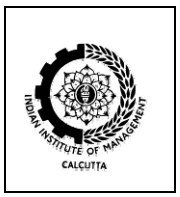


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# A Survey of Sustainable Supply Chain Management Practices in Indian Manufacturing Firms

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# A Survey of Sustainable Supply Chain Management Practices in Indian Manufacturing Firms

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## Abstract

Research on sustainable supply chain management (SSCM) has attracted increased attention in recent years. Although SSCM has been studied for developed and developing countries, there has been little information about the adoption of SSCM practices in India. This paper presents one of the earliest surveys on SSCM practices in Indian manufacturing firms. The items for the survey were developed based on the extant literature and feedback from corporates. Some of the major findings of the survey are as follows. We found that the state of adoption of SSCM practices by Indian firms was still in its infancy, the awareness of sustainability was quite low among consumers, and the regulatory framework was also lacking in terms of promoting sustainability. Results of data analysis showed that supplier collaboration for sustainability had a positive impact on sustainable product design and logistics, which in turn was positively related to competitiveness and economic performance of the firm. We also observed that Indian subsidiaries of multi-national corporations (MNC) were more likely to adopt SSCM practices than non-MNC domestic firms. We compared the results with the observations made by other researchers for developed and developing countries, and provided managerial implications for the government and manufacturers as to what steps need to be taken to generate awareness towards sustainability and facilitate the adoption of SSCM practices among Indian firms to a greater extent. We conclude the paper by indicating directions for future research on SSCM.

**Keywords:** Sustainability; Supply chain management; Survey; India; Factor analysis; Structural equation modelling

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## 1. Introduction

Sustainability or sustainable development is a much-discussed and significant topic of today in the light of increasing environmental degradation (global warming, depletion of the ozone layer etc.) and violation of human rights (Gladwin et al., 1995). Sustainable development is defined as the development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987, also known as the Brundtland Commission). Sustainability has three dimensions: economic, social and environmental, also known as the triple bottom line (TBL) or 3BL, as shown in Figure 1.

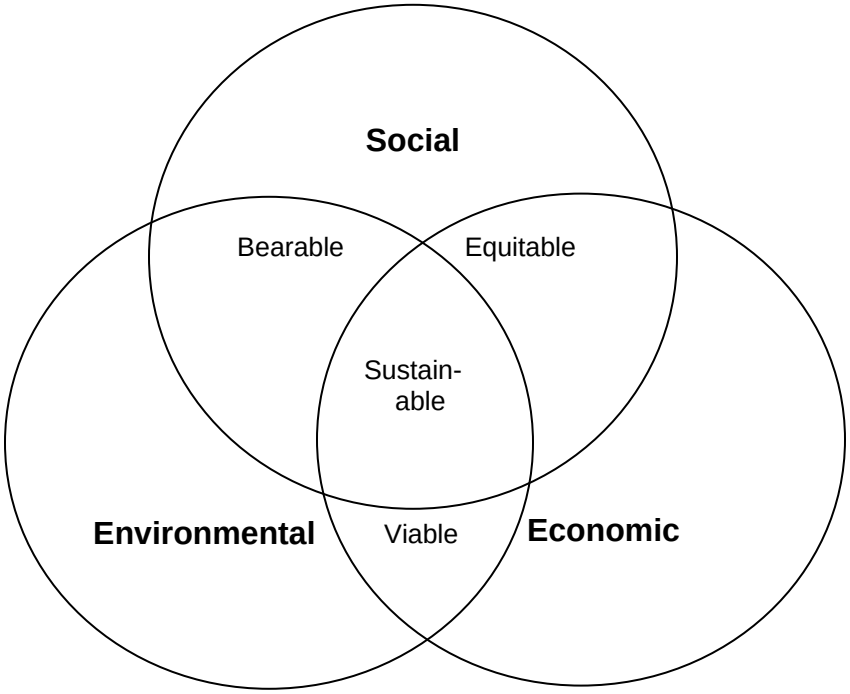



**Fig. 1: Dimensions of sustainability: Triple Bottom Line (TBL or 3BL)**

While economic viability is necessary for an organization to survive, it is not sufficient to sustain the organization in the long run if it causes irreversible damages to the ecosystem by emitting greenhouse gases (GHG) and toxic wastes and depleting non-renewable resources or it fails to ensure safety, security, dignity, healthcare, minimum wage,

indiscrimination and better working conditions for its employees, the community and the society in general. Therefore, it has become imperative for any organization to behave in a socially and environmentally responsible manner while trying to achieve its economic goals.

Although supply chain management has been widely studied since the last two decades, the discussion on sustainability in the supply chain literature has gained momentum since the early 2000s. Figure 2 traces the evolution of supply chain management (SCM) through the last four decades.

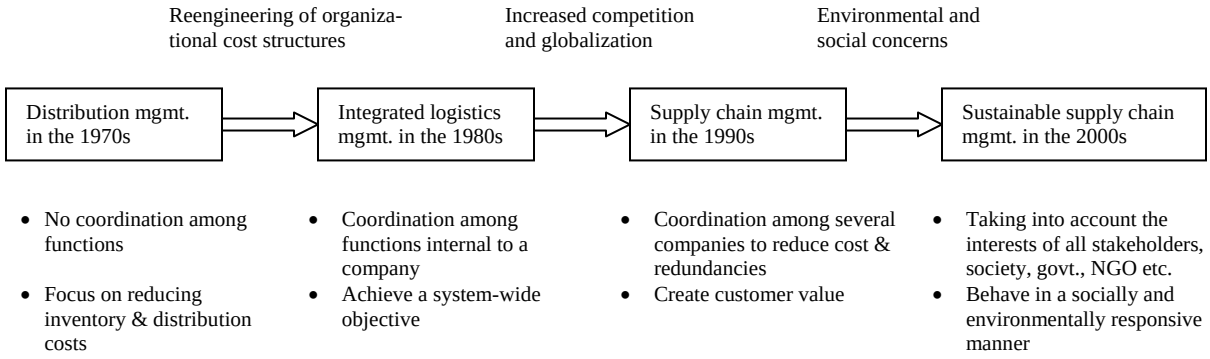



**Fig. 2: Evolution of supply chain management**

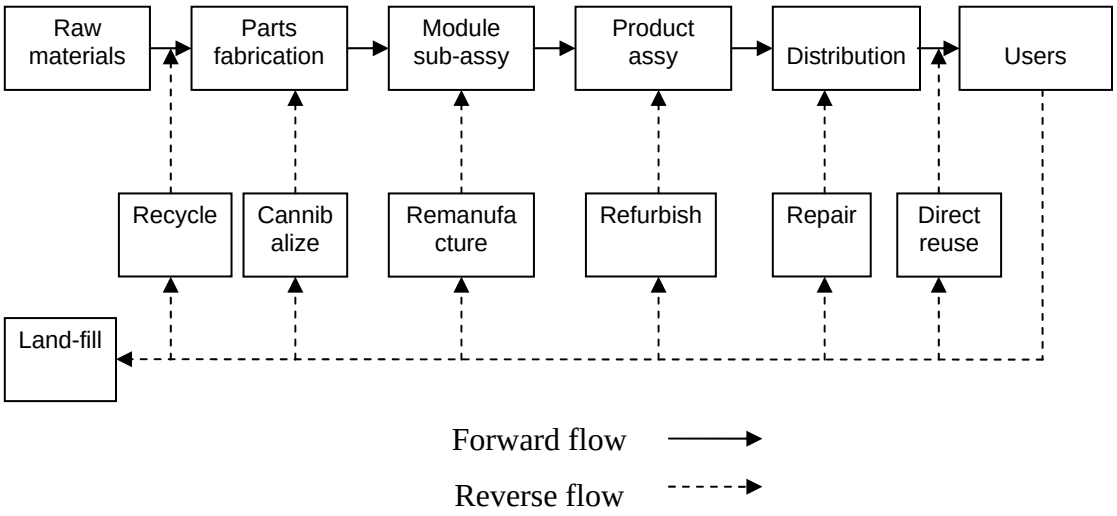
The evolution of SCM can be traced back to "distribution management" in the 1970s where there was no coordination among the various functions of an organization, and each was committed to attain its own goal. This myopic approach transformed into "integrated logistics management" in the 1980s that called for the integration of various functions to achieve a system-wide objective. SCM, which evolved in the 1990s due to increased competition and globalization, further widens this scope by including the suppliers and customers into the organizational fold, and coordinating the flow of materials and information from the procurement of raw materials to the consumption of finished goods. The objectives of SCM are to eliminate redundancies, and reduce cycle time and inventory so as to provide better customer service at lower cost (Mitra and Chatterjee, 2000). In the 2000s, it became imperative for a company to not only incorporate suppliers and customers into the supply chain, but also take into

consideration the interests of all the stakeholders including the community, society, government, NGOs and other public interest groups. The notion that besides fulfilling its economic objectives, a supply chain has to behave in a socially and environmentally responsive way gave birth to the concept of sustainable supply chain management (SSCM).

Carter and Rogers (2008) define SSCM as "the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key interorganizational business processes for improving the long-term economic performance of the individual company and its supply chains".

SSCM is a natural extension of the earlier philosophies of JIT, TQM and lean manufacturing, as argued by Corbett and Klassen (2006). According to the authors, any system that minimizes inefficiencies is also more environmentally sustainable. TQM that integrates internal process controls of suppliers, manufactures and customers, gives rise to Total Quality Environmental Management (TQEM) when other stakeholders and the natural environment are also taken into consideration. In the context of supply chains, sustainability has been referred to more in terms of conforming to environmental norms and standards than meeting social expectations. However, that does, in no way, mean that supply chains are indifferent to their social responsibilities. The agenda is gaining momentum in an increasing number of global supply chains, and as a result, the International Organization for Standardization (ISO) has initiated the development of the ISO 26000 international standard on social responsibility, following the well-known ISO 9000 and ISO 14000 standards on quality management and environmental management systems, respectively (Piplani et al., 2008). The role of environment comes more often in the discussion on sustainable supply chains in the context of environment-friendly product and process design, supplier collaboration for "green" purchasing, adoption of cleaner technologies, environmentally safe storage and transportation of goods, and returns management including disposal of end-of-life products and product recovery for reuse and reselling on secondary markets, leading to the evolution of phrases such as "reverse logistics", "closed-loop supply chains" and "green supply chains". Figure 3

represents a closed-loop supply chain and the different product recovery options based on the quality of returns and the degree of disassembly.




*Source: Thierry et al. (1995)*

**Fig. 3: Closed-loop supply chain and different product recovery options**

In many developed countries in North America and Europe, manufacturers are being held responsible by law for collection, transportation and disposal or recovery of their products and packaging after use since areas earmarked for land-filling are gradually shrinking. Even the awareness among the general public towards environment-friendly products and processes has substantially increased. There is a market for "green" products, which is estimated to be in excess of USD 200 billion (Carter and Ellram, 1998). Since manufacturers are now being held accountable for the entire life cycle of their products, they should strive to design more eco-friendly and easily recoverable products, and recover the economic value as far as possible from returns. This would not only help them achieve economic sustainability, but also facilitate projecting their environmental responsibility and building a "green" corporate image. Incorporating SSCM practices into their organizations, companies can realize first-mover, competitive advantages through cost leadership and differentiation that would be difficult for their competitors to easily imitate. Sustainability has evolved as another competitive priority

besides cost, quality, delivery, flexibility and innovation. Companies adopting SSCM practices can now explore new market opportunities and lobby with the government to frame laws and regulations to their advantage (Porter and van der Linde, 1995; Shrivastava, 1995; Kleindorfer et al., 2005; Krause et al., 2009; Flint and Golicic, 2009; Hazen et al., 2011; Schoenherr, 2012; Narasimhan and Schoenherr, 2012). Further reviews on SSCM or closed-loop supply chains are available in Linton et al. (2007), Carter and Rogers (2008), and Guide and van Wassenhove (2009).

Large MNCs such as Xerox, GE, GM, Volvo, HP, 3M and Dow Chemical have made SSCM a part of their corporate mission. 3M's Pollution Prevention Pays (3P) and Dow Chemical's Waste Reduction Always Pays (WRAP) programmes have saved the respective companies millions of dollars and prevented thousands of tonnes of pollution over a number of years (Shrivastava, 1995). Indian companies, especially the exporters, are also pressured into implementing environmental standards by their international clients. Automotive components manufacturers, drugs and pharmaceuticals majors, and large buyers of textiles, handicrafts, leather goods and food products in the U.S. and Europe are now demanding environmentally responsive behaviour from suppliers globally, including India (Mitra, 2004).

India is one of the top emitters of GHG, emitting about 2 billion tonnes of $CO_2$ into the environment in 2009. India ranks third in terms of total emissions in the world, after China (7.7 billion tonnes) and the U.S. (5.3 billion tonnes) (Source: http://www.worldbank.org). Presently, being a non-Annex-I country, India is not subjected to a mandatory emissions reduction target. However, in the event that India succumbs to the pressure from the developed countries to agree to a mandatory cut in emissions or it voluntarily sets a target for itself (e.g. 20% reduction in emissions by 2020), there are significant implications for Indian supply chains to reduce their carbon footprints in the coming years. The concept of sustainability in Indian supply chains is at an early stage (Gupta and Palsule-Desai, 2011). Indian consumers either lack awareness of sustainability (Das, 2012) or even if there is awareness, are not willing to pay premium prices for environment-friendly products (Ishaswini and Datta, 2011). To the best of the

authors' knowledge, there has been little study on SSCM practices in India so far. This paper is one of the earliest studies to conduct a survey to assess the extent of adoption of SSCM practices in Indian manufacturing firms and explore the causal relationships between SSCM practices and firm performance. The impact of adoption of SSCM practices on firm performance has so far been inconclusive (Carter et al., 2000; Pagell et al., 2004; Zhu et al., 2005; Hazen et al., 2011; Zhu et al., 2012; Green et al., 2012a, 2012b). If the present study finds a positive causal relationship between SSCM practices and firm performance, the same can act as a motivating factor for Indian supply chain managers to more proactively adopt sustainable practices. The objectives of the study have been three-fold – (a) to identify the key success factors (KSF) and key performance indicators (KPI) for successful implementation of SSCM practices, (b) to benchmark the Indian practices against the SSCM practices in other developed and developing countries, and (c) to draw implications for supply chain managers in terms of achieving better SSCM practices and thus making positive contributions to the firm, economy and environment.

In this paper, we focused on two dimensions of sustainability – economic and environmental. Therefore, SSCM, as it has been referred to throughout this paper, may as well be referred to as Green Supply Chain Management (GSCM) (Zhu and Sarkis, 2004; Zhu et al., 2005; Rao and Holt, 2005; Vachon and Klassen, 2006; Hazen et al., 2011; Giovanni (2012); Zhu et al., 2012; Kumar et al., 2012; Green et al., 2012b; Shi et al., 2012). The reason for dropping the social dimension of sustainability is that there are many aspects of this dimension such as dignity, diversity, human rights, education, indiscrimination, sanitation, healthcare, social security, food security, infrastructure, living condition and so on, which are very broad in concept and may have no direct link with supply chains per se. As noted by Giovanni (2012), it has been extremely difficult to identify the relevant items and measure social sustainability in supply chains. Although research has proposed some general indicators, till date it has not been able to develop a measurement scale to investigate the social bottom line. According to Shi et al. (2012), social aspects depend on the preferences and values of the people involved, and hence are more complex and less clear than environmental issues. Similar observation was made by

Hollos et al. (2012), who found that the environmental dimension was more observable than the social dimension. Krause et al. (2009) note that while many companies have made progress in terms of environmental and economic issues, significant progress is generally lacking in social issues. Many supply chain managers, who took part in the survey, expressed difficulty in linking the SSCM practices of their firms with the social initiatives and achievements. In literature, the environmental dimension has often received priority over the social dimension and except for a few papers incorporating the social dimension (Hollos et al., 2012; Giovanni et al., 2012; Zailani et al., 2012), most of the papers have dealt with the environmental and economic dimensions only. Also, in literature, SSCM and GSCM have often been interchangeably used (Flint and Golicic, 2009; Carter and Easton, 2011; Wu and Pagell, 2011).

The supply chain that we have considered in this paper consists of the manufacturer and its immediate (Tier-I) suppliers. Customers have not been included in the supply chain (except for 2 items on reverse supply chains, which have not been able to draw adequate responses and will be discussed later) since during the questionnaire design phase of the survey, discussions with the prospective respondents revealed that Indian customers were still lagging behind their U.S. and European counterparts in terms of their awareness towards sustainability and as such there was little or no involvement of customers with manufacturers towards collaborative product and process design, packaging, transportation and distribution of finished goods. This also draws support from the literature (Ishaswini and Datta, 2011; Das, 2012), as mentioned before. Further, the respondents to the survey, who belonged to manufacturing firms, felt comfortable to respond to questions related to their immediate or Tier-I suppliers. Tier-II, Tier-III and other higher-up suppliers have, therefore, been excluded from the survey. Also, in literature, very few papers have included items related to customers (Zhu and Sarkis, 2004; Zhu et al., 2005; Vachon and Klassen, 2006; Zhu et al., 2012; Green et al., 2012a; Green et al., 2012b) and Tier-II suppliers (Zhu and Sarkis, 2004; Zhu et al., 2005; Zhu et al., 2012; Green et al., 2012b).

The organization of the paper is as follows. In Section 2, we review the relevant literature and derive the items for the questionnaire survey. We then review the existing theory, build the research framework and develop the hypotheses to be tested in Section 3. In Section 4, we discuss the research methodology including the design and administration of the questionnaire, data collection and collation, and tools and techniques for data analysis. Section 5 presents the results of the data analysis along with discussions on the results. Section 6 discusses the major findings and their implications for supply chain managers. Finally, concluding remarks and directions for future research are presented in Section 7.

## 2. Literature review

As mentioned in Section 1, the primary objective of this paper has been to explore the causal relationships between SSCM practices and firm performance in the Indian context. SSCM practices include sustainable purchasing practices, and sustainable manufacturing and logistics practices. Drivers of SSCM practices have also been included. In this section, we review the relevant literature on the drivers of SSCM practices, sustainable purchasing practices, sustainable manufacturing and logistics practices, and firm performance, and derive the items for inclusion in the questionnaire.

### 2.1 Drivers of SSCM

Min and Galle (2001) note that many buying firms get involved in sustainable purchasing in a reactive manner in that they do so just to avoid violations of regulatory laws. Rao (2002) notes that adoption of SSCM practices is encouraged by government and market forces. Zhu and Sarkis (2004) also mention competitive and regulatory pressures as drivers of SSCM. Pagell et al. (2004) and Shi et al. (2012) mention about proactive and reactive strategies for sustainability. They note that while proactive strategies relate to pollution prevention rather than pollution control, reactive strategies essentially react to regulations by doing the minimum required by law and customer requirements on environmental concerns. Zhu et al. (2005) note that Chinese manufacturing firms have

increased their environmental awareness due to regulatory, competitive, and marketing pressures and drivers with regulatory factors being the most important among them all. According to Peters et al. (2011), sustainability strategies can be differentiated into compliance and proactive strategies. While compliance strategies reactively follow existing rules, norms and standards, proactive strategies in supply chains lead to voluntary adoption of SSCM practices. Green et al. (2012b) note that in addition to customer requirements, environmental legislations and regulations have been identified as drivers of the adoption of SSCM practices. Krause et al. (2009) and Walker and Jones (2012) note that some firms are driven from within by top management to adopt SSCM practices as part of their business strategy while others are coerced to do so and respond reactively to outside influences such as supplier and customer pressures and regulations.

From the discussion above, it is clear that firms may adopt SSCM practices voluntarily, without any external pressure, or they may be compelled to comply with regulations or adopt SSCM practices under pressure from customers and competitors. This forms the basis for developing the items on the drivers of SSCM.

### 2.2 Sustainable purchasing practices

According to Krause et al. (2009), a firm is no more sustainable than its suppliers and as such the purchasing function becomes central in a firm's sustainability effort. Rao and Holt (2005) note that stakeholders do not always distinguish between a manufacturer and its suppliers. They often hold the manufacturer responsible for any adverse environmental impact caused by the supply chain of which the manufacturer is a part (Rao, 2002). Eighty seven percent of customers would accuse the manufacturer of environmental negligence when its suppliers are environmentally irresponsible (Wong et al., 2012). Therefore, sensitizing suppliers and integrating them with the firm's SSCM initiatives become a priority for the manufacturer. The manufacturer has to generate awareness among its suppliers, and help them set up environment-friendly practices to reduce air emissions, solid and liquid wastes, and discharge of hazardous chemicals and effluents into the environment (Rao, 2002, 2004; Rao and Holt, 2005; Shi et al., 2012). In order to

make the final product non-polluting, bio-degradable and/or recyclable, the manufacturer insists that its suppliers provide materials conforming to pre-specified environmental criteria (Carter et al., 2000; Zailani et al., 2012). Here, by suppliers, we mean not only the suppliers of raw materials, parts and components, but also the suppliers of packaging materials and providers of upstream and downstream logistics services such as transportation, warehousing and so on because all of them are part of the same supply chain (Krause et al., 2009). To ensure that its suppliers strictly follow environment-friendly practices, the manufacture may select them based on environment-related criteria (Min and Galle, 2001; Rao, 2004; Rao and Holt, 2005; Giovanni, 2012) and then periodically monitor/audit their performance for conformance (Zhu and Sarkis, 2004; Rao, 2002; Shi et al., 2012; Zailani et al., 2012). The manufacturer may also insist that its suppliers implement an Environment Management System (EMS) and/or get ISO 14001 certified, which will give an assurance to the manufacturer that its suppliers are following environment-friendly practices, as certified by an external agency (Zhu and Sarkis, 2004; Vachon and Klassen, 2006; Giovanni, 2012; Green et al., 2012b; Shi et al., 2012; Wong et al., 2012; Zailani et al., 2012; Zhu et al., 2005, 2012). This is especially important when the manufacturer and its suppliers are geographically dispersed, e.g. U.S. and European companies sourcing from the South-East Asian region (Rao and Holt, 2005).

Hollos et al. (2012) note that buyers have two options – (a) select and accept only sustainable suppliers and drop suppliers that do not meet environmental standards, and (b) cooperate with existing or new suppliers for higher levels of sustainability. This leads to two types of buyer-supplier relationships – cooperative or collaborative and transactional. In contrast to transactional relationships, cooperative or collaborative relationships can increase the performance of both buyers and suppliers. Drawing from the resource-based view (RBV) (Barney, 1991)/natural resource-based view (NRBV) (Hart, 1995) of the firm, the authors mention sustainability as one of the valuable, rare, inimitable and non-substitutable resources that may be a source of competitive advantage to a firm. Cooperative or collaborative relationships with suppliers for higher levels of sustainability will, therefore, not only improve a firm's performance, but also provide the firm with a significant competitive advantage over its competitors. Vachon and Klassen

(2006) also mention collaborative and transactional or arms-length relationships between buyers and suppliers with the latter being referred to as environmental monitoring. The authors note that even if a firm is high on collaboration, it may be either high or low on monitoring (or vice versa). According to the theory of transaction cost economics (TCE), the cost of monitoring suppliers in arms-length relationships is higher than that for suppliers in collaborative relationships (Carter and Rogers, 2008). Geffen and Rothenberg (2000), based on case studies on the U.S. auto industry, discuss how the shift in buyer-supplier relationships from arms-length to supplier involvement led to greater environmental collaboration and innovations in product and process design. Zhu et al. (2005, 2012) note that greater cooperation and coordination with suppliers, through long-term and strategic relationships, lead to innovation and improved performance. Green et al. (2012a, 2012b) observe that environmental collaboration with suppliers is positively related to organizational performance. According to Narasimhan and Schoenherr (2012), integrated supply management, through supplier collaboration and development, may lead to significant competitive quality advantage. The importance and benefits of a collaborative relationship with suppliers are also highlighted by Pagell et al. (2004), Krause et al. (2009), Carter and Easton (2011), Peters et al. (2011) and Walker and Jones (2012).

Based on the literature review, the following items on collaborative and transactional relationships with suppliers have been adapted and included for the study – generating awareness of suppliers, helping suppliers set up environment-friendly practices, putting pressure on and incentivizing suppliers to implement EMS/ISO 14001, urging suppliers to supply environment-friendly materials, supplier audit and selection based on environment-related criteria.

### 2.3 Sustainable manufacturing and logistics practices

A firm has direct control over its manufacturing and logistics practices to make them environment-friendly. These practices encompass sustainable product and process design, sustainable packaging, storage, transportation and distribution of raw materials and

finished goods, and recovery and/or disposal of products and packaging discarded/returned after use (reverse supply chains).

### 2.3.1 Sustainable product design

Zhu et al. (2005) note that the design of products is critical in that it is the most effective way to reduce the environmental impact of products through pollution prevention. Products should be designed with environment-friendly raw materials, parts and components to reduce energy consumption, emissions, and generation of solid and liquid wastes during production, transportation, storage and usage. Moreover, if products need to be disposed of and/or recycled after use, they should contain more and more bio-degradable and recyclable materials (Carter et al., 2000; Zhu and Sarkis, 2004; Rao and Holt, 2005; Green et al., 2012b; Zhu et al., 2005, 2012). Also, the design should facilitate easy disassembly of products for reuse and recycling (Carter et al., 2000; Carter and Easton, 2011; Hollos et al., 2012; Shi et al., 2012; Wong et al., 2012). A firm along with its supply chain partners should conduct life cycle analysis for its products to assess their environmental impacts through various stages of their life cycles (Carter et al., 2000; Linton et al., 2007; Kumar et al., 2012; Shi et al., 2012; Zailani et al., 2012). Large U.S. electronics firms such as AT&T, Digital, IBM and Xerox have design-for-environment (DfE) practices that involve life cycle analysis of their products. The DfE group at AT&T developed an environmentally-responsible-product (ERP) matrix to assess the life cycle impact of product designs. The DfE group also developed a software tool, the Green Index, to provide product designers with decision support and environmental assessment. At Xerox, designers chose a minimal number of materials from the material-environmental-index to avoid toxic and hazardous materials. The index specified the impact of various materials on the environment and helped designers choose non-toxic materials safe for disposal, reuse and recycling (Lenox et al., 2000; Maslennikova and Foley, 2000).

Based on the literature review, the following items on sustainable product design have been included in the survey – designing products with bio-degradable/recyclable

materials, designing products for easy disassembly and designing in association with life cycle analysis for products.

### 2.3.2 Sustainable process design

Along with sustainable product design, manufacturing processes should also be so designed that energy and resource consumption (Wong et al., 2012), air emissions, and generation of solid and liquid wastes are minimized (Rao, 2002, 2004; Pagell et al., 2004; Rao and Holt, 2005; Giovanni, 2012; Hollos et al., 2012; Narasimhan and Schoenherr, 2012; Shi et al., 2012; Zhu et al., 2012). According to Porter and van der Linde (1995), pollution is equivalent to inefficiency. Pollution in the form of wastes is often created by inefficient material utilization and manufacturing processes. Moreover, there are additional costs for handling wastes, which are of no value. Therefore, pollution prevention, or sometimes called source reduction, should be embraced by manufacturers. Firms should also continuously strive to replace the conventional sources of energy such as coal, oil and natural gas with alternative environment-friendly, renewable sources such as solar and wind energy (Rao, 2002, 2004; Green et al., 2012a, 2012b).

The following items on sustainable process design have been identified for inclusion in the study – reducing energy usage and resource consumption during production, reducing emissions and generation of solid and liquid wastes, and using non-conventional sources of energy.

### 2.3.3 Sustainable packaging, storage, transportation and distribution

Packaging, storage, transportation and distribution activities also need to be designed in an environment-friendly way. Packaging prevents a product from damage and makes it easy to handle. However, packaging materials in the form of wood, metal, glass, plastic and paper also add to the waste stream, if not properly controlled. Therefore, many countries worldwide now issue packaging directives to minimize the flow of packaging materials into the waste stream (Rao and Holt, 2005). For example, in Germany, there is

a legislation that makes it mandatory for manufacturers to take back all the packaging after use (Zsidisin and Hendrick, 1998). Packaging materials should be minimal and light-weight (Carter et al., 2000), and should not have any adverse environmental impact (Rao, 2002; Shi et al., 2012). Moreover, they should be recyclable (Hollos et al, 2012; Wong et al., 2012; Zailani et al., 2012), i.e. used as many times as possible before disposal, and bio-degradable (Zhu et al., 2012) as they need to be disposed of at the end-of-life. Corrugated packaging is being more extensively used since it is easier to recycle. Standardized, reusable shipping containers are also gradually replacing disposable ones. Manufacturers are more and more devising refilling systems for their products that not only reduce packaging wastes, but also save money for consumers (Green et al., 1998). Xerox developed two returnable boxes made of wood and steel to deliver equipment and recover them at the end-of-life. This not only eliminated the need for disposable packaging, but also reduced costs to customers by USD 15 per unit on average and saved USD 3.5 million per annum for the company (Maslennikova and Foley, 2000). Wu and Dunn (1995) identify safe warehousing and storage as a critical issue in distribution. They argue that efficient and safe warehousing layouts not only make it easy for storage, access and retrieval, but also lead to operational improvements and environmental sustainability. For transportation and distribution, firms should explore railways and waterways as alternative modes of transport since they are more environment-friendly (Rao, 2002; Rao and Holt, 2005; Green et al., 2012b; Kumar et al., 2012; Shi et al., 2012; Wong et al., 2012) than the conventional road and air transportation. Railways will also provide economies of scale compared with roadways and airways, which would not only reduce fuel consumption and air pollution, but also decrease the prices of products. Zhu and Sarkis (2004) find a negative impact of the implementation of JIT on environmental performance. Since JIT requires frequent deliveries of small batches, it also leads to diseconomies of scale in transportation, causing additional fuel consumption and environmental pollution. Hence, firms should always strive to ship full truckload (FTL), rather than less-than-truckload (LTL), to achieve economies of scale in transportation.

The relevant items on sustainable packaging, storage, transportation and distribution included in the study are the following – using environment-friendly and recyclable

packaging, using environment-friendly storage, using alternative transport mechanisms and achieving economies of scale in transportation.

### 2.3.4 Recovery and/or disposal of products and packaging after use

Many countries have now passed legislations that hold manufacturers responsible for recovery and/or disposal of their products and packaging discarded/returned after use. The responsibilities of manufacturers include collection, transportation, inspection, recovery and/or disposal of returns. This reverse flow of materials is referred to as reverse logistics, and when integrated with the manufacturer's forward supply chain, is called a closed-loop supply chain. Although compelled by law to handle returns for recovery and/or disposal, manufacturers also find an economic incentive in engaging in the same. For example, in remanufacturing, one of the product recovery options shown in Figure 3, the quality of returns is upgraded to "as good as new" at 40-60% of the cost of manufacturing a virgin product with only 20% of the effort (Lund, 1984; Dowlatshahi, 2000). There is a market for remanufactured products where they are sold with the same warranty as that for a virgin product, but at substantially discounted prices (Thierry et al., 1995). Moreover, being engaged in recovery and/or disposal of returns boosts manufacturers' corporate image (Mitra, 2007, 2009).

There are many decision problems in reverse logistics such as the locations of collection and inspection centres and recovery facilities. Should inspection centres be located close to the points of collection or should they be centralized? In the former arrangement, there will be high investments in equipment for decentralized inspection, but transportation costs will be low since there is no need to carry irrecoverable returns for recovery. On the other hand, in the latter arrangement with centralized inspection, investments in equipment will be low, but transportation costs will be high (Mitra, 2007). Similarly, decisions have to be made on centralization/decentralization of recovery facilities, integration of recovery activities with normal production operations or outsourcing of recovery activities to third parties, and so on (Fleischmann et al., 1997).

Items that have been included for survey in the extant literature on SSCM are on packaging take-back and recycling (Zailani et al., 2012), end-of-life product recovery (Rao, 2002; Rao and Holt, 2005; Shi et al., 2012), returns collection and recycling (Wong et al., 2012; Zhu et al., 2012), and customer cooperation for product take-back (Zhu et al., 2012). Combining these items with the items gleaned from the literature on reverse logistics as mentioned above, the following items have been included in the questionnaire on recovery and/or disposal of products and packaging discarded/returned after use – customer awareness and cooperation, centralized/decentralized collection/inspection/recovery facility, integration of recovery activities with normal production operations or outsourcing of product recovery to third parties, environment-friendly disposal of returns, and pricing and market for recovered products.

### 2.4 Firm performance

There are different dimensions for measuring firm performance – environmental, operational, organizational, financial, economic, marketing and competitive. Environmental performance measures include improvement in compliance, reduction in consumption of energy and harmful materials (Zailani, et al., 2012), reduction in air emissions, and generation of solid and liquid wastes (Rao, 2002; Pagell et al., 2004; Giovanni et al., 2012; Shi et al., 2012; Wong et al., 2012), reduction in environmental accidents (Zhu et al., 2004, 2005; Green et al., 2012a, 2012b; Zhu et al., 2012), and so on. Since almost all the previous studies dealing with environmental performance have found positive relationships between sustainable practices and environmental performance, we felt that inclusion of the environmental dimension of firm performance would be redundant, and hence dropped it. Moreover, we felt that environment performance was better measured by external auditors rather than internal managers, who were the respondents to our survey.

Among the other dimensions, items for measuring firm performance do often overlap. For example, Rao (2002) and Rao and Holt (2005) combine financial, economic and marketing performance measures such as profitability, price, sales, market share and new

market opportunities under economic performance. They argue that adoption of SSCM practices improves a firm's corporate image, which in turn enables the firm to charge premium prices, increase sales and market share, and explore new market opportunities. Eventually, all this leads to increased profitability. Similarly, operational and competitive measures have been combined in the form of quality, productivity, efficiency and cost savings under the competitiveness dimension. Wong et al. (2012) consider different profitability measures under financial performance. Shi et al. (2012) consider quality, productivity, efficiency, flexibility and innovation under operational performance, and profitability, growth, market share and sales under financial performance. Green et al. (2012a, 2012b) consider profitability, growth, market share and sales under organizational performance. Giovanni (2012) consider profitability, market share and cost savings under economic performance. Zailani et al. (2012) consider cost savings under operational performance, and sales, market share and efficiency under economic performance. Zhu and Sarkis (2004), Zhu et al. (2005, 2012) and Green et al. (2012b), on the other hand, consider cost savings under economic performance and quality under operational performance. Hollos et al. (2012) consider quality and innovation under operational performance, and cost savings under a different dimension called cost reduction. Schoenherr (2012) uses cost, quality, delivery and flexibility as plant performance measures.

As indicated above, items may belong to different dimensions of firm performance depending on perception. We have followed Rao (2002) and Rao and Holt (2005), and retained the following two dimensions of firm performance – economic performance and competitiveness[2]. While economic performance covers organizational, financial, economic and marketing performance measures, competitiveness covers the operational and competitive dimensions of firm performance. The items that we felt relevant and have been included in the study are the following – quality, productivity, efficiency, innovation, cost savings, sales, market share, penetration of new market, acquisition of new customers, organizational profitability and growth. In addition, we felt the following items should be included in the study – corporate image, first-mover advantage, long-

[2] Factor analysis results discussed later show that the items have indeed loaded on two factors.

term benefits, patenting of products and processes, and influencing policy makers. It has already been mentioned that adoption of sustainable practices in supply chains enhances corporate image (Zailani et al. (2012) mentions this as a social performance measure). Adoption of sustainable practices also provides a first-mover competitive advantage including patenting of products and processes and influencing policy makers to frame rules and regulations to the advantage of the firm (Porter and van der Linde, 1995; Carter and Rogers, 2008). In the 1990s, German automaker BMW initiated a "design-for-disassembly" programme for product take-back and recycling, and being a first-mover, entered into long-term contractual agreements with a handful of sophisticated dismantlers. This initiative not only enhanced BMW's reputation as a maker of DfE automobiles, but also enabled BMW to influence the government to make product take-back and recycling a national standard in the German auto industry. When the other automakers had no other option but to follow suit, they were left to deal with small-scale, unorganized dismantlers and face diseconomies of scale. Since by then BMW had already built its dismantling infrastructure, it enjoyed a definite cost advantage over its competitors (Hart, 1995; Shrivastava, 1995).

## 3. Research framework

In this section, we review the existing theory, build the research framework and develop the hypotheses to be tested in this paper. In particular, the causal relationships among voluntary adoption, SSCM practices (sustainable purchasing and sustainable manufacturing and logistics practices) and firm performance are explored. The following subsections discuss the theory behind every pair of causal relationships and propose the hypotheses.

### 3.1 Voluntary adoption and firm performance

In the discussions on the drivers of SSCM, it was mentioned that firms could adopt SSCM practices voluntarily, without any external pressure from the regulators, customers and competitors. Voluntary adoption would provide firms with a first-mover competitive

advantage including innovations in design, patenting of products and processes, and influencing policy makers to frame rules and regulations to their advantage. Klassen and McLaughlin (1996), Flint and Golicic (2009) and Peters et al. (2011) note that proactive or voluntary sustainability strategies provide competitive advantages in terms of avoiding eventually higher costs of adoption of SSCM practices at a later point in time, putting pressure on competitors to invest in similar sustainability strategies and creating a market entry barrier for firms with unsustainable supply chains. Pagell et al. (2004), Zhu and Sarkis (2004), and Walker and Jones (2012) also note that proactivity in SSCM leads to firm competitiveness and economic performance. Therefore, we propose the following hypotheses.

Hypothesis H1a: Voluntary adoption of SSCM practices is positively related to competitiveness.

Hypothesis H1b: Voluntary adoption of SSCM practices is positively related to economic performance.

### 3.2 Voluntary adoption and SSCM practices

Firms adopt SSCM practices either voluntarily or under regulatory, competitive and customer pressure. Firms adopting SSCM practices voluntarily are more likely to take proactive sustainability initiatives in the form of guidelines, checklists, policies, codes of conduct, management systems, certification schemes, programmes and roundtables for their own and partner firms, than firms adopting SSCM practices under external pressure (Peters et al., 2011). Therefore, the following hypotheses are proposed.

Hypothesis H2a: Firms adopting SSCM practices voluntarily are more likely to engage in sustainable purchasing practices with their suppliers than firms that adopt SSCM practices under regulatory compliance and customer and competitive pressure.

Hypothesis H2b: Firms adopting SSCM practices voluntarily are more likely to engage in sustainable manufacturing and logistics practices than firms that adopt SSCM practices under regulatory compliance and customer and competitive pressure.

### 3.3 Sustainable purchasing, manufacturing and logistics practices

There is no consensus in the extant literature with respect to the causality between sustainable purchasing and sustainable manufacturing and logistics practices. Either no causality is assumed between these practices or if there is causality, there is no consensus on the direction of causality. Zhu and Sarkis (2004) consider no causal relationship between external GSCM practices and eco-design. Similarly Zailani et al. (2012) consider no causal relationship between environmental purchasing and sustainable packaging. Shi et al. (2012) propose a positive relationship between intra- and inter-organizational environmental practices. Giovanni (2012) considers a positive association between internal and external environmental management. Green et al. (2012a, 2012b) postulate that "green information system" (equivalent to sustainable manufacturing and logistics here) is positively related to environmental collaboration with suppliers/green purchasing. Green et al. (2012b), however, do not consider a causal relationship between green purchasing and eco-design. Rao (2002) finds a positive causal relationship directed from "environmental initiatives" (equivalent to sustainable manufacturing here) to "greening of suppliers". Rao and Holt (2005), on the other hand, find a significantly positive causal relationship directed from "greening inbound" (equivalent to sustainable purchasing here) to "greening outbound" (equivalent to sustainable logistics here). Hollos et al. (2012) also find a strong positive causal relationship directed from "sustainable supplier cooperation" to "green practices". Moreover, Peters et al. (2011) argue that collaboration and good relationships with suppliers help improve the adoption of green practices. Zhu et al. (2012) experiment with three different causal relationships between external (supplier and customer collaboration) and internal (internal environmental management, product and process design) GSCM – no causal relationship, a causal relationship from internal to external GSCM and a causal relationship from external to internal GSCM – and find their mixed effects on firm performance.

Although firms engage in sustainable purchasing practices as a consequence of adopting sustainable manufacturing and logistics practices, the former would have a positive learning effect on the latter in the long run (Hollos et al., 2012). According to Zhu et al. (2012), previous studies show that external GSCM practices facilitate the adoption of internal GSCM practices. Further, they note that environment-friendly inputs, through green purchasing, are a pre-requisite for eco-design of products. In other words, a firm is no more sustainable than its suppliers (Krause et al., 2009), which leads us to propose the following hypothesis.

Hypothesis H3: Sustainable purchasing practices are positively related to sustainable manufacturing and logistics practices.

### 3.4 SSCM practices and firm performance

As discussed before, the literature on the effect of SSCM practices on firm performance has been inconclusive. Klassen and McLaughlin (1996) note that earlier research on the linkage between environmental practices and financial performance has been mixed, although generally positively correlated. King and Lenox (2001) also do not find any conclusive link between the two and call for further investigation. For instance, sustainable purchasing practices are expected to reduce pollution at source, but whether that would translate into improved financial performance is not known. Similarly, sustainable manufacturing and logistics practices are expected to improve the competitiveness of a firm, but whether that would lead to improved financial performance is also not clear (Rao, 2002; Rao and Holt, 2005). Zhu et al. (2012) argue that the lower scale of adoption of external GSCM practices such as supplier collaboration compared with the scale of adoption of internal GSCM practices such as eco-design might explain the inconclusive results related to firm performance. Some are of the view that investments in SSCM practices are a zero-sum game, reducing profitability by an equal amount (Pagell et al., 2004). Others view these investments as a short-term reduction in profitability (Zhu et al., 2005, 2012; Wu and Pagell, 2011)

leading to a long-term economic and competitive advantage (Zhu and Sarkis, 2004; Krause et al., 2009).

Rao and Holt (2005) note that since consumers are becoming more and more aware of the environment, environmental issues have emerged as a source of competitive advantage. Adoption of SSCM practices would improve operational performance through increased efficiency of processes and recycling of wastes, and avoidance of penalties, disposal costs and higher future costs of compliance. Moreover, environmental practices would enhance corporate image, increase market share and new market opportunities, and thereby lead to improved financial performance (Klassen and McLaughlin, 1996; Carter et al. 2000).

According to Schoenherr (2012), previous research has shown a positive effect of investments in environmental practices on a firm's competitive advantage and operational performance. Shi et al. (2012) propose that intra- and inter-organizational environmental practices are positively related to operational and financial performance. Klassen and McLaughlin (1996), Carter et al. (2000), Zhu and Sarkis (2004), Rao and Holt (2005), Hollos et al. (2012), Zailani et al. (2012) and Zhu et al. (2012) also find a positive effect of environmental purchasing/green practices on firm performance. Green et al. (2012a, 2012b) find an indirect positive relationship between environmental practices and organizational performance through other performance measures. Giovanni (2012), on the other hand, finds no significant direct relationships between internal and external environmental management and economic performance. Wong et al. (2012) examine the moderating effect of the environmental management capability of suppliers on the causal relationships between product and process stewardship and pollution reduction and financial performance, and find mixed results.

A review of the recent literature, as above, indicates mostly positive linkages between SSCM practices and firm performance, and leads us to propose the following hypotheses.

Hypothesis H4: Sustainable purchasing practices are positively related to competitiveness.

Hypothesis H5: Sustainable purchasing practices are positively related to economic performance.

Hypothesis H6: Sustainable manufacturing and logistics practices are positively related to competitiveness.

Hypothesis H7: Sustainable manufacturing and logistics practices are positively related to economic performance.

In addition, the following hypothesis is proposed based on the literature (Rao, 2002; Rao and Holt, 2005; Hazen et al. 2011) that suggests a positive relationship between competitiveness and economic/financial performance.

Hypothesis H8: Competitiveness is positively related to economic performance.
Figure 4 shows the research framework and hypotheses to be tested.

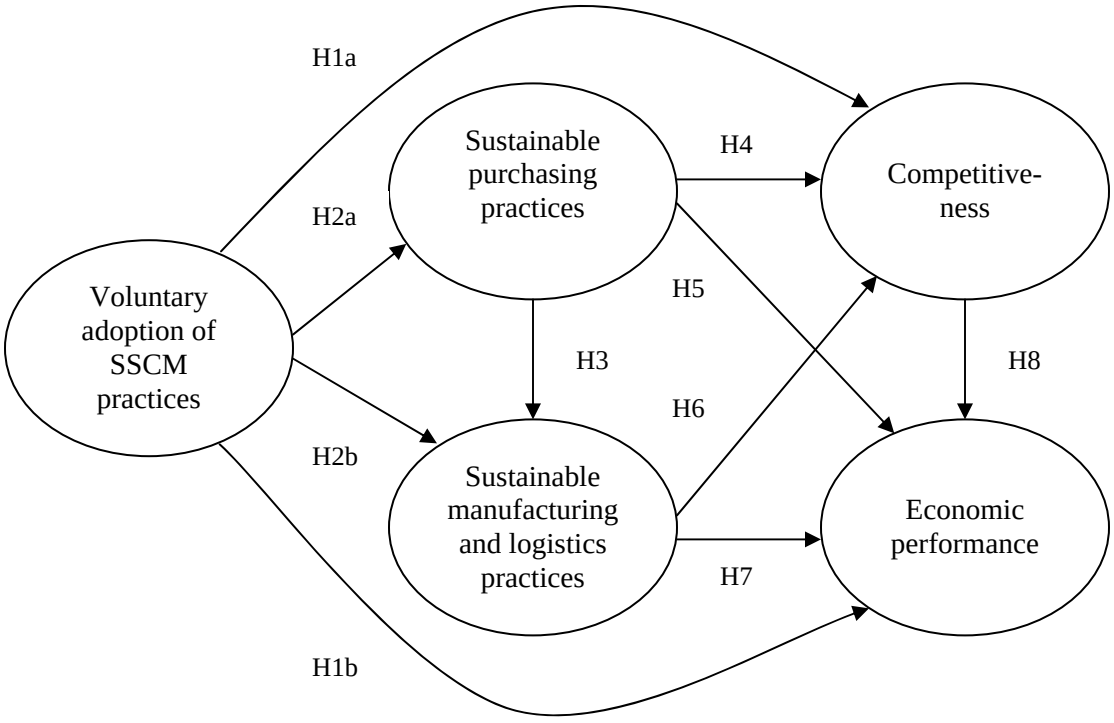



**Fig. 4: Research framework**

We also intend to explore the causal relationships between the following – (a) being ISO 14000 certified and adoption of SSCM practices, and (b) being an MNC and adoption of SSCM practices. Carter and Rogers (2008) associate the implementation of ISO 14000 standards with reduced costs, shorter lead times and better product quality. Pagell et al. (2004) note that a certified EMS, such as ISO 14000, leads to higher levels of operational performance. Schoenherr (2012) also finds a positive relationship between the extent of investments in ISO 14000 certification programmes and plant performance in terms of cost, quality, delivery and flexibility. Zhu and Sarkis (2004) and Zhu et al. (2012) find a positive relationship between internal environmental management, of which ISO 14000 certification is a part, and firm performance. However, Zhu et al. (2012) also observe that when green purchasing acts as a mediating variable for the relationship between internal environmental management and firm performance, the mediating effect is not significant.

The literature cited above explores the relationship between ISO 14000 certification and firm performance. However, the literature on the relationship between being ISO 14000 certified and adoption of SSCM practices is rather limited. Rao (2002, 2004) and Rao and Holt (2005) present their findings based on only ISO 14000 certified firms. Therefore, whether firms that are ISO 14000 certified are more likely to voluntarily adopt SSCM practices than firms that are not ISO 14000 certified is not explored. Green et al. (2012a, 2012b) find positive relationships between internal environmental management, of which ISO 14000 certification is a part, and green information system/eco-design (equivalent to sustainable manufacturing and logistics practices) and environmental collaboration with suppliers/green purchasing (equivalent to sustainable purchasing practices). In this studies, however, ISO 14000 is only one of the items of the construct, internal environmental management, and hence the direct causal relationship between ISO 14000 certification and adoption of SSCM practices is not explored. We believe that ISO 14000 certification, besides internal environmental improvement, leads to external collaborations with suppliers and other supply chain partners, and eventual adoption of SSCM practices. To examine the same, we propose the following hypothesis.

Hypothesis 9: ISO 14000 certified firms are more likely to voluntarily adopt SSCM practices, including sustainable purchasing, manufacturing and logistics practices, than firms that are not ISO 14000 certified.

The literature on the effect of being an MNC/non-MNC on the adoption of SSCM practices is scarce. Zhu and Sarkis (2004), in their study on Chinese manufacturing firms, observe that globalization increases MNC investments in developing countries where their subsidiaries are expected to engage in sustainable practices more than their domestic counterparts do. This is also true that MNCs prefer to institute the same environmental practices in every country they operate in, irrespective of the existing rules and regulations, since doing the same would not only confirm their environmental responsibility, but also make it easy for them to replicate and standardize the same set of practices across all the countries. Therefore, we propose the following hypothesis.

Hypothesis 10: MNCs are more likely to voluntarily adopt SSCM practices, including sustainable purchasing, manufacturing and logistics practices, than non-MNC Indian firms.

## 4. Research methodology

The research methodology was based on a survey of Indian manufacturing firms to assess the extent of adoption of SSCM practices and their impact on firm performance in terms of testing the proposed hypotheses. The items and scales for the survey questionnaire, shown in the Appendix, were adapted from the extant literature, as mentioned before, to suit the Indian context. Each response was measured on a 5-point Likert scale where “1” meant “strongly disagree” and “5” meant “strongly agree”. The questionnaire was pre-tested among 10 firms, and based on their feedback, the questionnaire was finalized. Subsequently, we approached in person and over telephone the senior executives looking after or knowledgeable about the supply chain management function of about 232 firms located in the major industrial belts of India with a write-up on SSCM and the survey questionnaire asking the firms whether they deployed some of the SSCM practices listed

in the write-up and the questionnaire. In a way, this was akin to convenience sampling, which was felt appropriate for a developing country at this stage when the awareness of SSCM is still at a low level leading to difficulties in data collection, as also observed by Zhu and Sarkis (2004) in the case of China. Among the firms that responded in the affirmative, 114 agreed to fill in the questionnaire, and finally 81 filled-in, usable questionnaires were received. Since the respondents agreed to fill in the questionnaire and all the questionnaires were filled in in person by appointment, we conclude that there is no non-response bias. The respondent firms varied in size, from tens of millions of USD to a few hundred million USD in revenues (Max: USD 376 million, Min: USD 38 million, Mean: USD 106 million, Median: USD 77 million)[3], and the industry sectors they represented, from automobiles (8.64%), electronics (7.41%), engineering (17.28%) and consumer goods (14.81%) to leather (17.28%), textiles (14.81%), pharmaceuticals (11.11%), cement/iron and steel (8.64%). Therefore, we feel that the findings of this study are generalizable to a great extent across diverse industries and firms of different sizes. All respondent firms are ISO 9000 certified. Seventy two of them have implemented some form of EMS and 29 of them are ISO 14000 certified. The number of MNCs in the sample is 29. We defend the somewhat small sample size by the following arguments. First, since the concept of SSCM is still new in India and we required responding firms to have adopted at least some of the listed SSCM practices, many firms we contacted felt they were not yet ready to respond to the questionnaire. Secondly, our sample size still exceeds, or is comparable with, the sample sizes used by some of the published papers on SSCM/GSCM (See, for example, Rao (2002, 2004), Rao and Holt (2005), Vachon and Klassen (2006), and Hollos et al. (2012)). Finally, our sample size also exceeds the minimum sample size of 50 for multivariate data analysis, as recommended by Hair et al. (2007, p. 136).

Data collected were collated in Microsoft Excel, and analyzed using regression, factor analysis, confirmatory factor analysis and structural equation modelling. Although previous studies conducted factor analysis and assigned items/variables to different latent

[3] Many firms being unlisted and private did not wish to share financial data. The estimates made by the authors were based on informal information and secondary data. The USD~INR (Indian Rupees) exchange rate was taken as the average prevailing in the month of February, 2013.

constructs, there has been non-uniformity in the definition of items and their inclusion in constructs, as already mentioned before. Also, since this is one of the earliest studies on SSCM practices in India, items/constructs specific to the Indian context have not been developed yet. Therefore, we decided to include items in the questionnaire based on literature review and feedbacks received during pre-testing, and conduct factor analysis to identify the latent constructs and their composition of items. A confirmatory factor analysis was carried out for validity, reliability and an overall fit of the model. Regression analysis and structural equation modelling were employed to test the proposed hypotheses. As far as the software is concerned, SAS was used for factor analysis, and AMOS was used for confirmatory factor analysis and structural equation modelling.

## 5. Results and discussions

In this section, we present the results of factor analysis, confirmatory factor analysis, structural equation modelling and regression, followed by discussions. We have followed Hair et al. (2007) throughout for data analysis.

### 5.1 Factor analysis

The following points relate to factor analysis.

- Normality, linearity, homoscedasticity and homogeneity of the sample are assumed.
- The following criteria were satisfied:
    (a) The minimum sample size is 50.
    (b) The minimum respondents-to-variables ratio is 5.
    (c) There exist significant correlations among many of the variables.
    (d) Partial correlations among most of the variables are 0.5 or less.
    (e) The measures of sampling adequacy (MSA), overall and for individual variables, are at least 0.5.
    (f) Based on Harmon's one-factor test, it is found that the unrotated factor solution reveals no single factor, which accounts for more than 50% of the

variance, indicating the non-significance of the issue of common method bias (Hazen et al., 2011).

- We employed the principal components analysis with varimax rotation.
- The number of factors was decided based on the following criteria – (i) empirical evidence, (ii) eigen value is more than 1, and (iii) cumulative percentage of total variance extracted is at least 60%.
- To consider an item to load on a factor, a minimum absolute factor loading of 0.65 is required.
- Communalities of variables should be at least 0.5.
- Content/face validity is assessed through the following means – (i) items taken from the extant literature, (ii) expert opinions, and (iii) pre-testing of the questionnaire.
- Unidimensionality is assessed in terms of items loading on a single factor and non-existence of significant cross-loadings.
- Reliability is assessed through the following means – (i) item-to-item correlation is more than 0.3, (ii) item-to-total (summated scale) correlation is more than 0.5, and (iii) Cronbach's alpha is at least 0.7.

### 5.1.1 Drivers of SSCM

Items 8a-8d in the questionnaire relate to the drivers of SSCM. Table 1 shows the descriptive statistics.

**Table 1: Descriptive statistics related to the drivers of SSCM**

| Questionnaire item | Mean | Standard deviation | % agree or strongly agree |
|---|---|---|---|
| 8a | 3.89 | 0.71 | 77.78 |
| 8b | 2.59 | 1.17 | 27.16 |
| 8c | 2.05 | 0.63 | 0.00 |
| 8d | 2.39 | 0.74 | 4.94 |

The following observations can be made from Table 1.

(a) Most of the respondents adopted SSCM practices voluntarily as the item 8a: Voluntary adoption has a mean score of 3.89 and 77.78% respondents either agree or strongly agree with the item.

(b) Few adopted SSCM practices to comply with regulations with a mean score of 2.59, well below the mid-point of the scale, i.e. 3 for the item 8b: Complying with regulations. This shows that in India, environmental norms are still not as stringent as in developed countries. Strict laws are yet to be put in place to compel firms to follow sustainable practices. Wu and Pagell (2011) also mention about the lack of stringent environmental regulations in China and India.

(c) Items 8c: Adoption under pressure from customers and 8d: Adoption under pressure from competition, are not relevant in the Indian context as evidenced by their very low mean scores and insignificant percentages of the respondents agreeing or strongly agreeing with the items. This shows the lack of external pressure on firms to adopt SSCM practices. Indian customers are still not sensitive towards environmental degradation and like their counterparts in developed countries do not demand environment-friendly practices from manufacturing firms (Ishaswini and Datta, 2011; Das, 2012).

By factor analysis, two meaningful factors were identified. One may be termed *voluntary adoption* and the other *adoption under external pressure*. Table 2 shows the items and their loadings on the respective factors.

**Table 2: Factor loadings for the drivers of SSCM**

| Questionnaire item | Factor 1: Voluntary adoption | Factor 2: Adoption under external pressure |
|---|---|---|
| 8a | 0.77411 | |
| 8b | -0.75544 | |
| 8c | | 0.77606 |
| 8d | | 0.68716 |

*Note: Absolute factor loadings of at least 0.65 are only shown.*

*Items are arranged in the descending order of their factor loadings.*

It may be noted from Table 2 that items 8a: Voluntary adoption and 8b: Complying with regulations, load on the same factor with a negative factor loading for item 8b. This is also confirmed by the significant negative correlation between items 8a and 8b. This indicates that firms, which adopt SSCM practices voluntarily, do not do so for regulatory compliance. Items 8c: Adoption under pressure from customers and 8d: Adoption under pressure from competition, load on the same factor indicating adoption under external pressure. It has already been observed that none of the respondent firms adopted SSCM practices under external pressure. Cronbach's alpha for Factor 1: *Voluntary adoption* is 0.772570 (after reverse scoring item 8b because of its negative factor loading) and the same for Factor 2: *Adoption under external pressure* is 0.731634.

### 5.1.2 Sustainable purchasing practices

Seven items, 9a-9g in the questionnaire relate to sustainable purchasing practices. Table 3 shows the descriptive statistics.

**Table 3: Descriptive statistics related to sustainable purchasing practices**

| Questionnaire item | Mean | Standard deviation | % agree or strongly agree |
|---|---|---|---|
| 9a | 3.15 | 1.00 | 32.10 |
| 9b | 3.04 | 0.81 | 32.10 |
| 9c | 2.38 | 0.75 | 6.17 |
| 9d | 2.19 | 0.63 | 2.47 |
| 9e | 3.58 | 0.74 | 55.56 |
| 9f | 2.96 | 0.84 | 28.40 |
| 9g | 3.31 | 0.94 | 41.98 |

The following observations can be made from Table 3.

(a) Except for the items, 9c: Putting pressure on suppliers to implement EMS and ISO 14001 and 9d: Incentivizing suppliers for conformance to EMS/ISO 14001, all other items have mean scores either very close to 3 or well above 3, the centre of the scale. Also, very small percentages of the respondents either agree or strongly agree in terms of the items 9c and 9d, meaning thereby that Indian firms

do not engage in putting pressure on and incentivizing suppliers as part of their sustainable purchasing practices.

(b) In terms of the percentage of respondents, who agree or strongly agree with an item, the most practised sustainability initiative is to urge suppliers to provide environment-friendly materials. Other sustainable purchasing practices, in the order of their importance, are selecting suppliers based on environment-related criteria, educating and generating awareness among suppliers, helping suppliers set up environment-friendly practices, and auditing suppliers' environmental performance.

By factor analysis, two meaningful factors were identified. One may be termed *collaborative relationships with suppliers* and the other *arms-length or transactional relationships with suppliers*. Table 4 shows the items and their loadings on the respective factors.

**Table 4: Factor loadings for sustainable purchasing practices**

| Questionnaire item | Factor 1: Collaborative relationships with suppliers | Factor 2: Arms-length or transactional relationships with suppliers |
|---|---|---|
| 9f | 0.86574 | |
| 9a | 0.86041 | |
| 9b | 0.83901 | |
| 9g | 0.83271 | |
| 9e | 0.67486 | |
| 9c | | 0.88801 |
| 9d | | 0.83617 |

*Note: Factor loadings of at least 0.65 are only shown.*

*Items are arranged in the descending order of their factor loadings.*

It is not surprising to observe from Table 4 that the items with which considerable percentages of the respondents agreed or strongly agreed belong to the same factor, and the items with which very small percentages of the respondents agreed or strongly agreed belong to the other factor. It may seem counterintuitive to have items 9f: Auditing

suppliers' environmental performance and 9g: Selecting suppliers based on environment-related criteria loaded on Factor 1: *Collaborative relationships with suppliers* while in the literature they have been included as items for environmental monitoring/transactional relationships of/with suppliers (Vachon and Klassen, 2006; Green et al., 2012a). The literature also mentions that after selecting suppliers based on environment-related criteria, the manufacturer should engage in supplier development and collaborative relationships with suppliers for supply chain sustainability, with continuous monitoring/auditing of supplier performance for conformance (Green et al., 2012a). Therefore, in a way, supplier selection and monitoring/auditing are related to supplier collaboration, and this could possibly explain the inclusion of these items in the corresponding factor.

Cronbach's alpha for Factor 1: *Collaborative relationships with suppliers* is 0.881658 and the same for Factor 2: *Arms-length or transactional relationships with suppliers* is 0.796878.

### 5.1.3 Sustainable manufacturing and logistics practices

There are 23 items, 10a-10h, 11a-11e and 13a-13j in the questionnaire on sustainable manufacturing and logistics practices. However, since there were only 24 responses for the items, 13a-13j related to reverse supply chains, we had to drop these items for further analysis, and continue with the remaining 13 items, 10a-10h and 11a-11e on product and process design, packaging, storage and transportation. Table 5 shows the descriptive statistics.

**Table 5: Descriptive statistics related to sustainable manufacturing and logistics practices**

| Questionnaire item | Mean | Standard deviation | % agree or strongly agree |
|---|---|---|---|
| 10a | 3.20 | 1.02 | 44.44 |
| 10b | 3.21 | 0.99 | 44.44 |
| 10c | 3.12 | 0.86 | 35.80 |
| 10d | 3.69 | 0.82 | 61.73 |
| 10e | 3.85 | 0.67 | 76.54 |
| 10f | 2.48 | 0.89 | 17.28 |
| 10g | 3.78 | 0.67 | 76.54 |
| 10h | 3.78 | 0.72 | 75.31 |
| 11a | 3.67 | 0.79 | 64.20 |
| 11b | 3.57 | 0.77 | 54.32 |
| 11c | 3.35 | 0.79 | 39.51 |
| 11d | 2.96 | 0.89 | 25.93 |
| 11e | 3.21 | 0.86 | 33.33 |

The following observations can be made from Table 5.

(a) Except for the item, 10f: Using non-conventional sources of energy, all other items have mean scores either very close to 3 or considerably above 3, the mid-point of the scale. Also, a very small percentage of the respondents agree or strongly agree with item 10f, which indicates that Indian firms still lag behind in terms of using non-conventional sources of energy probably due to their unavailability (Alternative and nuclear energy accounts for only about 3% of total energy use in India, Source: http://www.worldbank.org) and lack of economies of scale.

(b) Except for item 10f, considerable percentages of the respondents either agree or strongly agree with the other items. Items 10e: Reducing energy usage during production, 10g: Reducing resource consumption during production and 10h: Reducing wastage and spill-over during production, are the leading practices indicating that Indian firms accord a high priority to the sustainable design of their production processes.

Factor analysis results showed two meaningful factors. One may be termed *sustainable product design and logistics* and the other *sustainable process design*. Table 6 shows the items and their loadings on the respective factors.

**Table 6: Factor loadings for sustainable manufacturing and logistics practices**

| Questionnaire item | Factor 1: Sustainable product design and logistics | Factor 2: Sustainable process design |
|---|---|---|
| 10c | 0.78160 | |
| 10a | 0.78032 | |
| 11d | 0.72643 | |
| 11e | 0.72425 | |
| 10b | 0.71002 | |
| 11a | 0.70160 | |
| 11b | 0.68780 | |
| 11c | 0.67507 | |
| 10g | | 0.89988 |
| 10e | | 0.84364 |
| 10h | | 0.82528 |

*Note: Factor loadings of at least 0.65 are only shown.*

*Items 10d and 10f are dropped for low factor loadings.*

*Items are arranged in the descending order of their factor loadings.*

Item 10d: Carrying out life cycle analysis for products, although had a high mean score and a significant percentage of the respondents either agree or strongly agree with the item, had to be dropped because of its low factor loading. One probable explanation for this exclusion could be the fact that nowadays firms carry out life cycle analysis for their products for various purposes such as to assess the total cost of ownership (TCO) or transaction cost economics (TCE) other than to assess the environmental impacts of their products. Therefore, it may be possible that firms, which score not so high on other dimensions of sustainable practices, may have a formal procedure to carry out life cycle analysis and score high on this item, leading to little correlation of this item to either of the factors.

Item 10f: Using non-conventional sources of energy, having below-average mean score and fewer respondents either agreeing or strongly agreeing with the item, displays little correlation to either of the factors, as expected, and hence is dropped.

Items 10e: Reducing energy usage during production, 10g: Reducing resource consumption during production and 10h: Reducing wastage and spill-over during production, having high percentages of the respondents agreeing or strongly agreeing with the items, have expectedly loaded on a single factor, Factor 2: *Sustainable process design*.

Cronbach's alpha for Factor 1: *Sustainable product design and logistics* is 0.91884 and the same for Factor 2: *Sustainable process design* is 0.933555.

### 5.1.4 Firm performance

There are 15 items, 15a-15o in the questionnaire on firm performance. Table 7 shows the descriptive statistics.

**Table 7: Descriptive statistics related to firm performance**

| Questionnaire item | Mean | Standard deviation | % agree or strongly agree |
|---|---|---|---|
| 15a | 3.51 | 0.91 | 51.85 |
| 15b | 3.75 | 0.73 | 62.96 |
| 15c | 2.80 | 1.10 | 24.69 |
| 15d | 3.86 | 0.65 | 71.60 |
| 15e | 3.30 | 0.84 | 49.38 |
| 15f | 3.31 | 0.85 | 51.85 |
| 15g | 3.32 | 0.85 | 55.56 |
| 15h | 3.31 | 0.89 | 58.02 |
| 15i | 3.65 | 0.62 | 70.37 |
| 15j | 3.57 | 0.81 | 70.37 |
| 15k | 3.26 | 0.92 | 55.56 |
| 15l | 3.26 | 0.86 | 41.98 |
| 15m | 3.93 | 0.69 | 82.72 |
| 15n | 2.65 | 0.88 | 18.52 |
| 15o | 2.27 | 0.91 | 8.64 |

The following observations can be made from Table 7.

(a) Except for the items, 15c: Innovation in product and process design, 15n: Patenting of products and processes and 15o: Influencing policy makers and regulators, all other items have mean scores well above 3, the centre of the scale, and significant percentages of the respondents either agree or strongly agree with the items. It seems that since the majority of the respondent firms adopted SSCM practices voluntarily, and not under regulatory, customer and competitive pressure, as evidenced by their mean scores (See Table 1), the motivation towards innovation, patenting and influencing as a consequence of the adoption of SSCM practices has been low. As observed in practice and also from the examples cited in the academic literature, firms are more likely to innovate, patent and influence under regulatory compliance and external pressure from customers, competitors, investors, shareholders, environmentalists, public interest groups and other stakeholders (Porter and van der Linde, 1995; Hart, 1995; Shrivastava, 1995; Pagell et al., 2004; Carter and Rogers, 2008).

(b) One important observation is that for the item 15m: Reaping long-term benefits, the mean score is close to 4 (representing "Agree" on the scale) and also 82.72% of the respondents either agree or strongly agree with the item. This indicates that although the adoption of SSCM practices in India is at an initial stage, the respondents feel that doing so firms will benefit in the long run even if the short-term gains may be limited (Zhu and Sarkis, 2004; Krause et al., 2009).

Factor analysis resulted in two meaningful factors. One may be termed *economic performance* and the other *competitiveness*. Since, as mentioned before, there is a lack in consistency of inclusion of the items under different performance measures, we follow Rao and Holt (2005) in naming the factors. It may be noted that the factor *economic performance* includes items related to economic, marketing, financial and organizational performance criteria while the factor *competitiveness* includes items related to competitiveness and operational performance criteria. Table 8 shows the items and their loadings on the respective factors.

**Table 8: Factor loadings for firm performance**

| Questionnaire item | Factor 1: Economic performance | Factor 2: Competitiveness |
|---|---|---|
| 15h | 0.89110 | |
| 15g | 0.87515 | |
| 15j | 0.85478 | |
| 15k | 0.82334 | |
| 15f | 0.79907 | |
| 15l | 0.75359 | |
| 15e | 0.74003 | |
| 15i | 0.70997 | |
| 15n | | 0.84948 |
| 15c | | 0.83814 |
| 15o | | 0.83719 |
| 15b | | 0.72622 |
| 15a | | 0.65568 |

*Note: Factor loadings of at least 0.65 are only shown.*

*Items 15d and 15m are dropped for low communalities (< 0.5).*

*Items are arranged in the descending order of their factor loadings.*

Items 15d: Cost savings in production and distribution and 15m: Reaping long-term benefits, although having the highest mean scores and significant percentages of the respondents agreeing or strongly agreeing with the items, have been dropped from factor analysis due to their low communality estimates. It may be noted that the loading of the items on the factors has similarities with the factor analysis results of Rao and Holt (2005). Cronbach's alpha for Factor 1: *Economic performance* is 0.954852 and the same for Factor 2: *Competitiveness* is 0.925758.

### 5.2 Confirmatory factor analysis

The following are related to confirmatory factor analysis (CFA).

- We considered an overall model fit rather than separately examining the fit for individual constructs.

- We included constructs having at least 3 items. Constructs with less than 3 items (*Voluntary adoption*, *Adoption under external pressure* and *Arms-length or transactional relationships with suppliers*) had to be dropped to mitigate the problem of underidentification.
- Convergent validity was established in the following way:
    (a) Factor loadings
        - Should be statistically significant.
        - Standardized loading estimates should be at least 0.6, preferably 0.7 or more.
    (b) Average Variance Extracted (AVE) should be at least 0.5.
    (c) Construct Reliability (CR) should be at least 0.7.
- Discriminant validity was established by ensuring that between two constructs, AVE for either construct exceeded the squared correlation between the two constructs.
- Absolute values of the standardized residuals should be less than 2.5.

For convergent validity and an overall model fit, some of the items/constructs needed to be dropped (Construct *Sustainable process design* was dropped) and the measurement model was respecified. Table 9 shows the constructs and items that have been retained for testing the structural model along with the standardized loading estimates and critical ratios for the items and AVE and CR for the constructs.

**Table 9: Results of confirmatory factor analysis**

| Construct | Questionnaire item | Std. loading estimate | Critical ratio | AVE | CR |
|---|---|---|---|---|---|
| Collaborative relationships with suppliers | 9a: Educating and generating awareness among suppliers | 0.826 | -* | 0.66 | 0.91 |
| | 9b: Helping suppliers set up environment-friendly practices | 0.771 | 7.847 | | |
| | 9f: Auditing suppliers' environmental performance | 0.849 | 9.019 | | |
| | 9g: Selecting suppliers based on environment-related criteria | 0.813 | 8.460 | | |
| Sustainable product design and logistics | 10a: Designing products with bio-degradable materials | 0.636 | -* | 0.67 | 0.86 |
| | 11d: Using alternative transport mechanisms | 0.927 | 6.662 | | |
| | 11e: Achieving economies of scale in transportation | 0.854 | 6.323 | | |
| Economic performance | 15f: Increase in market share | 0.892 | -* | 0.77 | 0.96 |
| | 15g: Penetration of new markets | 0.941 | 14.207 | | |
| | 15h: Acquisition of new customers | 0.987 | 16.290 | | |
| | 15j: Increase in organizational growth | 0.705 | 7.863 | | |
| | 15k: Enhancement of corporate image | 0.829 | 10.487 | | |
| Competitiveness | 15a: Improvement in product and process quality | 0.864 | -* | 0.65 | 0.90 |
| | 15b: Improvement in efficiency and productivity | 0.752 | 7.927 | | |
| | 15c: Innovation in product and process design | 0.782 | 8.419 | | |
| | 15n: Patenting of products and processes | 0.820 | 9.062 | | |

*Note: * indicates the items for which the factor loading estimates have been set to 1 by the software.*

It may be observed from Table 9 that the factor loadings of all items are statistically significant and the standardized loading estimates exceed 0.7 except for item 10a: Designing products with bio-degradable materials, for which the standardized loading estimate exceeds 0.6. Also, AVE and CR for all constructs exceed 0.5 and 0.7, respectively, confirming convergent validity. Discriminant validity was confirmed by the criterion given above. Also, the absolute values of all standardized residuals were less than 2.5. Overall model fit statistics: Chi-square = 153.31, Degrees of freedom = 98, Relative Chi-square value (Chi-square/Degrees of freedom) = 1.56 (< 3 recommended for a good fit), GFI = 0.81, AGFI = 0.74, CFI = 0.95 and RMSEA = 0.08 indicate a good fit.

### 5.3 Structural equation modelling

Since some of the constructs were dropped during CFA, not all of the hypotheses could be tested by structural equation modelling (SEM) and the remaining had to be reframed based on the naming of the factors during factor analysis. Hypotheses H1a, H1b, H2a and H2b could not be tested by SEM, which were tested by regression (along with Hypotheses H9 and H10) and discussed later, while Hypotheses H3, H4, H5, H6 and H7 had to be reframed before testing by SEM as follows:

H3R: Collaborative relationships with suppliers are positively related to sustainable product design and logistics.

H4R: Collaborative relationships with suppliers are positively related to competitiveness.

H5R: Collaborative relationships with suppliers are positively related to economic performance.

H6R: Sustainable product design and logistics are positively related to competitiveness.

H7R: Sustainable product design and logistics are positively related to economic performance.

Hypothesis H8 remains unchanged.

Maximum Likelihood Estimation (MLE) was used for the structural model. Figure 5 shows the path diagram indicating the significant relationships among constructs with the corresponding critical ratios for an overall fit of the structural model.

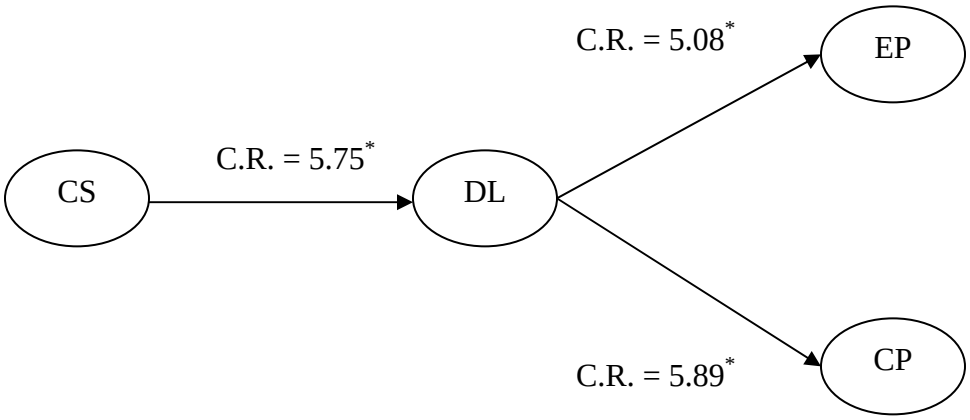



**Fig. 5: Structural model showing significant relationships**

*Note: CS = Collaborative relationships with suppliers, DL = Sustainable product design and logistics, EP = Economic performance, CP = Competitiveness, C.R. = Critical Ratio, * indicates significance at 0.01 level*

Table 10 shows the directions of significant relationships with the corresponding standardized path estimates.

**Table 10: Directions and standardized path estimates for significant relationships**

| Construct | Direction | Construct | Std. path estimate |
|---|---|---|---|
| CS | ⟶ | DL | 0.903 |
| DL | ⟶ | EP | 0.683 |
| DL | ⟶ | CP | 0.886 |

It was observed that standardized loading estimates for items determined by CFA virtually remained the same in SEM. Absolute values of the standardized residuals were less than 2.5. Also, overall model fit statistics: Chi-square = 154.699, Degrees of freedom = 101, Relative Chi-square value (Chi-square/Degrees of freedom) = 1.53 (< 3 recommended for a good fit), GFI = 0.81, AGFI = 0.75, CFI = 0.95 and RMSEA = 0.08 indicated a good fit.

SEM results show that Hypotheses H3R, H6R and H7R are supported while Hypotheses H4R, H5R and H8 are not supported.

### 5.4 Regression

Hypotheses H1a, H1b, H2a, H2b, H9 and H10 were tested by regression.

To test Hypothesis H1a, we conducted simple linear regression with items 15a-15c and 15n (items loaded on the construct *Competitiveness*) as the criterion variables and item 8a as the predictor variable. Table 11 shows the t-stats and p-values corresponding to the regression coefficients of the predictor variable for each criterion variable.

**Table 11: Regression results for Hypothesis H1a**

| Questionnaire item | t-stat | p-value |
|---|---|---|
| 15a: Improvement in product and process quality | 1.50* | 0.138 |
| 15b: Improvement in efficiency and productivity | 2.39 | 0.019 |
| 15c: Innovation in product and process design | 1.48* | 0.143 |
| 15n: Patenting of products and processes | 2.37 | 0.020 |

*Note: * indicates that the model fit is not significant at 5% level of significance. For others, both the model fit and the regression coefficient are significant at 5% level of significance.*

Regression results shown in Table 11 lend only weak support to the hypothesis that voluntary adoption of SSCM practices is positively related to competitiveness.

For testing Hypothesis H1b, we conducted simple linear regression with items 15f-15h and 15j-15k (items loaded on the construct *Economic performance*) as the criterion variables and item 8a as the predictor variable. Table 12 shows the t-stats and p-values corresponding to the regression coefficients of the predictor variable for each criterion variable.

**Table 12: Regression results for Hypothesis H1b**

| Questionnaire item | t-stat | p-value |
|---|---|---|
| 15f: Increase in market share | 2.16 | 0.016 |
| 15g: Penetration of new markets | 3.80 | 0.000 |
| 15h: Acquisition of new customers | 2.94 | 0.004 |
| 15j: Increase in organizational growth | 2.45 | 0.016 |
| 15k: Enhancement of corporate image | 3.78 | 0.000 |

*Note: For all items, both the model fit and the regression coefficient are significant at 5% level of significance.*

Regression results shown in Table 12 lend support to the hypothesis that voluntary adoption of SSCM practices indeed improves economic performance.

To test Hypotheses H2a and H2b, we conducted simple linear regression with items 9a-9g, 10a-10h and 11a-11e as the criterion variables and item 8a as the predictor variable. Table 13 shows the t-stats and p-values corresponding to the regression coefficients of the predictor variable for each criterion variable.

**Table 13: Regression results for Hypotheses H2a and H2b**

| Questionnaire item | t-stat | p-value |
|---|---|---|
| 9a: Educating and generating awareness among suppliers | 2.68 | 0.009 |
| 9b: Helping suppliers set up environment-friendly practices | 1.64* | 0.106 |
| 9c: Putting pressure on suppliers to implement EMS and ISO 14001 | -1.17* | 0.245 |
| 9d: Incentivizing suppliers for conformance to EMS/14001 | -0.58* | 0.564 |
| 9e: Urging suppliers to supply environment-friendly materials | 2.24 | 0.028 |
| 9f: Auditing suppliers' environmental performance | 2.04 | 0.045 |
| 9g: Selecting suppliers based on environment-related criteria | 2.37 | 0.020 |
| 10a: Designing products with bio-degradable materials | 2.89 | 0.005 |
| 10b: Designing products with recyclable materials | 2.61 | 0.011 |
| 10c: Designing products for quick disassembly | -0.53* | 0.597 |
| 10d: Carrying out life cycle analysis for products | 2.44 | 0.017 |
| 10e: Reducing energy usage during production | 0.86* | 0.392 |
| 10f: Using non-conventional sources of energy | 3.89 | 0.000 |
| 10g: Reducing resource consumption during production | 0.70* | 0.483 |
| 10h: Reducing wastage and spill-over during production | -0.22* | 0.829 |
| 11a: Use of environment-friendly packaging | -0.40* | 0.692 |
| 11b: Use of recyclable packaging materials | 0.84* | 0.404 |
| 11c: Use of environment-friendly storage | 1.84* | 0.069 |
| 11d: Use of alternative transport mechanisms | 2.13 | 0.037 |
| 11e: Achieving economies of scale in transportation | 2.23 | 0.028 |

*Note: * indicates that the model fit is not significant at 5% level of significance. For others, both the model fit and the regression coefficient are significant at 5% level of significance.*

We observe from Table 13 that out of 20 items related to sustainable purchasing, product and process design, packaging, storage and transportation, only 10 items barely show the significance of the regression coefficients at 5% level of significance. Even after considering items 9c and 9d representing arms-length or transactional relationships with suppliers where expectedly no significant relationships have been found, the observation lends only weak support to the hypotheses that firms that adopt SSCM practices voluntarily are more likely to develop collaborative relationships with suppliers and engage in sustainable manufacturing and logistics practices. On the other hand, regression results show that firms adopting SSCM practices to comply with regulations put pressure on suppliers to implement EMS and ISO 14001 (t-stat: 3.48, p-value: 0.000822), and incentivize suppliers for conformance to EMS/ISO 14001 (t-stat: 5.23, p-value: 1.38e-06) indicating that they maintain an arms-length or transactional relationship with their suppliers. Moreover, they do not take any steps towards designing products with recyclable materials (t-stat: -3.97, p-value: 0.000155), carrying out life cycle analysis for products (t-stat: -2.83, p-value: 0.005889) and using non-conventional sources of energy (t-stat: -2.55, p-value: 0.01279).

For testing Hypotheses H9 and H10, we conducted simple linear regression with items 8a, 9a-9g, 10a-10h and 11a-11e as the criterion variables and items 4 and 6 as the dummy predictor variables (one at a time). Table 14 shows the t-stats and p-values corresponding to the regression coefficients of the predictor variables for each criterion variable.

**Table 14: Regression results for Hypotheses H9 and H10**

| Questionnaire item | MNC | | ISO 14000 | |
|---|---|---|---|---|
| | t-stat | p-value | t-stat | p-value |
| 8a: Adopting SSCM practices voluntarily | 4.92 | 4.57e-06 | 3.19 | 0.002 |
| 9a: Educating and generating awareness among suppliers | 4.26 | 5.59e-05 | 1.33* | 0.189 |
| 9b: Helping suppliers set up environment-friendly practices | 2.32 | 0.023 | 1.12* | 0.266 |
| 9c: Putting pressure on suppliers to implement EMS and ISO 14001 | 1.52* | 0.13 | -2.59 | 0.012 |
| 9d: Incentivizing suppliers for conformance to EMS/14001 | 0.59* | 0.56 | -1.61* | 0.111 |
| 9e: Urging suppliers to supply environment-friendly materials | 3.02 | 0.003 | 1.64* | 0.105 |
| 9f: Auditing suppliers' environmental performance | 2.89 | 0.005 | 0.568* | 0.572 |
| 9g: Selecting suppliers based on environment-related criteria | 2.55 | 0.013 | 1.50* | 0.138 |
| 10a: Designing products with bio-degradable materials | 2.16 | 0.034 | 1.20* | 0.232 |
| 10b: Designing products with recyclable materials | 3.17 | 0.002 | 2.12 | 0.037 |
| 10c: Designing products for quick disassembly | 1.48* | 0.144 | 0.38* | 0.704 |
| 10d: Carrying out life cycle analysis for products | 4.39 | 3.46e-05 | 0.84* | 0.405 |
| 10e: Reducing energy usage during production | 3.41 | 0.001 | 0.10* | 0.919 |
| 10f: Using non-conventional sources of energy | 5.43 | 5.93e-07 | 2.99 | 0.004 |
| 10g: Reducing resource consumption during production | 1.55* | 0.125 | 1.55* | 0.125 |
| 10h: Reducing wastage and spill-over during production | 1.76* | 0.082 | 0.78* | 0.438 |
| 11a: Use of environment-friendly packaging | 2.63 | 0.010 | -0.98* | 0.332 |
| 11b: Use of recyclable packaging materials | 3.72 | 0.000 | 0.76* | 0.452 |
| 11c: Use of environment-friendly storage | 4.56 | 1.83e-05 | 1.16* | 0.248 |
| 11d: Use of alternative transport mechanisms | 3.04 | 0.003 | 1.07* | 0.290 |
| 11e: Achieving economies of scale in transportation | 2.78 | 0.007 | 2.18 | 0.032 |

*Note: * indicates that the model fit is not significant at 5% level of significance. For others, both the model fit and the regression coefficient are significant at 5% level of significance.*

Hypothesis H9 that ISO 14000 certified firms are more likely to voluntarily adopt SSCM practices, enter into collaborative relationships with suppliers and engage in sustainable manufacturing and logistics practices than firms that are not ISO 14000 certified, is not supported since for only a handful of items, t-stats are significant. This may be due to the fact that many Indian firms being suppliers to U.S. and European firms are mandated to go through the ISO 14000 certification by their customers, although there may be a lack in adoption of commensurate sustainable practices in their supply chains. Also, as Schoenherr (2012) mentions, in developing countries, ISO 14000 certification is seen more from the point of view of compliance than for adoption of SSCM practices.

From the regression results shown in Table 14, the following inferences about MNCs operating in India may be drawn:

(a) MNCs adopt SSCM practices voluntarily, not for regulatory compliance only and not under customer and competitive pressure.
(b) With respect to purchasing practices, MNCs believe more in supplier development and collaborative relationships than in arms-length or transactional relationships such as putting pressure on or incentivizing suppliers.
(c) With respect to the design of products and processes, except for a few items, MNCs are well-focused on environment-friendly practices. The absence of any significant relationship between being an MNC and some of the items may possibly be attributed to the virtually non-existent market for remanufactured and refurbished products and less rigorous environmental regulations as compared to developed countries.
(d) With respect to packaging, storage and transportation, MNCs are well ahead in terms of environment-friendly packaging, storage, transportation and distribution of raw materials and finished goods.

The observations about MNCs as given above lend support to Hypothesis H10 that MNCs are more likely to voluntarily adopt SSCM practices, enter into collaborative relationships with suppliers and engage in sustainable manufacturing and logistics practices than Indian firms.

Table 15 summarizes the results of hypothesis testing.

**Table 15: Summary of hypothesis testing**

| Hypothesis | Brief description | | | Result |
|---|---|---|---|---|
| H1a | Voluntary adoption | → | Competitiveness | Weakly supported |
| H1b | Voluntary adoption | → | Economic performance | Supported |
| H2a | Voluntary adoption | → | Sustainable purchasing | Weakly supported |
| H2b | Voluntary adoption | → | Sustainable manufacturing & logistics | Weakly supported |
| H3R | Collaboration with suppliers | → | Sustainable product design & logistics | Supported |
| H4R | Collaboration with suppliers | → | Competitiveness | Not supported |
| H5R | Collaboration with suppliers | → | Economic performance | Not supported |
| H6R | Sustainable product design & logistics | → | Competitiveness | Supported |
| H7R | Sustainable product design & logistics | → | Economic performance | Supported |
| H8 | Competitiveness | → | Economic performance | Not supported |
| H9 | ISO 14000 | → | SSCM practices | Not supported |
| H10 | MNC | → | SSCM practices | Supported |

## 6. Major findings and managerial implications

The major findings of this study and the consequent managerial implications can be summarized as follows.

The concept of SSCM in India is still in its infancy. The rate of adoption of SSCM is still very low as in China (Zhu and Sarkis, 2004). Larger firms have access to more resources, and therefore, are more likely to adopt sustainability practices compared to smaller firms (Min and Galle, 2001; Zhu and Sarkis, 2004; Vachon and Klassen, 2006; Wu and Pagell, 2011; Zailani et al., 2012). The regulatory environment does not enforce the adoption of SSCM practices. Wu and Pagell (2011) note that many environmentally conscious exemplar firms do not wish to source from countries such as China and India where the environmental norms are less stringent even if sourcing from these countries would have been cheaper. India being one of the prominent exporters of goods and merchandise would do better if it takes steps in the direction of making the environmental regulations more stringent in line with the same in developed countries. Also, there are not enough external pressures from customers and competitors for making supply chains sustainable. As mentioned before, the awareness of sustainability among Indian customers is low. Although there were only 24 responses for items 13a-13j on reverse supply chains, we found that for item 13a, 75% of the respondents maintained that the extent of environment-consciousness among their customers was low. Only firms that had adopted some form of SSCM were the respondents to the survey, and most of them adopted SSCM practices voluntarily, not for regulatory compliance or under customer and competitive pressure. As Flint and Golicic (2009) note, in the short term regulations may be appropriate for compliance, but in the longer term it is more robust to rely on market pressures for implementation of SSCM. According to Krause et al. (2009), sustainability is less visible compared with the other dimensions of competitive priorities, i.e. cost, quality, delivery, flexibility and innovation. Therefore, firms adopting sustainability would benefit by documenting and communicating their SSCM practices to their customers and the markets in which they compete.

Firms that have adopted SSCM voluntarily are not found to engage in SSCM practices to a significant extent. However, had they done so, they would have been better off since results show that supplier collaboration is positively related to sustainable product design and logistics, which in turn has a positive impact on competitiveness and economic performance. The observations corroborate the findings of many a recent paper on SSCM/GSCM. Results also indicate that firms adopting sustainability for regulatory compliance engage in arms-length/transactional relationships with suppliers and deploy little or no SSCM practices. However, since "it pays to be green", reactive firms would be better off if they voluntarily adopt sustainability and engage in SSCM practices to a significant extent.

We find no direct impact of supplier collaboration on firm performance; rather sustainable design and logistics has a mediating effect on the relationship between the two. Competitiveness also has no effect on economic performance, probably because of the early phase of implementation of SSCM in India. With the increase in adoption of SSCM practices, it is expected that economic benefits may be reaped not only in the short term, but also in the long term through the development of competitive advantages. Although voluntary adoption of SSCM has an insignificant impact on competitiveness, it has a significantly positive effect on economic performance, reinforcing once again the importance of engaging in SSCM practices to a significant extent for firms that have voluntarily adopted SSCM.

No relationship was found between being ISO 14000 certified and engaging in SSCM practices. It seems, as mentioned before, that Indian firms obtain ISO 14000 certification to comply with the requirements of their foreign buyers. Unfortunately, the same does not translate to the adoption of sustainable practices in supply chains.

MNCs in India, on the other hand, have more voluntarily adopted sustainability and engaged in SSCM practices than non-MNC domestic firms. Most of the MNCs prefer to extend their environmental practices across all the countries of their operation, however less stringent the existing rules and regulations may be, for ease of replicability,

standardization and economies of scale. One of the top global automobile manufacturers has followed the standard practice of setting up a supplier park adjacent to its manufacturing facility in India for co-locating critical suppliers for better integration and coordination, shorter lead times, and increased productivity, efficiency and flexibility. The company considers its suppliers as partners and has developed a collaborative relationship with them based on mutual trust and confidence. Unlike other Indian automobile manufacturers, who maintain an arms-length relationship with suppliers, this company requires its suppliers to obtain ISO 14000 certification, involves them in the product design and manufacturing process, trains them, monitors their performance and makes a genuine effort to help them overcome any problem that they may have come across. While Indian manufacturers force their suppliers to build up huge inventories to cater to rush orders, this company shares its production schedule with suppliers to help them plan accordingly and do away with the requirement of maintaining excess stock. Naturally, this leads to supplier satisfaction and preference over the competitors.

Domestic firms should learn how to adopt SSCM practices from MNCs, especially when doing the same leads to improved firm performance both in the short and long term. Many of the domestic firms are also suppliers to these MNCs requiring them to implement sustainability practices in order to retain the status of preferred suppliers in the long run. As observed by Zhu and Sarkis (2004) for China, due to globalization, the increasing presence of MNCs in India would create a market pressure for domestic firms to eventually adopt SSCM practices to a greater extent.

Collection of products after use for recovery/disposal is virtually non-existent in India. The 24 responses received on items, 13a-13j on reverse supply chains relate to recovery/disposal of products from the point of view of normal business operations rather than from the closed-loop supply chain perspective. For example, for automobiles, there is no return of used vehicles to the manufacturer; only defective auto parts are brought back from the field and replaced. For engineering and iron and steel, defective items are melted, re-moulded and recycled. For pharmaceuticals, medicines damaged during transportation or beyond the date of expiry are collected, returned and disposed of. For

leather goods, rejected export items are either sold as they are or re-cut, re-stitched and re-labelled before selling in the domestic market at a lower price. For textiles, if there is any printing defect, they are brought back to the natural base colour and re-printed. Rejected items are re-cut and re-labelled for selling at a lower price. For electronics, consumer goods and cement, there are no returns.

The non-existence of reverse logistics or closed-loop supply chains in India can be attributed to the lack of legislations, awareness, infrastructure and technology, as also observed by Zhu and Sarkis (2004) in the case of China. Like in developed countries, there is no legislation in India that holds manufacturers responsible for collection/recovery/disposal of their products and packaging after use. The level of awareness of environment-friendly products is also low. Among the 24 responses received for item 13i, 87.5% indicated that there was no market for recovered products. This was corroborated by a senior executive of a top global construction and mining equipment manufacturer, who could not convince his large Indian customers that remanufactured equipment were not “second-hand”; in fact, they were comparable with new equipment in terms of functionality and performance, cost less and bore the same warranty. His company was trying to sell its equipment based on life cycle costing where the price paid by the customer would include the purchase price and the fees payable towards maintenance and repair throughout the life cycle of the equipment. Customers were given the option of buying either a newly manufactured equipment at its original price or a remanufactured equipment at 40-60% discount. However, as experience showed, there were a few takers of the latter offer. The company also could not fully replicate its sustainability practices in other developed countries in its Indian operations although it wished to. The less stringent regulatory norms in India made investments in advanced technologies uneconomical, e.g. the clean fuel the company used worldwide for its engines for fuel efficiency and reduced carbon emissions were not available in India, and importing the same would have been cost-prohibitive. The same executive also mentioned that although his company had a remanufacturing base in its home country, it could not set up a base in India since for this they had to bring used equipment from other Asian countries into India for scale economies, which was not permitted under the

existing law that banned the import of “used” or “second-hand” items on the apprehension of dumping by developed countries. The company felt that in the absence of a supporting regulatory infrastructure, its remanufacturing business in India was not viable.

There are evidences that recovery of used products and packaging not only reduces environmental pollution by eliminating the need for disposal and additional resource consumption, but also adds to corporate profitability and enhances corporate image. The government should revisit the regulatory framework to facilitate product recovery. Efforts should be made to generate awareness towards the benefits of collection and recovery of used products and packaging. Once Indian consumers become more environment-conscious, the market for remanufactured/refurbished products is expected to take off. This may also reduce the import bill for the country. Therefore, increasing product recovery activities and the development of a secondary market for recovered products would have the potential to create a “win-win-win-win” situation for the government, manufacturer, customer and environment.

In this paper, we have not considered the social dimension of sustainability; rather we focused on the environmental dimension. We mentioned the difficulties in incorporating the social dimension in SSCM. However, it is imperative that this dimension is also as important as the environmental dimension, and requires equal attention. This is evident from the fact that nowadays more and more companies are publishing corporate social responsibility (CSR) reports, and also the social dimension is addressed in the SSCM literature more than ever before (Carter and Easton, 2011). Some authors, e.g. Shi et al. (2012) have incorporated the social dimension under the environmental dimension. In pursuit of the appropriate items to be included under social sustainability for SSCM research, some authors (Krause et al., 2009; Giovanni, 2012; Hollos et al., 2012; Shi et al., 2012) have argued for the inclusion of employees’ health and safety (EHS) and better working conditions. Carter and Rogers (2008) and Zailani et al. (2012) have noted that investments in pollution-free processes expose employees to reduced emissions leading to improved health conditions, reduced number of accidents and related medical costs,

reduced absenteeism and employee turnover rate, and improved employee satisfaction, productivity and efficiency. Although we have not specifically addressed social sustainability in this paper, results show that productivity and efficiency improve as part of competitiveness with the implementation of SSCM practices. Also, Zailani et al. (2012) consider the image of the firm in the eyes of customers and community stakeholders as an item under social performance, which is the same as the item, corporate image coming under economic performance in this paper, and results again show that economic performance indeed improves with the adoption of SSCM practices. Giovanni (2012) also finds support for the hypothesis that social performance mediates the relationship between internal environmental management and economic performance. Therefore, we may say that investments in environment-friendly practices are positively related to social sustainability in terms of EHS, better working conditions and improved corporate image.

## 7. Conclusions and directions for future research

In this paper, we have presented one of the earliest surveys on SSCM practices in India. We have developed India-specific items for the survey based on the relevant literature and feedback from corporates. The items on SSCM practices and firm performance may be of use to academicians and practitioners as key success factors (KSF) and key performance indicators (KPI), respectively, for future reference. We have given an overview of the extent of adoption of SSCM practices by Indian manufacturing firms and the related issues in the backdrop of the observations made by other researchers for developed and developing countries. We have also drawn managerial implications for the government and manufacturing firms based on the findings from the primary and secondary data. We expect that the results of the study would facilitate the development of an appropriate regulatory framework and adoption of SSCM practices to a greater extent in India's pursuit of emissions reduction and environmental sustainability.

We have considered the manufacturer and Tier-I suppliers as the constituents of the supply chain, and the manufacturer has been the respondent to the survey. Future studies

may include items on Tier-II and Tier-III suppliers and customers, and explore a dyadic relationship between suppliers and manufacturers (Hollos et al., 2012). We have focused on the environmental dimension only. Future studies may also include social sustainability for which, of course, the relevant items may have to be identified. We have solicited responses from diverse industries and hence there may be apprehensions with regard to the generalizability of results. We propose future research to focus on specific industries so that the findings relate to, and are generalizable for, these industries. Although we have observed how being an MNC increases the propensity to adopt SSCM practices and commented on the lessons to be learnt by domestic firms, we feel a more focused study may be designed to address the impact of globalization, and hence more investments by MNCs, on the extent of adoption of SSCM practices in India. Similarly, we feel more comparative studies between India and other developed and developing countries with respect to SSCM may be taken up by future studies, especially from the point of view of regulatory and cultural differences. We have considered manufacturing firms in this study. Future studies may examine the adoption of sustainability in service supply chains (Carter and Easton, 2011). Finally, the state of adoption of SSCM practices in India being still in its infancy, this study is relatively exploratory. Therefore, longitudinal studies with larger samples to assess the change in the extent of implementation of sustainable practices and causal relationships in supply chains may be an interesting direction for future research (Zhu et al., 2005, 2012).

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# Appendix

**Questionnaire for A Survey of Sustainable Supply Chain Management Practices in India**

1. Name of the company: _____ Division: _____

2. Address and contact information:

   Phone: Fax: E-mail:

3. Main product lines: _____

4. Ours can be best described as an Indian / multi-national company (Please encircle your response)

5. We are ISO 9000 certified: Yes / No (Please encircle your response) If "Yes", which year: _____

6. We are ISO 14000 certified: Yes / No (Please encircle your response) If "Yes", which year: _____

7. We have implemented Environment Management System (EMS): Yes / No (Please encircle your response) If "Yes", which year: _____

8. We have adopted SSCM practices (Please encircle your response)
   (1: Strongly disagree, 2: Disagree, 3: Neither agree nor disagree, 4: Agree, 5: Strongly agree)

| | | | | | |
|---|---|---|---|---|---|
| (a) voluntarily | 1 | 2 | 3 | 4 | 5 |
| (b) to comply with regulations | 1 | 2 | 3 | 4 | 5 |
| (c) under pressure from customers | 1 | 2 | 3 | 4 | 5 |
| (d) under pressure from competition | 1 | 2 | 3 | 4 | 5 |

9. With regard to our suppliers, we do the following (Please encircle your response)
   (1: Strongly disagree, 2: Disagree, 3: Neither agree nor disagree, 4: Agree, 5: Strongly agree)

| | | | | | |
|---|---|---|---|---|---|
| (a) educate and generate awareness | 1 | 2 | 3 | 4 | 5 |
| (b) help set up environment-friendly practices | 1 | 2 | 3 | 4 | 5 |
| (c) put pressure to implement EMS and ISO 14001 | 1 | 2 | 3 | 4 | 5 |
| (d) incentivize for conformance to EMS/ISO 14001 | 1 | 2 | 3 | 4 | 5 |
| (e) urge to supply environment-friendly materials | 1 | 2 | 3 | 4 | 5 |
| (f) audit supplier performance for conformance | 1 | 2 | 3 | 4 | 5 |
| (g) select based on environment-related criteria | 1 | 2 | 3 | 4 | 5 |

10. While designing our products and processes, we do the following (Please encircle your response)
(1: Strongly disagree, 2: Disagree, 3: Neither agree nor disagree, 4: Agree, 5: Strongly agree)

| | | | | | |
|---|---|---|---|---|---|
| (a) design products with bio-degradable materials | 1 | 2 | 3 | 4 | 5 |
| (b) design products with recyclable materials | 1 | 2 | 3 | 4 | 5 |
| (c) design products for quick disassembly | 1 | 2 | 3 | 4 | 5 |
| (d) carry out life cycle analysis for products | 1 | 2 | 3 | 4 | 5 |
| (e) reduce energy usage during production | 1 | 2 | 3 | 4 | 5 |
| (f) use non-conventional sources of energy | 1 | 2 | 3 | 4 | 5 |
| (g) reduce resource consumption during production | 1 | 2 | 3 | 4 | 5 |
| (h) reduce wastage and spill-over during production | 1 | 2 | 3 | 4 | 5 |

11. In packaging, storage, transportation and distribution of raw materials and finished products, we focus on the following (Please encircle your response)
(1: Strongly disagree, 2: Disagree, 3: Neither agree nor disagree, 4: Agree, 5: Strongly agree)

| | | | | | |
|---|---|---|---|---|---|
| (a) use of environment-friendly packaging | 1 | 2 | 3 | 4 | 5 |
| (b) use of recyclable packaging materials | 1 | 2 | 3 | 4 | 5 |
| (c) use of environment-friendly storage | 1 | 2 | 3 | 4 | 5 |
| (d) use of alternative transport mechanisms | 1 | 2 | 3 | 4 | 5 |
| (e) achieve economies of scale in transportation | 1 | 2 | 3 | 4 | 5 |

12. We are engaged in the disposal and/or recovery of our products and packaging discarded/returned after use: Yes / No (Please encircle your response) If "Yes" go to Q. 13, If "No" go to Q. 15

13. With regard to reverse supply chains, disposal and/or recovery of our products and packaging, we have the following observations (Please encircle your response)
(1: Strongly disagree, 2: Disagree, 3: Neither agree nor disagree, 4: Agree, 5: Strongly agree)

| | | | | | |
|---|---|---|---|---|---|
| (a) our customers are environment-conscious | 1 | 2 | 3 | 4 | 5 |
| (b) our customers cooperate in returns handling | 1 | 2 | 3 | 4 | 5 |
| (c) we have a centralized returns collection facility | 1 | 2 | 3 | 4 | 5 |
| (d) we have a centralized returns inspection facility | 1 | 2 | 3 | 4 | 5 |
| (e) we engage in environmentally friendly disposal | 1 | 2 | 3 | 4 | 5 |
| (f) we have a centralized returns recovery facility | 1 | 2 | 3 | 4 | 5 |
| (g) we have integrated production with recovery | 1 | 2 | 3 | 4 | 5 |
| (h) we engage third-parties for product recovery | 1 | 2 | 3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| (i) there is a market for our recovered products | 1 | 2 | 3 | 4 | 5 |
| (j) pricing for our recovered products is competitive | 1 | 2 | 3 | 4 | 5 |

14. The product recovery option(s) that best describe(s) our recovery operation(s) is (are) the following:

    refurbishing / remanufacturing / cannibalization / recycling (Please encircle your response(s))

15. By adopting SSCM practices, we have achieved the following (Please encircle your response)
    (1: Strongly disagree, 2: Disagree, 3: Neither agree nor disagree, 4: Agree, 5: Strongly agree)

| | | | | | |
|---|---|---|---|---|---|
| (a) improvement in product and process quality | 1 | 2 | 3 | 4 | 5 |
| (b) improvement in efficiency and productivity | 1 | 2 | 3 | 4 | 5 |
| (c) innovation in product and process design | 1 | 2 | 3 | 4 | 5 |
| (d) cost savings in production and distribution | 1 | 2 | 3 | 4 | 5 |
| (e) increase in sales of products | 1 | 2 | 3 | 4 | 5 |
| (f) increase in market share | 1 | 2 | 3 | 4 | 5 |
| (g) penetration of new markets | 1 | 2 | 3 | 4 | 5 |
| (h) acquisition of new customers | 1 | 2 | 3 | 4 | 5 |
| (i) increase in organizational profits | 1 | 2 | 3 | 4 | 5 |
| (j) increase in organizational growth | 1 | 2 | 3 | 4 | 5 |
| (k) enhancement of corporate image | 1 | 2 | 3 | 4 | 5 |
| (l) achieving first-mover advantage | 1 | 2 | 3 | 4 | 5 |
| (m) reaping long-term benefits | 1 | 2 | 3 | 4 | 5 |
| (n) patenting of products and processes | 1 | 2 | 3 | 4 | 5 |
| (o) influencing policy makers and regulators | 1 | 2 | 3 | 4 | 5 |

16. Any other comments:

*Thank you for taking your precious time off to fill out the questionnaire*

Name of the respondent: _____ Designation: _____

Mobile: _____ E-mail: _____ Signature with date: _____