample size is only 54 so in such case researcher prefer to use PLSR which is discussed in detail in next chapter.

Table 4.1: Respondent's Experience

Experience (Years)	No.of employees	Cumulative no. of employees
0-10	1	1
11-15	7	8
16-20	33	41
21-25	8	49
26-30	2	51
31-35	2	53
35-40	1	54

Greater no. of manufacturing activities are carried and performed by the employees with an experience falling within the range of 16-20 years, it can be attributed to the fresh young talent infusing ideas and innovations that every requires.

Also, the above table shows that respondents having less experienced people (less than 10 years) are few.

Table 4.2: Company's Employee strength

Employee strength of Companies	No.of companies	Cumulative
0-100	2	2
101-200	31	33
201-300	12	45

301-400	4	49
401-500	1	50
501-600	1	51
601-700	1	52
701-800	2	54

Most of the companies fall in the employee category of 101-200 employees. And the majority of companies have employee strength upto 300. This clearly implies that these respondent's companies are having lesser number of people but who are highly efficient rather than creating a large chunk of employees which just add to cost and have less productivity.

Table 4.3: Respondent's Qualification

Qualifications	No.of Employees
B.E	20
B.E(Electrical),FIE(I)	1
B.E(Electrical),MBA	1
B.E(Electrical),PGDM	1
B.E(Mech.)	3
B.E(Mech.),MBA	1
B.E(Mech.),MBA,CPIM	1
B.E(Mech.),MBA,CSCP,CPIM,ICWAI	1
B.E(Mech.),PGDBM	1
B.E(Mech.),PGPM	2
B.E(Mechanical)	15
B.E,MBA	1
B.Sc,PGD(Polymer Engineering)	1
MBA	5
Grand Total	**54**

On an average the respondent's possessing the degree of B.E.(Electrical) [FIE(I)], closely followed by the employees with an MBA degree ,B.E. [MBA], B.E. (Mech)[MBA, CSCP,CPIMI,ICWA]. This implies respondents mostly are B.E qualified people who are specialised in their area irrespective of whether they hold any additional degree or not.

It is interesting to note that in Cement and basic & fabricated metal sector only MBAs are the ones governing these sectors. For the rest of the sectors the employees with an engineering background are the ones who are handling the sectors.

Table 4.4: Respondent's Designation

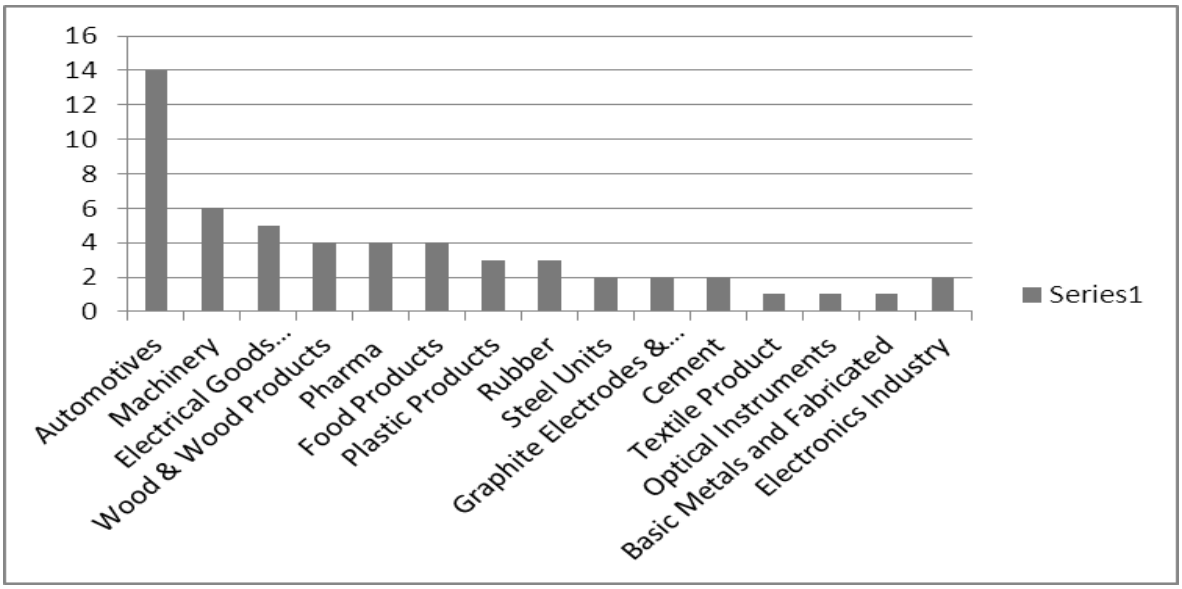
Designation	Experience	No. of employees
General Manager	17-23	5
Manager	10-20	35
Managing Director	37	1
Plant Logistics Head	26-34	2
Sr.Manager	12-27	10
Vice President	32	1

Maximum respondents are managers, followed by Sr. managers, General managers and so on. Almost all the managers are concentrated in the automotive sector. This study targeted managers at middle or higher management levels. Following previous studies such as Carter *et al.* (2000), researcher considered that mid-level managers could facilitate incremental adoption of environmental practices, which is consistent with this research findings. Furthermore, Bowen (2000), who completed a study with middle managers, found positive relationships between middle managers' perceptions of corporate environmental proactivity and GSCM.

The above table clearly shows that experience pays off well. Most of the employees with 10-20 years of experience are either Managers or Sr. Managers. At maximum few with this level of experience have reached to position of General Manager. Managing Director holds the highest years of experience followed by Vice President and other similar top level positions.

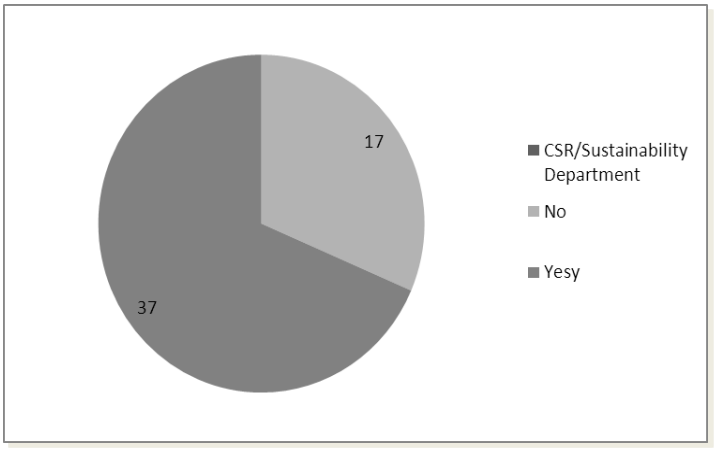
The frequency distribution of the companies who responded to questionnaires is shown in Figure 4.1.

Figure 4.1: Frequency Distribution of various Industries



Out of 54 companies who have responded to the questionnaire, 17 companies have indicated that they do not have CSR/Sustainability department and 37 companies have indicated that they have CSR/ Sustainability Department. The response related to this question is represented as shown in Figure 4.2.

Figure 2: CSR/Sustainability Department



Out of 54 companies surveyed, all 54 companies have indicated that they are aware of GSCM practices. It is quite encouraging that Indian manufacturing sector is aware of sustainability practices.

Arithmetic mean is calculated from the various items values to get some information. As we know that proposed 6 items belong to “green process & product design” , 5 items related to “ green procurement” , 5

items to “green logistics” , 6 items to “ regulatory norms”, 5 items to “environmental performance” and 3 items to “ business performance”.

Table 4.5: Arithmetic Mean and Standard Deviation of Response

Scale	Arithmetic Mean	Standard Deviation
Green Process &Product Design	3.105	0.09
Green Procurement	3.042	0.10
Green Logistics	3.283	0.11
Regulatory Norms	2.689	0.11
Business Performance	3.155	0.13
Environmental Performance	3.469	0.097

The arithmetic mean table shows that respondents have rated regulatory norms least and Green Logistics maximum, though the value is less than 3.5 shows that respondents feel that GSCM practices are in infancy stage in India and has a long way to go.

Though, it is encouraging to note that some of Indian companies have taken lead and in near future there is strong indication that green supply chain will be the governing philosophy of sustainable manufacturing practices.

5.3 Exploratory Factor Analysis:

Generally, exploratory factor analysis (EFA) is used for the situation where the relationships between the observed and latent (factors) variables are unknown or uncertain(Dubey et al 2013, Krishnaswamy et al.,2006,Tucker and MacCallum,1991;Sureshchandar et al.,1987).The objective of EFA is to unearth the underlying factors (Dickey,1996), thereby illustrating the relationships between the latent factors and the observed variables(Roberts,1999;Hair etal.,1998).The purpose is to come out with the minimum number of

factors that will explain the co-variation among the observed variables. In this research, twenty-two variables of drivers of GSCM and eight variables of successful implementation of GSCM for firm performance were identified from the literature. According to Hair et. al., (1999) factor analysis, should be used to analyze and create a new set of variables. Exploratory factor analysis is applied, to identify the drivers of GSCM and successful implementation of GSCM for firm performance. It is done using, step-by-step repetitious process of principal component factor analyses, with orthogonal rotation to arrive at the most interpretable and significant factor solution. The process includes all variables in the factor analysis. In this step, factor structures are identified on the basis of the significance and clarity of the factor loadings, the communalities and most importantly, the interpretability and meaningfulness of the factors within the theoretical framework. Variables that did not fit well with others in the structures were identified and excluded gradually, one variable at a time, from the list of variables. Factor analysis was re-performed at each of the exclusions to explore new factor solutions. The process ended when a clear, interpretable and meaningful factor solution. The application of factor analysis requires several statistical conditions at a satisfactory level for results to be reliable. These requirements entail the significance of the factor loadings and the correlation appropriateness of factor analysis.

Factor analysis was conducted on 22 independent variables. Large values for the KMO measure indicate that a factor analysis of the variables is appropriate (Ali and Bhardwaj 2010). It should be greater than 0.5 for a satisfactory factor analysis to proceed. In our present research the value for KMO is 0.703 which is greater than 0.5.

Table 4.6: KMO and Bartlett Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.703
Bartlett's Test of Sphericity	Approx. Chi-Square	888.933
	Df	231
	Sig.	.000

Extracted variables using Principal component analysis (PCA) shows that 4 factors contribute more than 70.1% of the total variance. The factor loadings, also called component loadings in PCA, is the correlation coefficients between the variables (rows) and factors (columns). Analogous to Pearson's r, the squared factor loading is the percent of variance in that indicator variable explained by the factor. To get the percent of variance in all the variables accounted for by each factor, add the sum of the squared factor loadings for that factor (column) and divide by the number of variables.

Table 4.7: Rotated Component Matrix

	F1	F2	F3	F4
GP1		.695		
GP2		.843		
GP3			.599	
GP4	.521			
GP5			.727	
GP6			.814	
GL1	.644		.524	
GL2	.579			
GL3	.823			
GL4	.859			
GL5	.900			
SRM1	.780			
SRM2		.567		
SRM3		.888		
SRM4		.800		

SRM5		.643	.535	
IF1		.725		
IF2				.653
IF3				.693
IF4				.716
IF5				.783
IF6	.656			

In order to obtain these stable structure researcher has assumed two criteria as:

- The researcher has eliminated variables having weak factor loadings(less than 0.5) ;
- those variables having cross loadings on two factors; (Tucker and MacCallum,1991;Krishnaswamy,2006)

Here in the above table GL1 and SRM5 has cross loadings. Hence to obtain parsimonious structure these two rows were eliminated.

Table 4.8: Parsimonious Orthogonal Factors

	F1	F2	F3	F4
GP1		.695		
GP2		.843		
GP3			.599	
GP4	.521			
GP5			.727	
GL1			.814	
GL2	.579			

GL3	.823				
GL4	.859				
SRM1	.900				
SRM2	.780				
SRM3		.567			
SRM4		.888			
SRM5		.800			
IF1		.725			
IF2				.653	
IF3				.693	
IF4				.716	
IF5				.783	
IF6	.656				
Eigen Value	3.869442299	3.470511	1.549396	2.032484	10.92183
% of Variance	19.34721149	17.35255	7.74698	10.16242	54.60916

Table 4.9: Highly Correlated Variables

F1(Green Process and Product Design)		
	GP4 Substitution of environmental questionable materials	.521
	GL3 Taking back of packing material	.579
	GL4 Eco product life-cycle approach for distribution	.823
	GL5 Strategic factors to consider in reverse logistics include cost, overall quality, customer service, environmental concerns and legislative concern	.859
	SRM1 Designing products for quick disassembly	.900
	SRM2 Designing products with bio-degradable materials	.780
	IF6 Use of cleaner technology processes to make saving(energy, water, wastage)	.656
F2(Green Purchasing)		
	GP1Providing design specification to suppliers that include environmental requirements for purchased Items	.695
	GP2 Cooperation with suppliers for environmental objectives	.843
	SRM3 Informing suppliers about benefits of cleaner production and Technologies	.567
	SRM4Urging/pressuring suppliers to take environmental actions	.888
	SRM5 Sending in-house company's auditor to appraise environmental performance of the suppliers	.800
	IF1 Central governmental environmental regulations	.725

F3 (Green Logistics)		
	GP3 Environmental audit for suppliers' inner management	.599
	GP5 Choice of transport by environmental criteria	.727
	GL1 Recovery of the company's end of life products	.814
F4 (Regulatory Norms)		
	IF2 Regional environmental regulations	.653
	IF3 Export countries' environmental regulations	.693
	IF4 Establishing company's green image	.716
	IF5 Sustainability business practices for suppliers	.783

Once this four-factor solution was obtained in which all variables have significant loadings on a factor, an attempt should be made to give some meanings to the patterns of factor loadings. Variables with higher loadings were considered more important and have greater influence on the name or label selected to present a factor (Hair et al. 1999). Therefore, examining all the underlined variables for a particular factor and placing greater emphasis on those variables with higher loadings will attempt to assign a name or label to a factor that accurately reflects the variables loading on that factor as shown in Table 4.9(Annexure 4).

Similarly, on performance variables same procedure is applied. The EFA output explains two factors solution which explain over 66% of total variance as shown in Table 4.10.

Table 4.10: Parsimonious Factors of Performance Variable

	F1	F2	
P1		.792	
P2		.823	
P3		.705	

P4	.576		
P5	.837		
P6	.900		
P7	.916		
P8	.897		
Eigen Value	3.485348215	1.800812463	5.286161
Variance%	43.56685269	22.51015579	66.07701

Once this two-factor solution was obtained in which all variables have significant loadings on a factor, an attempt should be made to give some meanings to the patterns of factor loadings. Variables with higher loadings were considered more important and have greater influence on the name or label selected to present a factor (Hair et al. 1999). Therefore, examining all the underlined variables for a particular factor and placing greater emphasis on those variables with higher loadings will attempt to assign a name or label to a factor that accurately reflects the variables loading on that factor as shown in Table 4.11.

Table 4.11: Highly Correlated Dependent Variable

F1(Business Performance)	Items	Factor Loadings
	P4	.576
	P5	.837
	P6	.900
	P7	.916
	P8	.897
F2(Environmental Performance)		
	P1	.792
	P2	.823

	P3	.705

4.3 Regression Model

Based upon EFA output, there are two regression models to be tested are shown in Figure 4.3 and Figure 4.4.

Figure 4.3: Business Performance-GSCM model

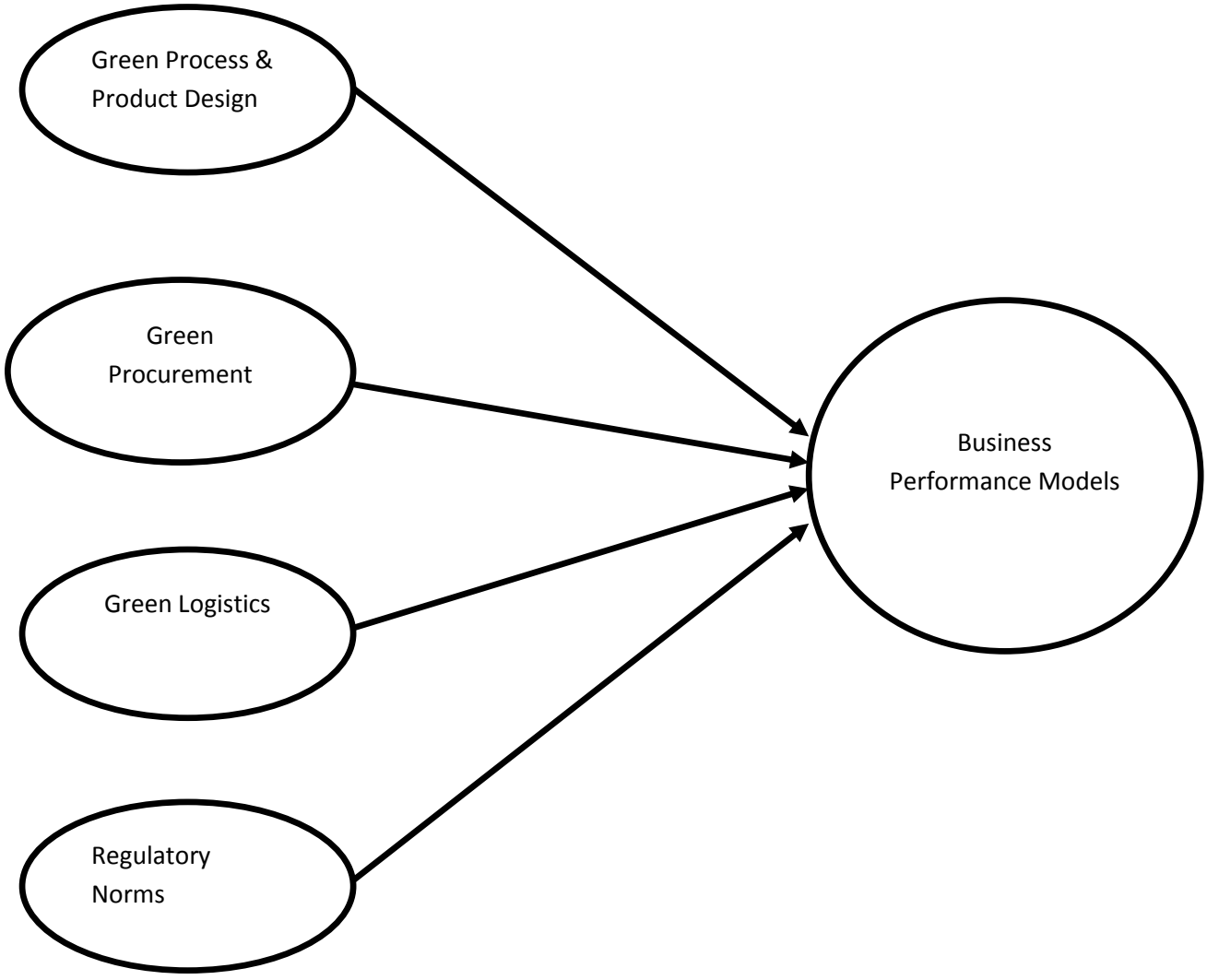
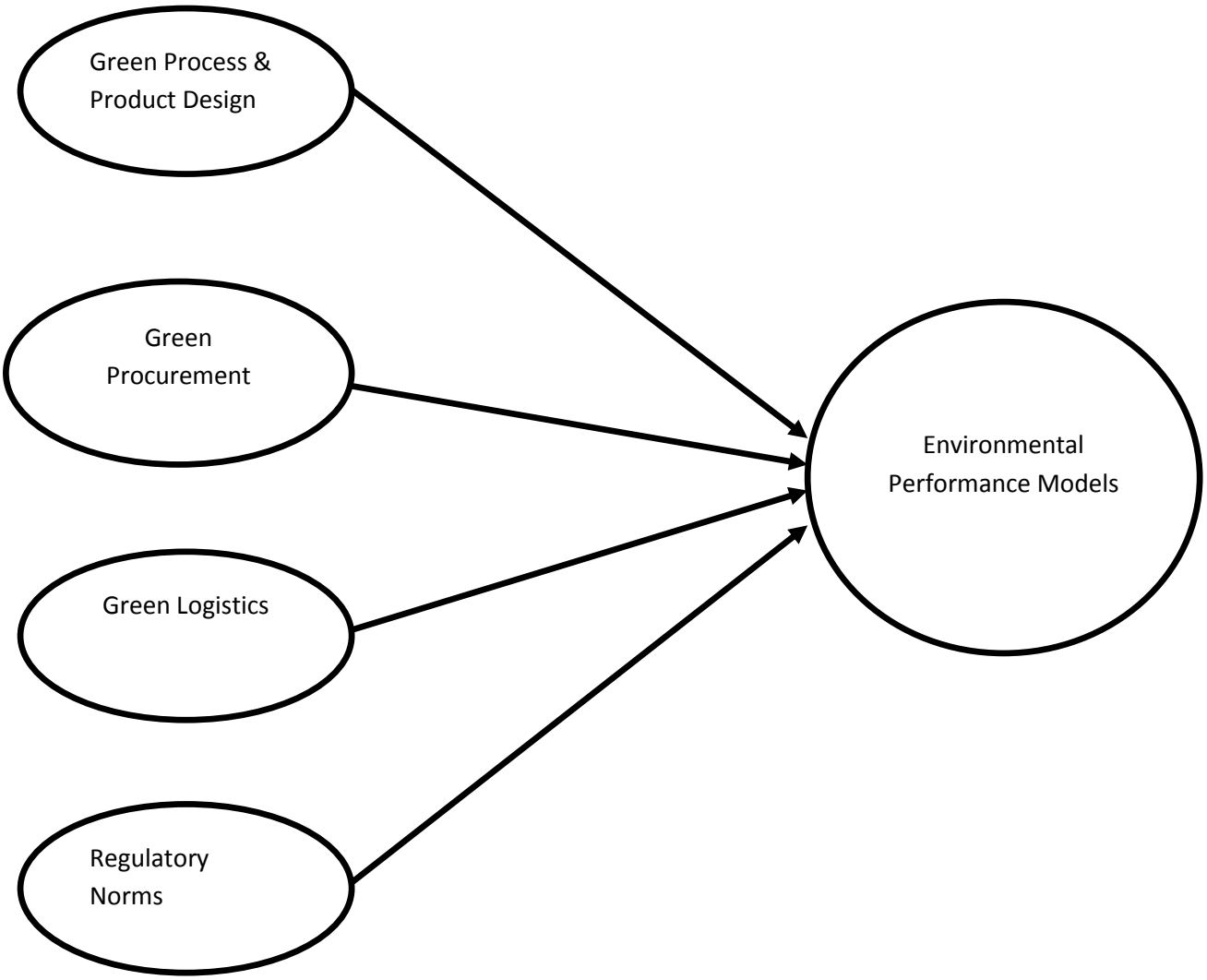


Figure 4.4: Environmental Performance-GSCM model



In order to test the above Regression Models, author has preferred to use PLSR (Partial Least Square Regression Analysis) using EFA output has input over Multiple Linear Regression Model (MLRA), due to two reasons;

Reason 1:

The data distribution was not normal**.**

Reason 2:

The data distribution is not normal as the value of Durbin-Watson statistics was found to be less than 1.5.

In such case when data distribution is not normal, autocorrelation effect is visible and certain degree of multicollinearity is said to have existed, PLSR is said to be much better technique which is variance based structural equation modeling (SEM) technique which is used for testing regression modeling.

Introduction to PLSR:

Unlike covariance-based SEM, PLS, was introduced by H. Wold (1975),under the name *NIPALS* (*nonlinear iterative partial least squares*), focuses on maximizing the variance of the dependent variables, explained by the independent ones, instead of reproducing the empirical covariance matrix.

Like any SEM, a PLS model consists of a structural part, which reflects the relationships between the latent variable and a measurement component, which shows how the latent variables and their indicators are related; but it also has a third component, the weight relations, which are used to estimate case values for

the latent variables. In contrast to covariance-based SEM, which estimates first model parameters and then case values (i.e., estimated values for each latent variable in each data set) by regressing them onto the set of all indicators (Dijkstra, 1983), PLS starts by calculating case values. For this purpose, the unobservable variables are estimated as exact linear combinations of their empirical indicators (Fornell & Bookstein,1982). PLS treats these estimated proxies as, perfect substitutes for the latent variables (Dijkstra, 1983). The weights used to determine these case values are estimated, so that the resulting case values capture most of the variance of the independent variables that is, useful for predicting the dependent variable. This is based on the implicit assumption that all measured variance of the variables in the model is useful variance. Thus researcher can conclude that PLS is a powerful method of analysis due to minimal demands on measurement scales; minimal demands on sample size; minimal demands on residual distributions; can be used for theory confirmation and can also be used to suggest where relationships might or might not exist and to suggest propositions for later testing (Chin, 1998).

Partial least squares regression is an extension of the multiple linear regression models. In its simplest form, a linear model specifies the relationship between a dependent variable *Y*, and a set of predictor variables, the *X*'s, so that Y= bo +b1X1+b2X2+…..+bpXp

In above equation b0 is the regression coefficient for the intercept and the bi values are the regression coefficients (for variables 1 through p) computed from the data. One could use linear regression, to estimate the respective regression coefficients but, partial least squares regression is probably the least restrictive of the various multivariate extensions of the multiple linear regression model. This flexibility allows it to be used in situations where the use of traditional multivariate methods is severely limited, such as when there are fewer observations than predictor variables. Furthermore, partial least squares regression can be used as an exploratory analysis tool, to select suitable predictor variables and to identify outliers before classical linear regression. Partial Least Squares (PLS) regression technique, is especially useful in quite common case, where the number of descriptors (independent variables), is comparable to or greater than the number of compounds (data points) and/or there exist other factors leading to correlations between variables. In this

case the solution of classical least squares problem does not exist or is unstable and unreliable. On the other hand, PLS approach leads to stable, correct and highly predictive models even for correlated descriptors.

Partial Least Square Regression (PLSR) Modeling

PLSR analysis is done using Minitab 15. It is statistical software that positions itself for the quality assurance market. It is specialized for many quality functions and is used by many industries for that purpose. Researcher has used Minitab 15 for PLSR analysis, on the collected data. Relationship is established between the factors selected from EFA and firm performance variable. The PLSR output is discussed below to understand how the output is different from above multiple linear regression output. In this case researcher has carried out PLSR analysis using selected four factors instead of performing on raw data to draw a comparison between result of both analysis and to eliminate the multi-collinearity effect on variables so that conclusive remark can be drawn. In this cross-validation, is commonly used to determine the optimal number of components to take into account, is controlled by the validation argument in the modeling functions (mvr,plsr).

PLS Regression: Business Performance versus Green Process & Product Design, Green Purchasing, Green Logistics and Regulatory Norms

Table 4.12: Model Selection and Validation

Components	Variance	R-Sq
1	0.57864	0.221690
2	0.75135	0.224116
3	0.87368	0.225855

4	1.00000	0.225990

The above Table 4.12 indicates that explanatory variables identified as parsimonious and orthogonal factors (i.e. Green product and process design, Green purchasing, Green logistics and Regulatory norms) explain, 22.6 % of total variance of business performance.

Table 4.13: ANOVA Analysis

Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	4	11.0584	2.7646	3.58	0.012
Residual Error	49	37.8749	0.7730		
Total	53	48.9333			

The Table 4.13 indicates that proposed regression model is statistically significant at 0.012 as the F-statistics value is greater than the Fcr(4,49).

Table 4.14: Regression Coefficient

Constant	0.893	Standardized coefficients
Green Process & Product Design		0.107
Green Procurement		0.321
Green Logistics		0.082
Regulatory Norms		0.0645

The Table 4.14 shows standardized Beta coefficients of explanatory variables. The positive sign shows that each explanatory variable positively influence the business performance. It can be also seen that manufacturing firms focusing more on “Green Process and Product Design” and “Green purchasing” can expect to achieve superior environmental performance.

Figure 4.5: PLS Coefficient Plot

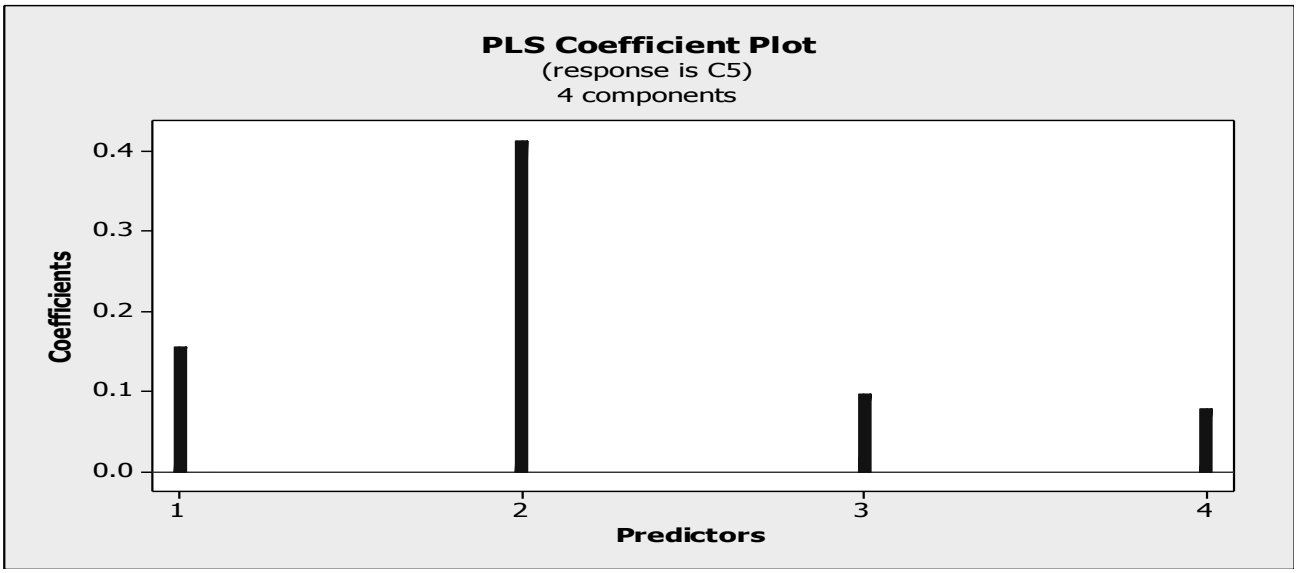
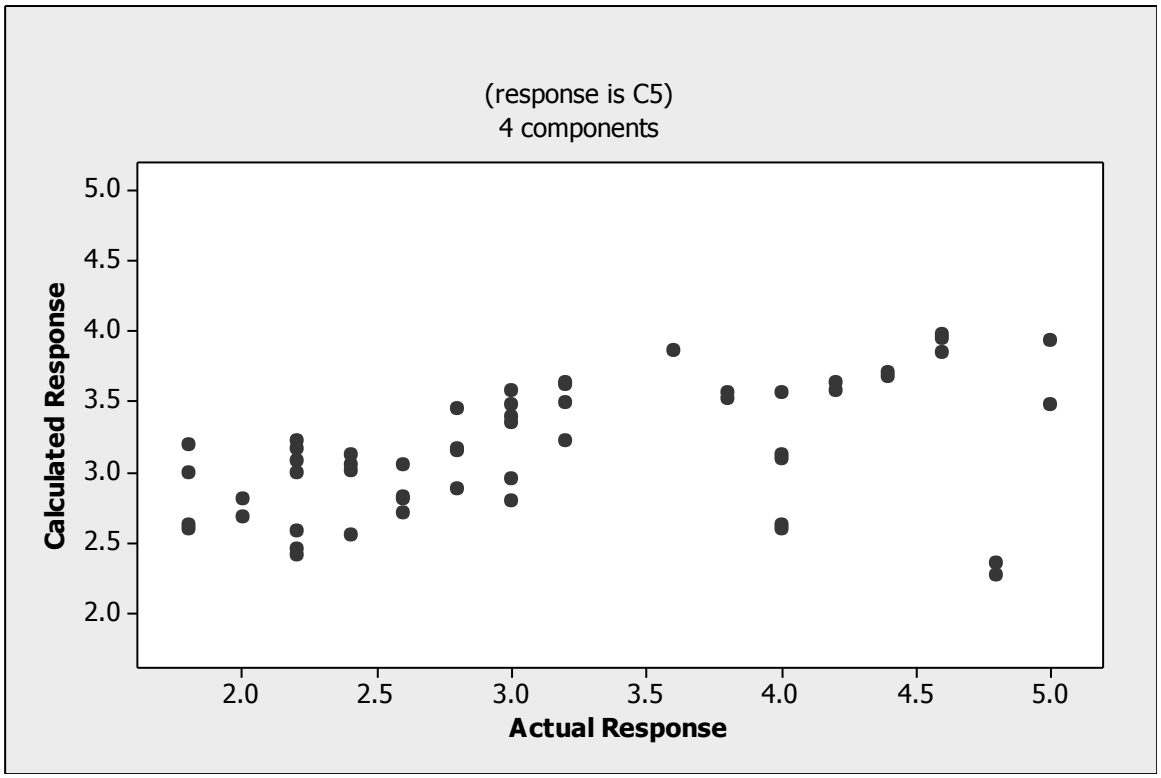


Figure 4.6: PLS Response Plot



The PLS response plot shows that calculated response plot vs actual response. The plot shows that the distance measured between two point increases towards right hand side as we move along the horizontal axis (Actual response axis).Thus we can see that the PLSR output is optimum up to 4 components. Thus here researcher has selected only four components output.

Business Performance= 0.89+0.11*Green Process & Product Design+0.32*Green Procurement +0.081*Green Logistics+0.065*Regulatory Norms + Error;

PLS Regression: Environmental Performance versus Green Purchasing, Supplier Relationship Management, Green Logistics and Regulatory Norms

Table 4.15: Model Selection and Validation

Components	Variance	R-Sq
1	0.50521	0.191607
2	0.79837	0.263297
3	0.90112	0.318223
4	1.00000	0.331687

The above Table 4.15 indicates that explanatory variables identified as parsimonious and orthogonal factors (i.e. Green process & product design, Green Procurement, Green logistics and Regulatory norms) explain, 33.2 % (approximately) of total variance of environmental performance.

Table 4.16: ANOVA Analysis

Source	DF	SS	MS	F	P
Regression	4	8.9601	2.24003	6.08	0.000
Residual Error	49	18.0537	0.36844		
Total	53	27.0138			

The Table 4.12indicates that proposed regression model is statistically significant at 0.000 as the F-statistics value is greater than the Fcr(4,49).

Table 4.17: Regression Coefficient

Constant	3.39367	Standardized coefficients
Green Process & Product Design		-0.482951
Green Procurement		0.813714
Green Logistics		-0.060707
Regulatory Norms		-0.207767

The Table 4.17 shows that except green procurement, other explanatory variables (i.e. green process & product design, green logistics and regulatory norms) are not supporting environmental performance (Annexure 5). However the findings do not conform to the findings of other literatures. The present findings suggest that Indian manufacturing sector need to adopt green process and product design, green logistics or respect regulatory norms to achieve superior environmental performance. However it should be further explored.

Figure 4.7: PLS Coefficient Plot

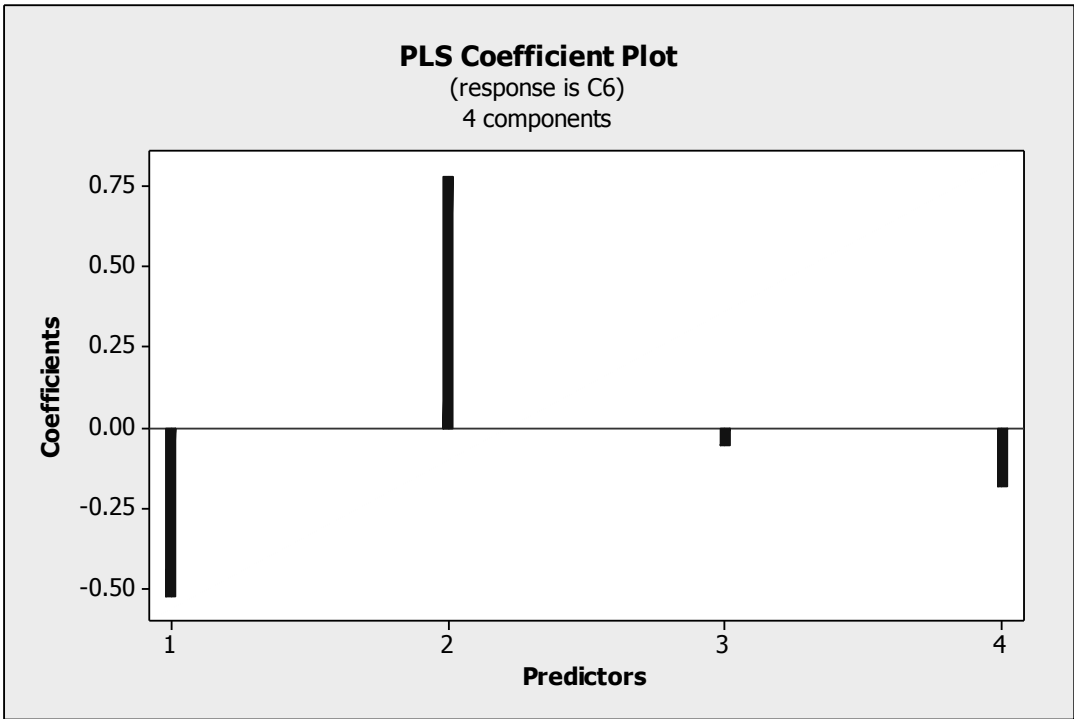
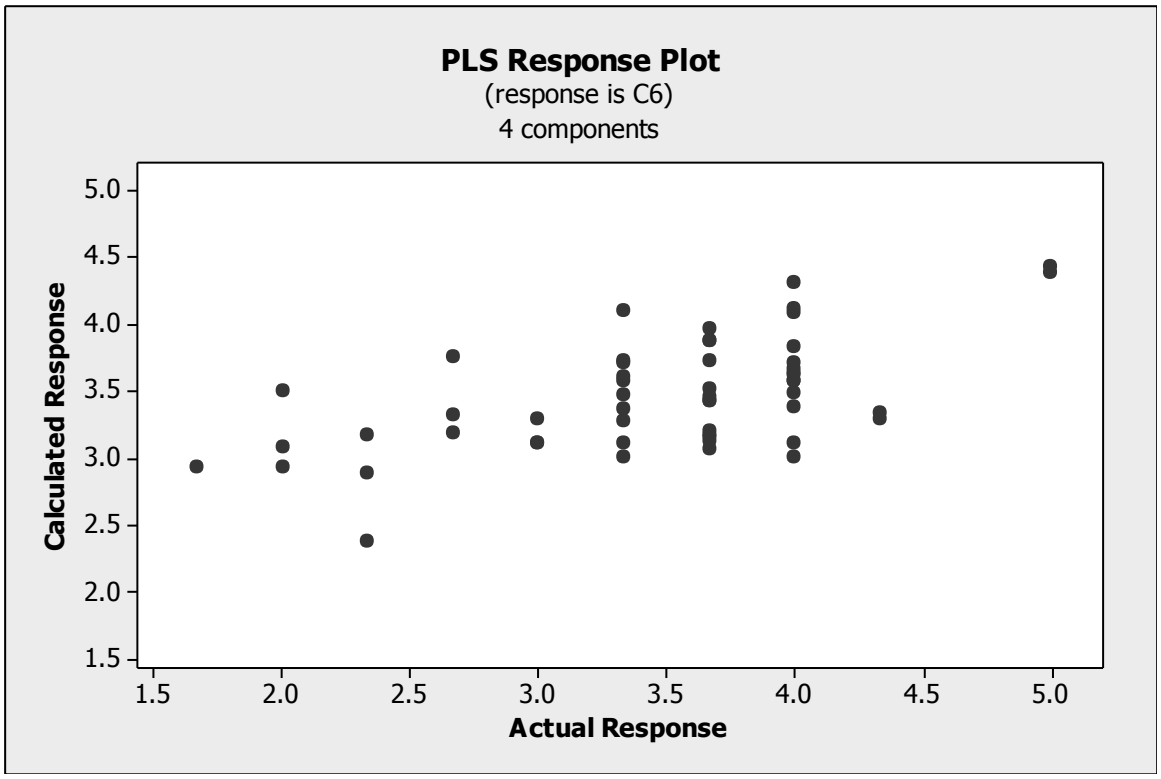


Figure 4.8: PLS Response Plot



Environmental Performance= 3.394-0.48*Green Product & Process Design+0.81*Green Procurement-0.061*Green Logistics-0.208*Regulatory Norms + Error

The above discussed the results, based on the response gathered with the help of questionnaire. First of all data set was prepared with the help of SPSS 20. To test the internal consistency of instrument used in present study, is checked by calculating the Chronbach's alpha and it is found that instrument is reliable. Exploratory factor analysis method was applied to identify the constructs of GSCM practices and organizational performance. Four GSCM practices antecedents namely green process and product design, green purchasing, green logistics and regulatory norms were identified with high factor loadings (greater than 0.5) and high reliability (Chronbach's alpha >0.7).

In case of performance measures, it is found that performance measures items are loaded on two factors namely business performance and environmental performance. The exploratory factor analysis output is

further used as an input for carrying out partial least square regression modeling. The next chapter presents conclusions, recommendations, limitations and further research directions.

6. Conclusion and Unique Contribution

The present study clearly highlights that Indian manufacturing firms have slowly realized the importance of sustainability practices. In India GSCM practices are in infancy stage and a long way to travel. However some interesting and encouraging findings has motivated researcher to offer some insights on the basis of findings which can certainly benefit those manufacturing companies who are willing to adopt GSCM practices.

The manufacturing company who believes in collaborative practices of process and product design and involves their suppliers in manufacturing strategy enjoys superior advantage in terms of positive business performance and environmental performance. However, it is limited only among Indian automotive component manufacturers. However majority of the manufacturing firms in India are yet to understand the importance of green practices.

Regulatory norms are one of the determinants of GSCM practices but respondents have rated as least preferred variable. It is important in initial stage but it provides an opportunity to law protectors to extract maximum benefits from these manufacturers or promotes unethical practices. Hence, in spite of strict environmental norms most of the manufacturers on small scale or medium enterprises are able to violate these norms. This is one of the prime reasons for high carbon emission level in India. It is thus important to conduct seminars and forums to address the potential benefits to these manufacturing companies in long terms in terms of superior business performance by implementing GSCM practices.

6.1 Limitations of Present Study

Like any other research, the present study has its own limitations which will become the future research directions. The present study outcome is based upon survey conducted among 54 manufacturing companies. However in order to take care of the small sample size researcher has used PLSR to test hypotheses.

Secondly, R-Sq value of the conclusive model is 22.6% and 33.2% which indicates that there are other variables which are not explored in present study. However, the study can be further explored with large sample size.

Thirdly, Convenience sampling technique has been adopted to conduct survey.

6.2 Future Research Directions

There is an immense opportunity to extend present work. In order to validate empirical findings a case study approach can be adopted as there are few players who have successfully implemented GSCM practices in India. Hence, survey methodology will have its own limitation. At present random sampling technique will be serious challenge as GSCM practices in India is in infancy stage.

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References:

[1] Angel del Brio, J. and Junquera, B. (2003), "A review of the literature on environmental innovation management in SMEs: implications for public policies", Technovation, Vol. 23, No. 12, pp. 939-48.

[2] Bai, Chunguang; Sarkis, Joseph; Wei, Xiaopeng and Koh, Lenny ((2012), "Evaluating ecological sustainable performance measures for supply chain management", Supply Chain Management; an International Journal, Vol. 17, No.1, pp. 78-92.

[3] Bhateja, A.K.; Babbar , R.; Singh, S. and Sachdeva,A (2012), "Study of the critical factor finding's regarding evaluation of green supply chain performance of Indian scenario for manufacturing sector", International Journal of Computational Engineering& Management, 15(1), pp. 74-80.

[4] Bhateja, A.K.; Babbar , R. ; Singh, S. and Sachdeva, A. (2011) Study of Green Supply Chain Management in Indian Manufacturing : A Literature Review cum An Analytical for a measurement of performance , International Journal of Computational Engineering , 13, 84-99

[5] Bjorklund, M., Martinsen, U. and Abrahamson, (2012), 'Performance measurements in the greening of supply chains', Supply Chain Management: An International Journal, Vol.17, No. 1, pp. 29–39.

[6] Carter, C.R. and P.L. Easton (2011), "Sustainable Supply Chain Management: Evolution and Future Directions", International Journal of Physical Distribution & Logistics Management, Vol. 41, No. 1, pp. 46-62.

[7] Carter, C. R., and Rogers, D.S. (2008) "A framework of sustainable supply chain management: moving toward new theory", International Journal of Physical Distribution & Logistics Management, Vol. 38, No. 5, pp. 360 – 387

[8] Chan, F. (2003) "Performance Measurement in a Supply Chain", The International Journal of Advanced Manufacturing Technology, Vol. 21, No. 7, pp. 534-548.

[9] CII- Mc Kinsey Report, Made in India-The next big manufacturing story, accessed on 15.9.12 at 12.16 pm from www.mckinsey.com/locations/india/mckinseyon india/pdf/made_in_india.pdf

[10] Darnall, N., Jolley, G.J., and Handfield, R., (2008), "Environmental Management Systems and Green Supply Chain Management: Complements for sustainability? " Business Strategy and the Environment, 17 (1) pp. 30-45

[11] Das, P. (2012), "Sustainable Supply Chains: Eco-friendly Packaging and the Indian Challenges", Available at http://www.managementcanvas.iimindore.in/icanvas/index.php (Accessed on February 8, 2013).

[12] Duarte, S; Cabrita, R and Machado, VC (2011) Exploring Lean and Green Supply Chain Performance Using Balanced Scorecard Perspective, Proceedings of the 2011 International Conference on Industrial Engineering and Operations Management , Jan 22-24,520-526.

[13] Dubey, R., Bag, S., Ali, S.S. and Venkatesh, V.G. (2013) 'Green purchasing is key to superior performance: an empirical study', International Journal of Procurement Management, Vol. 6, No. 2, pp. 187–210.

[14] Dües CM, Tan KH, Lim M, (2011), " Green as the new lean: How to use lean practices as a catalyst to greening your supply chain", Journal of Cleaner Production, doi: 10.1016/j.jclepro.2011.12.023.

[15] European Commission (2006), "Environmental fact sheet: industrial development", March 2006, (http://ec.europa.eu.pdf Retrieved April 8, 2013)

[16] Field, J., and Sroufe, R., (2007), "The use of recycled materials in manufacturing: implications for supply chain management", International Journal of Production Research, 45(18-19), pp. 4439-4463.

[17] Gangele, A., and Verma, A., (2011), "The investigation of green supply chain management practices in pharmaceutical manufacturing industry through waste minimization", International Journal of Industrial Engineering and Technology, Vol. 3, No. 4, pp. 403-415

[18] Gavronski, I. et al. (2011) 'A resource-based view of green supply management', Transportation Research Part E: Logistics and Transportation Review, Vol.47. No. 6, pp. 872–885.

[19] Geffen, C.A. and S. Rothenberg (2000), "Suppliers and Environmental Innovation: The Automotive Paint Process", International Journal of Operations and Production Management, Vol. 20, No. 2, pp. 166-186.

[20] Giovanni, P.D. (2012), "Do Internal and External Environmental Management Contribute to the Triple Bottom Line?",International Journal of Operations and Production Management, Vol. 32, No. 3, pp. 265-290.

[21] Giovanni, P. (2011) "Environmental collaboration in a closed-loop supply chain with a reverse revenue sharing contract," Annals of Operations Research, Jun Online 1572-9338.

[22] Green, Jr., K.W., P.J. Zelbst, J. Meacham and V.S. Bhadauria (2012 a), "Green Supply Chain Management Practices: Impact on Performance", Supply Chain Management: An International Journal, Vol. 17, No. 3, pp. 290-305.

[23] Green, Jr., K.W., P.J. Zelbst, V.S. Bhadauria and J. Meacham (2012 b), "Do Environmental Collaboration and Monitoring Enhance Organizational Performance?", Industrial Management & Data Systems, Vol. 112, No. 2, pp. 186-205.

[24] Green, K. W.; B. Morton and S. New (1998), "Green Purchasing and Supply Policies: Do They Improve Companies' Environmental Performance?" Supply Chain Management, Vol. 3, No. 2, pp. 89-95.

[25] Hall, J., Matos, S. and Silvestre, B. (2012), "Understanding why firms should invest in sustainable supply chains: a complexity approach", International Journal of Production Research, Vol. 50, No. 5, pp. 1332-1348.

[26] Hart, S.L. (1995), "A Natural-Resource-Based View of the Firm", The Academy of Management Review, Vol. 20, No. 4, pp. 986-1014.

[27] Sarkis, J. (2002), A strategic decision framework for green supply chain management, Journal of Cleaner Production 11, pp. 397–409.

[28] Hoffman, W. (2007), "Who's carbon-free? Wal-Mart takes on supply chains of products as expansive carbon measuring plan eyes distribution", Traffic World, Vol. 271, No. 42, pp. 15.

[29] Hollos D., C. Blome and K. Foerstl (2012), "Does Sustainable Supplier Cooperation Affect Performance? Examining Implications for the Triple Bottom Line", International Journal of Production Research, Vol. 50, No. 11, pp. 2968-2986.

[30] Hsu, C.W., & Hu, A.H. (2008), "Green Supply Chain Management in the Electronic Industry", International Journal of Science and Technology, Vol. 5, No. 2, pp. 205-216.

[31] Ish , aswini and S.K. Datta (2011), "Pro-environmental Concern Influencing Green Buying: A Study on Indian Consumers", International Journal of Business and Management, Vol. 6, No. 6, pp. 124-133.

[32] Jackson, H., (2010), "Is the cost of being green sustainable", pp. 36-41 available at www.cilt.org.uk (Accessed on September 2012).

[33] Johannesburg Summit, 2002. Retrieved from
http://www.un.org/jsummit/html/prep_process/asiapacific_prep1/malaysia_roudtable_report.htm

[34] Kim, J.H., Youn, S., and Roh, J.J. (2011), "Green Supply Chain Management Orientation and Firm Performance: an evidence from South Korea", International Journal of Services and Operations Management, Vol. 8, No.3, pp. 283-304.

[35] Krikke, H. R. *et al*. (2003), Concurrent Product and Closed-Loop Supply Chain Design with an Application to Refrigerators, International Journal of Production Research 41(16), pp. 3689-3719

[36] Kumar, S., S. Teichman and T. Timpernagel (2012), "A Green Supply Chain is a Requirement for Profitability", International Journal of Production Research, Vol. 5, No. 1, pp. 1278-1296

[37] Lamming, R., Cousins, P., Bowen, F. and Faruk, A. (1999), "A comprehensive conceptual model for managing environmental impacts, costs and risks in supply chains", Working paper, Centre for Research in strategic purchasing and supply, University of Bath, Bath.

[38] Lamming, R. and Hampson, J. (1996), "The Environment as a Supply Chain Management Issue", British Journal of Management, Vol. 7, No. S1 (supplement issue), pp. 45-62.

[39] Lenox, M., A. King and J. Ehrenfeld (2000), "An Assessment of Design-for-Environment Practices in Leading US Electronics Firms", Interfaces, Vol. 30, No. 3, pp. 83-94.

[40] Li *et al* (2006), The impact of supply chain management practices on competitive and organizational performance, Omega 34, 107–124

[41] Linton, J.D., R. Klassen and V. Jayaraman (2007), "Sustainable Supply Chains: An Introduction", Journal of Operations Management, Vol. 25, pp. 1075-1082.

[42] Lund, R. T. (1984). Remanufacturing, Technology Review, 87 (2), 19-27.

[43] Luthra, S., et.al, (2011),"Barriers to implement green supply chain management in automobile industry using interpretative structural modeling technique-An Indian perspective", Journal of Industrial Engineering and Management, Vol. 4. No. 2, pp. 231-257. ISSN: 2013-8423.

[44] Luthra, S., Kumar, V. ; Kumar, S. and Haleem Abid (2011), Barrier to Implement Green Supply Chain Management in Automobile Industry using interpretive structural modeling technique- An Indian Perspective , Journal of Industrial Engineering and Management , vol4, no2 ,231-257.

[45] Min, H. and W.P. Galle (2001), "Green Purchasing Practices of US Firms", International Journal of Operations and Production Management, Vol. 21, No. 9, pp. 1222-1238.

[46] Min, H. and Galle, W. (1997), "Green purchasing strategies: trends and implications", International Journal of Purchasing and Materials Management, Vol. 4, pp. 10-17.

[47] National Productivity Council (2006), "Development of Guidelines for water conservation in pulp and paper sector",(http://cpcb.nic.in/newitems/45.pdf retrieved on 7th,April 2013)

[48] Planning Commission Report of Working Group, Government of India (2012), "Effectively Integrating Industrial Growth and Environmental Sustainability: Twelfth Five Year Plan (2012-2017)" (http://planningcommission.nic.in/aboutus/committee/wrkgrp12/wg_es0203.pdf, retrieved on 7th April,2013)

[49] Porter, M.E. and C. van der Linde (1995), "Green and Competitive: Ending the Stalemate", Harvard Business Review, Vol. 73, pp. 120-133.

[50] Raghavendran, P.S., Xavier, M.J. and Israel, D. (2012) 'Green purchasing practices: a study of eprocurement in B2B buying in Indian small and medium enterprises', Journal of supply Chain and operations Management, Vol. 10, No. 1, pp. 13–23.

[51] Rao, P. and D. Holt (2005), "Do Green Supply Chains Lead to Competitiveness and Economic Performance?", International Journal of Operations & Production Management, Vol. 25, No. 9, pp. 898-916.

[52] Rao, P. (2002), "Greening the Supply Chain: A New Initiative in South East Asia", International Journal of Operations and Production Management, Vol. 22, No. 6, pp. 632-655.

[53] Sarkis, J., (2003), A strategic framework for Green Supply Chain Management, Journal of Cleaner Production, Vol. 11, No. 4, pp. 397-409.

[54] Schoenherr, T (2012), "The role of Environmental Management in Sustainable Business Development: A Multi-Country Investigation", International Journal of Production Economics, Vol. 140, pp. 116-128.

[55] Seman, N.A.A; Zakun, N. ; Jusoh , A and Arif, M.A. (2012), Green Supply Chain Management : A Review and Research Direction , International Journal of Managing Values and Supply Chain , Vol. 3, 1 , pp. 1-18.

[56] Seuring, S., and Muller, M., (2008), "From a literature review to a conceptual framework for supply chain management", Journal of Cleaner Production, Vol. 16, No. 15, pp. 1699-1710.

[57] Shi, V.G., S.C.L. Koh, J. Baldwin and F. Cucchiella (2012), "Natural Resource Based Green Supply Chain Management", Supply Chain Management: An International Journal, Vol. 17, No. 1, pp. 54-67.

[58] Shrivastava, P. (1995), "The Role of Corporations in Achieving Ecological Sustainability", The Academy of Management Review, Vol. 20, No. 4, pp. 936-960.

[59] Shukla, A.C., Deshmukh, S.G., and Kanda, A., (2009), "Environmentally responsive supply chains: Learning from the Indian auto sector", Journal of Advances in Management Research, Vol. 6, No. 2, pp. 154-171.

[60] Simpson, D. and D. Samson (2008) "Developing Strategies for Green Supply Chain Management," Decision Line, 39, 4, 12-15.

[61] Singh, A; Singh , Bhim and Dhingra , Ashwani K. (2012), "Drivers and Barriers of Green Manufacturing Practices: A survey of Indian Industries", International Journal of Engineering Sciences, Vol. 1, No. 1, pp. 5-19.

[62] Singh, L. P., et al, (2011), "Role of Logistics and Transportation in green supply chain management: An exploratory study of courier service industry in India", International Journal of Advanced Engineering Technology, 2(1), pp. 260-269

[63] Solvang,W. D., Z. Deng, and B. Solvang (2007) "A closed-loop supply chain model for managing overall optimization of eco-efficiency," in POMS 18th Annual Conference. Dallas Texas, U.S.A.

[64] Srivastava, S.K., (2007), "Green supply chain management: A state of the art literature review", International Journal of Management Reviews, Vol. 9, No. 1, pp. 53-80.

[65] Vachon, S., (2007), "Green supply chain practices and the selection of environmental technologies", International Journal of Production Research, 45(18-19), pp. 4357-4379

[66] Vachon, S. and Klassen, R.D. (2006), "Extending green practices across the supply chain: The impact of upstream and downstream integration", International Journal of Operations & Production Management, Vol. 26, No. 7, pp. 795-821.

[67] Wahid, N.A., Rahbar, E. and Shyan, T.S. (2011) "Factors influencing the green purchase behavior of Penang environmental volunteers", Journal of International Business Management, Vol.5, No. 1, pp. 38–49.

[68] Wong, C.W.Y., K-H.Lai, K-C.Shang, C-S. Lu and T.K.P. Leung (2012), "Green Operations and the Moderating Role of Environmental Management Capability of Suppliers on Manufacturing Firm Performance", International Journal of Production Economics, Vol. 140, pp. 283-294.

[69] Yang, C.L., and Sheu, C., (2011), "The effects of environmental regulations on green supply chains", African Journal of Business Management, Vol. 5, No.26, pp. 10601-10614.

[70] Yang, W. and Zhang, Y. (2012), "Research on factors on green purchasing practices of Chinese", Journal of Business Management and Economics, Vol. 3, No. 5, pp. 222–231

[71] Zhu, Q., Sarkis, J., Lai, K., and Geng, Y., (2008), "The role of organizational size in the adoption of green supply chain management practices in China", Corporate Social Responsibility and Environment Management, Vol. 15, No.6, pp. 322-337

[72] Zhu, Qinghua; Sarkis, Joseph (2007),The Moderating Effects of Institutional Pressures on Emergent Green Supply Chain Practices and Performance, International Journal of Production Research, 45 (18-19), pp. 4333-4355.

[73] Zhu Q, Sarkis J, Lai KH (2007) Green supply chain management: pressures, practices and performance within the Chinese automobile industry. J Clean Prod 15:1041–1052 Zhu,Q., e.al, (2005)

[74] Zhu, Q., Sarkis, J., (2007), " The moderating effects of institutional pressures on emergent green supply chain practices and performance', International Journal of Production Research, 45 (18-19), pp. 4333 4355

[75] Zhu, Qinghua; Sarkis, Joseph and Yong Geng (2005), Green supply chain management in China: pressures, practices and performance, International Journal of Operations & Production Management, Emerald Group Publishing Limited, 25 (5), pp. 449-68, 2005.

• Zhou, F., (2009), Study on the implementation of green supply chain management in textile enterprises, Journal of sustainable development, Vol. 2, No.1