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# Modeling Green Supply Chain Management framework using ISM and MICMAC analysis

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**In recent years, green supply chain management has gained popularity both in academics as well as in the industry and is reflected in the special issues of journals and themes of conferences. The rubber products manufacturing sector plays a pivotal role in the Indian economy and is considered to be one of the key players in global rubber business. Globalization and the increased number of countries entering the world trade organization have promoted GSCM practices in manufacturing organizations. Under market pressures and proactive government policies the developing countries' firms have realized the importance of improving the environmental image. The purpose of the study is to develop a GSCM model for the rubber goods manufacturing sector based on the results of Interpretive Structural Modeling (ISM) and MICMAC analysis. Both practitioners in the industry and academics might find the results useful, as it integrates natural resource based view theory and institutional theory, and also addressing both internal and external perspectives of the firm. Further, the paper identifies the gaps in the literature and show directions of future research.**

**Key words:** Green Supply Chain Management (GSCM), environmental management (EM), Rubber goods manufacturing sector, ISM, MICMAC analysis.

## INTRODUCTION

Global warming has become a burning issue worldwide and has led firms to adopt green supply chain management practices in order to reduce carbon footprint throughout the supply chain. It is very clear that environmental management is a key strategic issue for organizations due to its long lasting impact on an organization's performance. The objective of the paper is to develop a GSCM model for the rubber goods manufacturing sector. In the second section, we have presented the evolution of GSCM and few important terms. All these have been taken from published literature. The third section consists of the research methodology which is the main essence of any research. Here, the researchers have applied quantitative approach for designing the research and conducting the analysis. In the final section, the researchers have presented the

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interpretation of the analysis and recommendations.

### *Indian rubber industry*

The Indian rubber industry, which was practically non-existent and economically insignificant till independence, has developed beyond recognition over the past six decades, maintaining phenomenal growth. The industry consists of six sectors: Natural Rubber, Synthetic Rubber, Reclaim Rubber, Rubber article manufacturers, Rubber Machinery and Rubber Chemicals. The industry's current annual turnover is about Rs.250, 000 million (USD 5.5 billion). Among these, the most important are Natural rubber producing sector and rubber goods manufacturing sector.

The rubber products manufacturing sector can be broadly divided into three categories. The product making units are spread all over the country and they produce about 35,000 different items. The organized automobile tyre sector with 32 units account for about 45% of rubber consumption and 250 medium scale units account for 30% of rubber consumption. But the pillar of Indian rubber products manufacturing sector comprises more than 3500 small and micro scale units accounting for the balance 24% consumption. The distribution of registered rubber goods manufacturing firms across 28 wide ranges of industrial products groups showed that 7 industries, i.e., foot wear (17.90%), moulded products (13.5%), tread rubber (9.2%), foam products (6.6%), adhesives (5.20%), cycle parts (4.56%), tyre and tube (15.37%) accounted for more than 62% of the total manufacturing units. Kerala, Maharashtra, Punjab, West Bengal, Uttar Pradesh, Gujarat, Haryana and Karnataka are the states with highest rubber consumption in India.

The Indian rubber products manufacturing sector draws its strength and stability from the rapidly growing demand for the products in both domestic and overseas market. The exports are well over 85 countries including US, Russia, UK, Bangladesh, Afghanistan, Italy, Germany, France, Saudi Arabia, UAE, Canada and the African countries. The chemicals and the allied products export promotion council co-ordinates activities connected with the export of rubber products.

## LITERATURE REVIEW

The present review has been done based on the technique of Systematic Literature Review approach (SLR) as recommended by Tranfield et al. (2003). This eradicates the issues related to the application of correct methodology and easily helps to develop the later sections on the paper. The various stages of SLR are as follows:-

**Stage 1**: Planning for review

**Phase 0**: Need identification for literature review

We have reviewed related papers from secondary sources to understand the present GSCM practices in the manufacturing sector both globally and in Indian context. The objective of conducting the review is to identify the research gaps from published literature and further develop the problem statement, research questions and research objective for our present research. The study focuses on rubber goods manufacturing sector. Rubber goods manufacturing sector is a key to the growth of Indian economy. India is home to some of the world's largest rubber enterprises through direct investment and technical collaboration. There is no doubt that with rubber consumption stagnating in various Western countries and the shift in consumption of rubber to the Asia Pacific region, the focal country for this decade is India. There exists a huge scope for expansion; causing import of machinery, technology, raw materials and exported rubber goods. Creation of niche products, such as the green material (Ekoprena) for green tyre production, has placed Malaysian rubber goods superior to such products from elsewhere in the world in terms of quality and competitiveness.

Major Indian tyre manufacturers, such as JK Tyres and MRF have come up with a new range of eco-friendly tyres that can improve fuel efficiency without affecting protection and toughness. Besides, various major global tyre manufacturers, such as Bridgestone, Michelin, Goodyear, and Continental are also offering a range of green tyres in the country. Various research and development activities are still going on in order to come up with better eco-friendly tyres.

Globalization and the increased number of countries entering the WTO have promoted GSCM practices in manufacturing organizations. Under market pressures and proactive government policies, developing countries firms have realized the importance of improving the environmental image. Also numerous challenges like exporting products or becoming suppliers to foreign customers, the continuous increase of energy and raw material prices and the increasing shift of emission standards have caused these firms to overcome green barriers and increase their international competitive ability (Diabat et al., 2013).

**Phase 1: Preparation for review**

Our literature review focuses mainly on journal articles. To set up a time span, a starting position was set at 2003. Library databases (EBSCO) were used through a keyword search using keywords such as 'green supply chain', 'environmental supply chain', 'green purchasing', 'green manufacturing', 'green operations', 'green logistics' and 'carbon and GHG emission reduction'. We utilized the published literature from 2003 onwards to go back to

other papers by cross referencing. As the published literature is interlinked to a considerable degree, one paper leads to others. So, when we pick up one thread, we are able to find others. As references accumulated, we found that some of them were more vital and useful than others. We consider such references as seminal papers which were also found to be generally referenced a number of times in subsequent literature. Thus, within our defined objective, this work integrates and takes forward the literature on GSCM since its conceptual-lization. The list of cited references is given at the end.

**Phase 2: Development of a review protocol**

This is a debatable area among the researchers because literature review is a never ending process. Therefore one must know where to stop and build ones research work on the basis of the strings identified to reach the final destination.

**Stage 2: Conducting literature review**

**Phase 3: Identification of research**

Earlier published papers related to GSCM practices in the manufacturing sector are reviewed in order to identify the area which has been unattended by past researchers and which needs attention due to its relevance in the present scenario.

**Phase 4: Selection of studies**

In the present section we have highlighted some of the relevant works related to green supply chain manage-ment.

If we look into history, we see that before 1980 during the Agrarian era, supply chain type was ‘standard’ and firm characteristics used to be small, organic, horizontal hierarchy and depended on quality of product to sell. Between 1780 and 1960, it was the era of Industrial revolution where a major change took place and the standard supply chain type shifted towards lean with expansion in size, variety, complexity and diversity. After 1960, the post industrial revolution phase witnessed another sea change globally and the trend shifted from lean to agile, hybrid and presently green (Nelson et al., 2009).

Sarkis et al. (2011) documented various organizational theories applied to GSCM related study such as Complexity theory, Ecological modernization theory, Information theory, Institutional theory, Resource based view, Resource dependence theory, Social network theory, Stakeholder theory, and Transaction cost economics.

Kogg (2003) defined GSCM as “the set of supply chain management policies held, actions taken and relation-ships formed in response to concerns related to the natural environment with regard to the design, acquisition, production, distribution, use, re-use and disposal of the firm's goods and services”.

Srivastava (2007) defined GSCM as “integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final products to the consumers, and end-of-life management of the product after its useful life”.

Globally, there has been rising concern about the degrading environment resulting from manufacturing operations. Today consumers are more conscious than before and demand environmental friendly products. Organizations think that environmental practices lead to increase in cost which may decrease profitability and is therefore a disadvantage for the firm. This has been proved wrong by recent studies on GSCM. A firm can develop a competitive advantage by adopting GSCM and can beat the competitors in the market. Today GSCM is the only path to achieve sustainability. In reality, there are three approaches to green supply chain and they are the environment, strategy, and logistics (Gilbert, 2001).

Linking to the definition by Srivastava (2007), we see that GSCM is in the DNA of the product and thus all activities encompassing the life cycle of product must be greened. The activities of GSCM involve green design, green purchasing, green manufacturing and green trans-portation.

Green design is the first stage to green the supply chain. In this stage the designs are finalized considering the environmental effects of the product from its birth to end of life. A green design involves innovation and out of the box thinking so as to develop the blue prints of the green product.

The second stage is green purchasing and is considered an important stage of greening the supply chain. Green purchasing is defined as the purchasing of environmental friendly goods that has minimum effect on the environment. We know that in many firms, green purchasing accounts to 60 to 70% of the cost of goods sold. Therefore a purchaser always tries his level best to develop a good vendor base who can support the GSCM adoption by supplying eco-friendly material at the best price and consistent in quality parameter.

Supplier relationship management is key to the success of green purchasing program. The firm has to develop a bond with its suppliers and motivates them to supply eco friendly and non hazardous raw material. Suppliers should be trained and educated to adopt ISO 4001. Firms which create pressure on their suppliers and review periodically to monitor progress are seen to adopt green practices successfully. Supplier collaboration

results in developing eco-friendly products faster; rather than only relying on the in-house R&D team. Good SRM practices create transparency and hence the costs involved in developing the eco-friendly raw material are visible and therefore chances of over spending are less. Motivating suppliers to maintain inventory at their works and issuing an open purchase order/contract can be one of the strategy. This will ensure that the material is supplied in time meet the production demand saves inventory carrying cost of firm. Strategic sourcing is a must for firms practicing GSCM as multiple suppliers need to be identified for mitigating the supply risk and support GSCM program.

Dubey and Bag (2013) conducted a study and suggested that Indian manufacturing organizations, implementing GSCM are motivated by four key drivers namely, green purchasing, supplier relationship, green logistics and regulatory norms and performance. These are measured both in terms of tangible performance measures i.e. Business performance and intangible performance measure i.e. environmental performance. PLSR coefficient output suggests that supplier relationship management (SRM) is the positive determinant of environmental performance outcome.

Selection of the right material will ensure that the input will minimize the harmful effect of the product on the environment during its life cycle.

The drivers of green procurement are buying organization's environmental collaboration with suppliers which positively and significantly impacts their adoption of green procurement and top management commitment also positively and significantly impacts environmental collaboration with suppliers (Yen and Yen, 2011).

Customer satisfaction and market share are important response in context to firm performance parameter. Supplier pressure, CSR activity, Brand image are those items which constitute market pressure and haves positive impact on customer satisfaction; whereas consumer pressure and green management cost have negative impact on customer satisfaction (Dubey et al., 2013).

Wu et al. (2011)'s proposed framework can be used as an analytical tool to improve the GSCM supplier selection.

Green manufacturing is the activity where a firm adopts green technology and best practices to ensure that the output meets the environmental standards and regulatory norms. Green technology involves usage of alternate energy and equipment by which the productivity increases with reduced solid waste generation/effluent and also reduces emission of greenhouse gases. Green manufacturing strategy is a complex area since it presents a multidimensional impact on performance. Even a simple decision to introduce clean machine requires a manager to consider the impact of the machine on environment throughout its life cycle and might need to reorganize the logistics part to take back end of life material for recycling.

There are three key drivers for the adoption of green production initiatives: regulatory demands, market value creation and cost reduction programs (Baines et al., 2012). There are 3 key challenges: changes to production technologies and hardware, acceptance by customer base, and buy-in of stakeholders across the operations of the manufacturer.

According to Singh et al. (2012), green manufacturing drivers/pressures are employees' motivation, health and safety, environmental concerns and legislature, green image, global marketing and competitiveness, global climatic pressure and ecological benefits, social and environmental responsibility, government rules and regulations.

Barriers are lack of research and empirical studies, increment in overall cost or financial burden and lack of awareness in companies and lack of management commitment.

Companies are integrating various environmental policies and programs into their operations strategy and specific decisions concerning operations such as product design, process technology selection and quality management to succeed in the competitive market (Gupta, 1995).

Green transportation is an activity where there is good scope to reduce the carbon emission. Uses of alternate fuels are generally practiced in developed countries. Selecting the right mode of transport can reduce significantly the cost and emission of green house gases in the environment. Chaabane et al. (2011) presented a comprehensive methodology to address sustainable supply chain design problems where carbon emissions and total logistics costs, including suppliers and sub-contractors selection, technology acquisition and the choice of transportation modes, are considered in the design phase. The proposed methodology provides decision makers with a multi-objective mixed-integer linear programming model to determine the trade-off between economic and environmental considerations. Case studies on reverse logistics have been developed by various researchers (Pohlen and Farris, 1992; Stock 1998).

The key drivers of GSCM are regulatory pressures and market pressures. In developed countries government has framed environmental policy and guidelines to provide environmental solution to the manufacturers. In European Union they have a policy (WEE) for disposing waste electrical and electronic equipment after the end of their life so as to reduce the harmful effects.

Cap and trade legislation for GHG emission is applicable for manufacturers across European Union, U.S and Australia. Aberdeen group survey reports that 50% of the companies are planning to redesign their entire supply chain in order to be more sustainable and 80% of them have to comply with new environmental policies. As a result, companies face new challenges and

need to adopt best technologies to meet their legal obligations.

Companies can earn carbon credits through one of the mechanism such as Emission trading system and carbon trading or contribution to climate change technology fund.

In an effort to reduce the GHG emissions globally the carbon trading markets were first introduced under the Kyoto Protocol, known as the United Nations framework convention on climate change (UNFCCC).

Market pressures play a vital role in driving firms to adapt GSCM. Foreign customers demand environment friendly product and services from their suppliers globally including India. Foreign customers conduct strict environmental audit of their Indian suppliers before placing the first order as they demand environmental friendly goods.

GSCM can be used as an environmental tool to improve the environmental image with in the business arena and enhancing export sales. Suppliers and community stake holders also influence GSCM adoption. GSCM project requires tremendous support from the top management to highlight that the project is really important and will receive proper attention from the members of the organization. Lack of resources and financial support will lead to failure of the GSCM project. Top management commitment with respect to the GSCM project leads to success of GSCM adoption. Firms having proper environmental policy are always ahead and the success rates of GSCM adoption are high. Top management must motivate junior managers and ensure that every employee within the organization is aware of the environmental policy (Zhu et al., 2005). TQM is another key parameter for the success of any GSCM project.

Several studies were conducted in Chinese context. Without environmental awareness it is difficult to implement green practices. Regulatory, competitive, and marketing pressures lead to increased environmental awareness and are the drivers of GSCM. Chinese manufacturers have taken proactive measures in closing the supply chain loop by adopting GSCM practices. GSCM can be used as an environmental tool to improve the environmental image and gain competitiveness within the international business arena (Zhu et al., 2008b). Greening any supply chain involves imbibing environmental principles in the design and operations of supply chain. A background of environmental principles for achieving eco-efficiency and building of environmentally friendly organization system have been presented and emphasis is put on application of such principle in life cycle of product (Tsoulfas and Pappis, 2006).

It is very important for any practicing manager to understand the links between GCSM practices, environmental and economic performance for successful GSCM implementation. Environmental pressure acts as a driver for successful GSCM practices.

Market and regulatory pressures help organization to improve environmental pressures which are believed to influence eco-design and green purchasing.

Manufacturers facing higher regulatory pressure tend to implement green purchasing and investment recovery. Competitive pressure significantly improves the economic benefits from adoption of different GSCM practices (Zhu et al., 2007).

Computer parts manufacturers in Thailand have adopted GSCM practices and Environmental Management Systems. GSCM pressures are environmental regulations and export Pressure (Ninlawan et al., 2010).

Environmentally and socially responsive supply chains are in the early adoption stages in Indian automobile industry and actual implementation lacks a holistic approach (Shukla et al., 2009). Major Indian manufacturing firms feel that there is lack of awareness of environmental issues which is a challenge and biggest perceived barrier to adopting GSCM is that it is not cost effective (Bhateja et al., 2011).

Important factors to implement GSCM in Indian manufacturing industry are innovative green practices, awareness level of customers; supplier motivation; technology advancement and organization adoption, organization encouragement, quality of human resources, IT enablement, top management commitment, Government support policies, International Environmental agreements (Luthra et al., 2011).

Hierarchical sustainability framework for evaluating the barriers to the GSCM adoption was developed using ISM technique and 32 barriers to GSCM adoption have been identified (Balasubramanian, 2012).

Natural Resource Based View-GSCM links to performance measures: Organizations implementing GSCM develop causally ambiguous and socially complex resources that are expected to translate into improved environmental and operational performance that may further lead to improvements in terms of the organization's financial performance.

The association between intra- organizational and performance measures suggests that by adopting proactive intra-organizational environmental practices, such as environmental management systems and pollution prevention technologies, would create tacit knowledge and efficient management routines that are causally ambiguous to its competitors and would improve an organization's performance measures.

The link between inter-organizational environmental practices and performance measures suggests that improvement on collaborative inter-organizational environmental practices, such as implementing green purchasing, design for environment and green distribution practices would create socially complex resources to its competitors leading to improvement of the organization's performance measures.

Institutional theory's link to Natural Resource Based View

–GSCM: Research based on institutional theory has shown that a firm's motivation to undertake GSCM practices is affected by pressures from regulators and the market. Institutional theory suggests that external forces motivate firms to undertake similar strategic actions. Under institutional theory, firms are not only profit seeking entities but also recognize the importance of achieving social legitimacy (Suchman, 1995).

DiMaggio and Powell (1983) stressed the importance of coercive, normative and mimetic pressures and how these pressures lead to organizational homogeneity. Relating to decisions in adopting GSCM practices, previous research indicates that institutional pressures from regulators, the market and competitors may play a particularly important role in encouraging firms to adopt similar GSCM practices.

With respect to the advancement of theory, GSCM has been explored on a more in-depth and theoretical level, by integrating NRBV and institutional theories, and addressing both internal and external perspectives of the firm.

**Phase 5: Study quality evaluation**

The above studies have been evaluated on the basis of

i. Research objective of the study
ii. Research methodology applied in the study
iii. Contributions of the study
iv. Research gaps and future research directions

On the basis of the research gaps identified, the present research objectives have been identified and further subjected to the appropriate methodology which will be discussed in the methodology section.

**Research gaps**

The review reveals various insights and gaps in the existing GSCM literature.

(1) Lack of adequate literature support explaining the possible interaction among GSCM variables in Indian rubber goods manufacturing sector context.
(2) Lack of a specific GSCM model for the rubber goods manufacturing sector.

**Research questions**

(1) What are the key variables and the nature of relationship between them in Indian rubber goods manufacturing sector context?
(2) Can a GSCM model be developed for the Indian rubber goods manufacturing sector?

**Research objectives**

Literature review has given a direction to identify the research gaps and to develop the two specific research objectives for the present study as follows:-

(1) To identify the key factors influencing GSCM practices and the underlying relationships in the context of rubber goods manufacturing sector.
(2) To develop a GSCM model for the rubber goods manufacturing sector.

**Phase 6: Data extraction and monitoring progress**

The research variables have been derived from the above literature review. To reduce the redundancy and check their relevancy in present Indian context the pretesting has been carried out among selected experts. The final shortlisted variables have been used to design the questionnaire which we have used to collect response in the form of structural self interaction matrix for ISM modeling.

**Phase 7: Data synthesis**

Based on the synthesis of Systematic Literature Review and expert's opinion we have identified ten variables. Our research variables are as under:-

1) Supplier Relationship Management (SRM)
2) Customer Relationship (CR)
3) Top Management Commitment (TM)
4) Regulatory Pressures (RP)
5) Market Pressures (MP)
6) Green Technology Adoption (GT)
7) Total Quality Management (TQM)
8) Reduction in Carbon Emissions (RC)
9) Market Share (MS)
10) Profitability (PR)

## METHODOLOGY

This section discusses theoretical model development. The purpose of research methodology is to present the research design that will be used to conduct the empirical research for this study. The research design connects the broader assumptions of a study to its detailed methods of data collection, analysis, and inter-pretation. Research designs enable researchers to achieve the goal of answering research questions as validly, objectively, accurately, and economically as possible.

### Data analysis

#### *ISM based model*

There is a confusion related to the underlying relationship existing

among the research variables and; therefore the researcher develops a model for formulating the relationship based on the results of Interpretive Structural Modeling technique (ISM).

ISM is a proven and popular methodology for understanding relationships among specific items that define a problem. ISM is useful for achieving the objective in the presence of large number of directly and indirectly related elements and complex interactions among them which may or may not be expressed in a proper manner. ISM places a vital role in this kind of scenario and helps in understanding a structure within a system. The ISM model depicts the structure of a complex problem in a carefully designed pattern.

ISM has been used in the past by several researchers due to multiple benefits. It guides and records the results of group response on complex issues in an efficient and systematic manner (Attri et al., 2013; Sushil, 2012; Sushil, 2009; Sushil, 2005a; Sushil, 2005b; Warfield, 1999, 1994, 1974).

The ISM steps are presented in Figure 1.

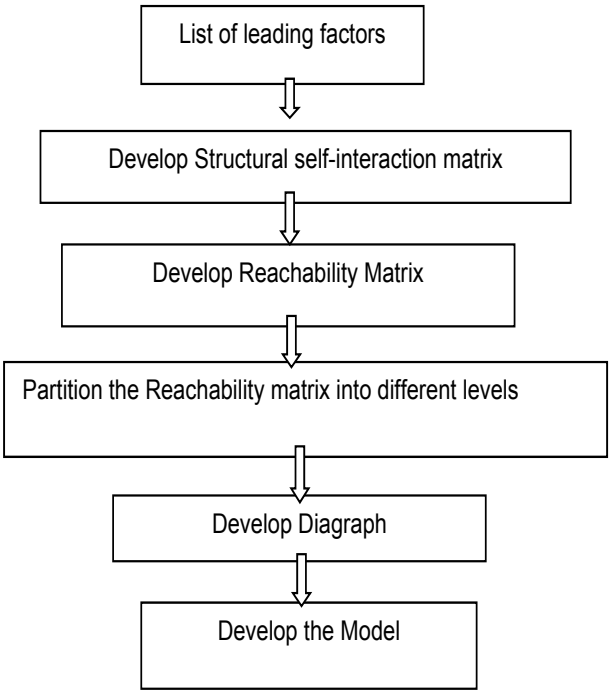


**Figure 1.** Flowchart for the ISM Methodology.

### *Identified variables*

Based on discussions with industry experts and synthesis of literature review, the key variables have been identified and considered as an input in ISM modeling.

### *Interpretative structural modeling*

### *Developing the structural self interaction matrix (SSIM)*

Developing a structural self-interaction matrix (SSIM) indicates pair-wise relationships between elements of the system (Table 1). To analyze the elements, a contextual relation of 'achieve' was selected. This means that one element will achieve another element; the latter will be achieved by another element; the two elements will help achieve each other or the element will be unrelated. For developing SSIM, the following four symbols have been used to denote the direction of relationships between elements (i and j):

V: i leads to j but j does not lead to i
A: i does not lead to j but j leads to i
X: i leads to j and j leads to i
O: i and j are unrelated to each other

**Table 1.** Structural self interaction matrix (SSIM).

| | X | IX | VIII | VII | VI | V | IV | III | II | I |
|---|---|---|---|---|---|---|---|---|---|---|
| I | V | V | V | A | V | V | A | A | O | |
| II | V | V | V | A | V | V | O | A | | |
| III | V | V | V | A | V | V | A | | | |
| IV | O | O | V | X | O | V | | | | |
| V | O | V | V | A | A | | | | | |
| VI | V | V | V | A | | | | | | |
| VII | O | O | V | | | | | | | |
| VIII | O | V | | | | | | | | |
| IX | O | | | | | | | | | |
| X | | | | | | | | | | |

### *Developing reachability matrix*

The SSIM was converted into a binary matrix i.e., the reachability matrix (Table 2) by substituting V, A X and O by 1 and 0. The substitutions of '1' and '0' are:

A. If the (i, j) entry in the SSIM is V, then the (i.j) entry in the reachability matrix becomes '1' and (j,i) entry becomes '0'

B. If the (i, j) entry in the SSIM is A, then the (i.j) entry in the reachability matrix becomes '0' and (j,i) entry becomes '1'

C. If the (i, j) entry in the SSIM is X, then the (i.j) entry in the reachability matrix becomes '1' and (j,i) entry also becomes '1'

D. If the (i, j) entry in the SSIM is O, then the (i.j) entry in the reachability matrix becomes '0' and (j,i) entry also becomes '0'

### *Level partitioning*

The final reachability matrix obtained in Table 3 is now partitioned into different levels. After the first iteration, the variables classified to level 1 are discarded and the partitioning procedure is repeated on the remaining variables to determine the level 2. These iterations are continued until the level of each variable is determined. The results for iterations 1 to 7 are presented in Tables 3-9.

From the final Reachability matrix and level partitions, the structural model is generated by means of vertices or nodes and lines of edges. If there is a relationship between the variables j and i, this is shown by an arrow which points to from i to j. This is called graph or Digraph (Figure 2).

### *MICMAC analysis*

MICMAC analysis (Matrice d' Impacts croises multiplication appliqué

**Table 2.** Reachability matrix.

| | I | II | III | IV | V | VI | VII | VIII | IX | X | Driving Power (Y) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 6 |
| II | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 6 |
| III | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 8 |
| IV | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 6 |
| V | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 3 |
| VI | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 5 |
| VII | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 8 |
| VIII | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| IX | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| X | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Dependence Power (X) | 4 | 3 | 3 | 2 | 7 | 5 | 2 | 8 | 7 | 5 | |

**Table 3.** Level partitioning (Iteration 1).

| Variables | Reachability set | Antecedent set | Intersection set | Level |
|---|---|---|---|---|
| 1 | 1,5,6,8,9,10 | 1,3,4,7 | 1 | |
| 2 | 2,5,6,8,9,10 | 2,3,7 | 2 | |
| 3 | 1,2,3,5,6,8,9,10 | 3,4,7 | 3 | |
| 4 | 1,3,4,5,7,8 | 4,7 | 4,7 | |
| 5 | 5,8,9 | 1,2,3,4,5,6,7 | 5 | |
| 6 | 5,6,8,9,10 | 1,2,3,6,7 | 6 | |
| 7 | 1,2,3,4,5,6,7,8 | 4,7 | 4,7 | |
| 8 | 8,9 | 1,2,3,4,5,6,7,8 | 8 | |
| 9 | 9 | 9 | 9 | *Level1* |
| 10 | 10 | 10 | 10 | *Level1* |

**Table 4.** Level partitioning (Iteration 2).

| Variables | Reachability set | Antecedent set | Intersection set | Level |
|---|---|---|---|---|
| 1 | 1,5,6,8 | 1,3,4,7 | 1 | |
| 2 | 2,5,6,8 | 2,3,7 | 2 | |
| 3 | 1,2,3,5,6,8 | 3,4,7 | 3 | |
| 4 | 1,3,4,5,7,8 | 4,7 | 4,7 | |
| 5 | 5,8 | 1,2,3,4,5,6,7 | 5 | |
| 6 | 5,6,8 | 1,2,3,6,7 | 6 | |
| 7 | 1,2,3,4,5,6,7,8 | 4,7 | 4,7 | |
| 8 | 8 | 1,2,3,4,5,6,7,8 | 8 | *Level 2* |

an classment) a (cross-impact matrix multiplication applied to classification) is abbreviated as MICMAC. The objective of MICMAC analysis is to analyze the drive power and dependence power of variables. Based on the drive power and dependence power the variables have been classified into four variables: autonomous variables, linkage variables, dependent and independent variables (Table 10; Figure 3).

## FINDINGS FROM MICMAC ANALYSIS

### Cluster 1: Autonomous variables

These variables have a weak drive power and weak dependence power. In this cluster we do not have any

**Table 5.** Level Partitioning (Iteration 3).

| Variables | Reachability set | Antecedent set | Intersection set | Level |
|---|---|---|---|---|
| 1 | 1,5,6 | 1,3,4,7 | 1 | |
| 2 | 2,5,6 | 2,3,7 | 2 | |
| 3 | 1,2,3,5,6 | 3,4,7 | 3 | |
| 4 | 1,3,4,5,7 | 4,7 | 4,7 | |
| 5 | 5 | 1,2,3,4,5,6,7 | 5 | *Level 3* |
| 6 | 5,6 | 1,2,3,6,7 | 6 | |
| 7 | 1,2,3,4,5,6,7 | 4,7 | 4,7 | |

**Table 6.** Level partitioning (Iteration 4).

| Variables | Reachability set | Antecedent set | Intersection set | Level |
|---|---|---|---|---|
| 1 | 1,6 | 1,3,4,7 | 1 | |
| 2 | 2,6 | 2,3,7 | 2 | |
| 3 | 1,2,3,6 | 3,4,7 | 3 | |
| 4 | 1,3,4,7 | 4,7 | 4,7 | |
| 6 | 6 | 1,2,3,6,7 | 6 | *Level 4* |
| 7 | 1,2,3,4,6,7 | 4,7 | 4,7 | |

**Table 7.** Level partitioning (Iteration 5).

| Variables | Reachability set | Antecedent set | Intersection set | Level |
|---|---|---|---|---|
| 1 | 1 | 1,3,4,7 | 1 | *Level 5* |
| 2 | 2 | 2,3,7 | 2 | *Level 5* |
| 3 | 1,2,3 | 3,4,7 | 3 | |
| 4 | 1,3,4,7 | 4,7 | 4,7 | |
| 7 | 1,2,3,4,7 | 4,7 | 4,7 | |

**Table 8.** Level Partitioning (Iteration 6).

| Variables | Reachability set | Antecedent set | Intersection set | Level |
|---|---|---|---|---|
| 3 | 3 | 3,4,7 | 3 | *Level 6* |
| 4 | 3,4,7 | 4,7 | 4,7 | |
| 7 | 3,4,7 | 4,7 | 4,7 | |

variable.

### Cluster 2: Dependence variables

These variables have a weak drive power but strong dependence power. In this cluster we have four variables: 5 (Market Pressures), 8 (Reduction in Carbon Emissions), 9 (Increase in Market Share) and 10 (Increase in Profit).

### Cluster 3: Linkage variables

These variables have a strong drive power as well as strong dependence power. In this cluster we have two variables: 1(Supplier Relationship Management) and 6 (Green Technology Adoption).

### Cluster 4: Driving variables

These variables have a strong drive power but weak dependence power. In this cluster we have four variables: 2 (Customer Relationship Management), 3 (Top Management Commitment), 4 (Regulatory Pressures) and 7 (Total Quality Management).

Based on the MICMAC analysis we propose the GSCM

**Table 9.** Level Partitioning (Iteration 7).

| Variables | Reachability set | Antecedent set | Intersection set | Level |
|---|---|---|---|---|
| 4 | 4,7 | 4,7 | 4,7 | *Level 7* |
| 7 | 4,7 | 4,7 | 4,7 | *Level 7* |

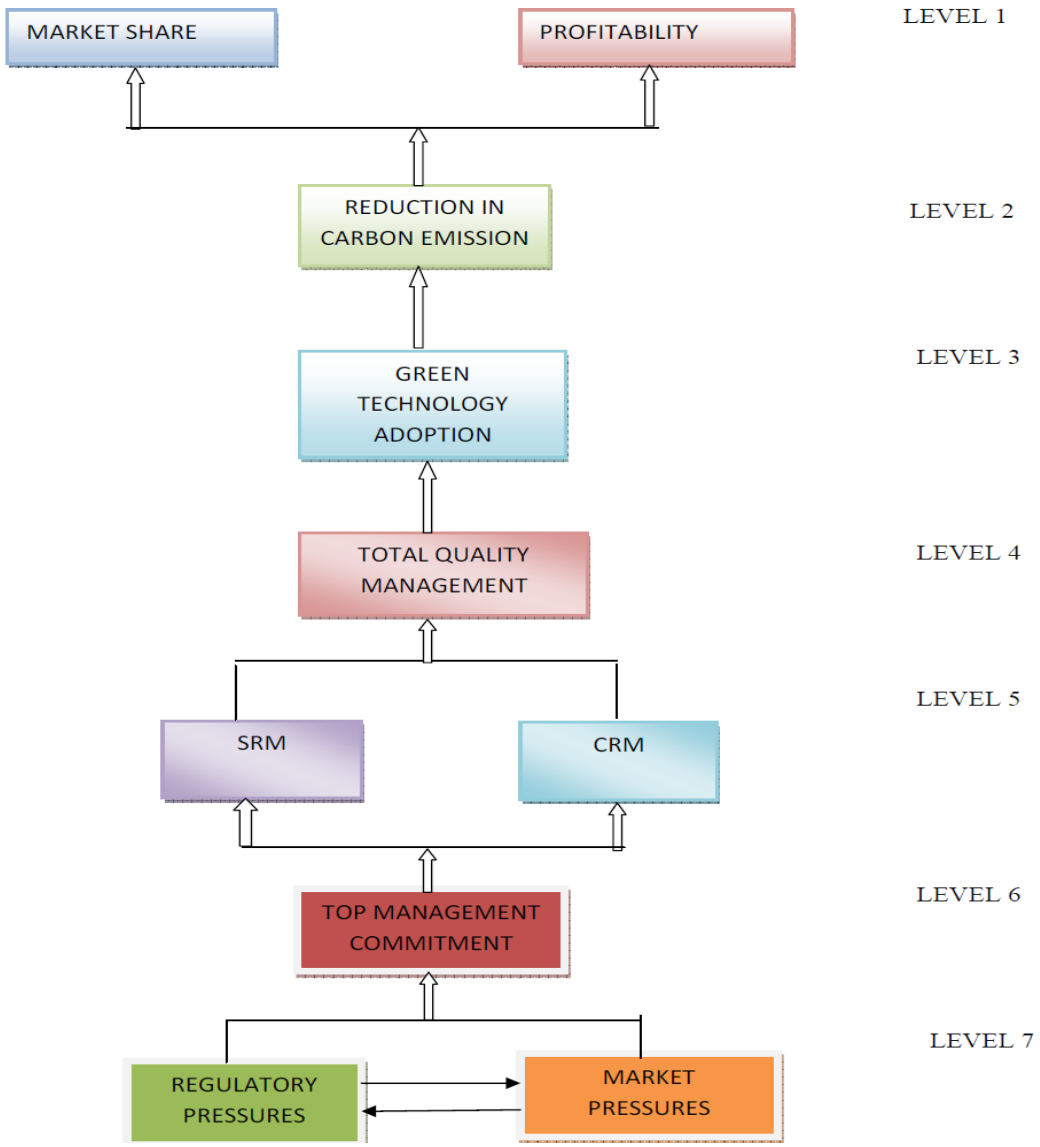


**Figure 2.** ISM model.

model as shown in Figure 4.

## Conclusion

1. The resent study provides a systematic approach in developing a structural GSCM model for Indian rubber goods manufacturing sector. The ISM model shows a hierarchy for better decision making and building a clean system with minimum environmental impact from Indian rubber goods manufacturing sector operations.
2. It is evident from past studies that GSCM practices lead to develop competitiveness in global market. Currently, Rubber Board of India and AIRA is focusing on

**Table 10.** Position coordinates of identified variables.

| Variables | Dependence Power(X) | Driving Power(Y) |
|---|---|---|
| 1 | 4 | 6 |
| 2 | 3 | 6 |
| 3 | 3 | 8 |
| 4 | 2 | 6 |
| 5 | 7 | 3 |
| 6 | 5 | 5 |
| 7 | 2 | 8 |
| 8 | 8 | 2 |
| 9 | 7 | 1 |
| 10 | 5 | 1 |

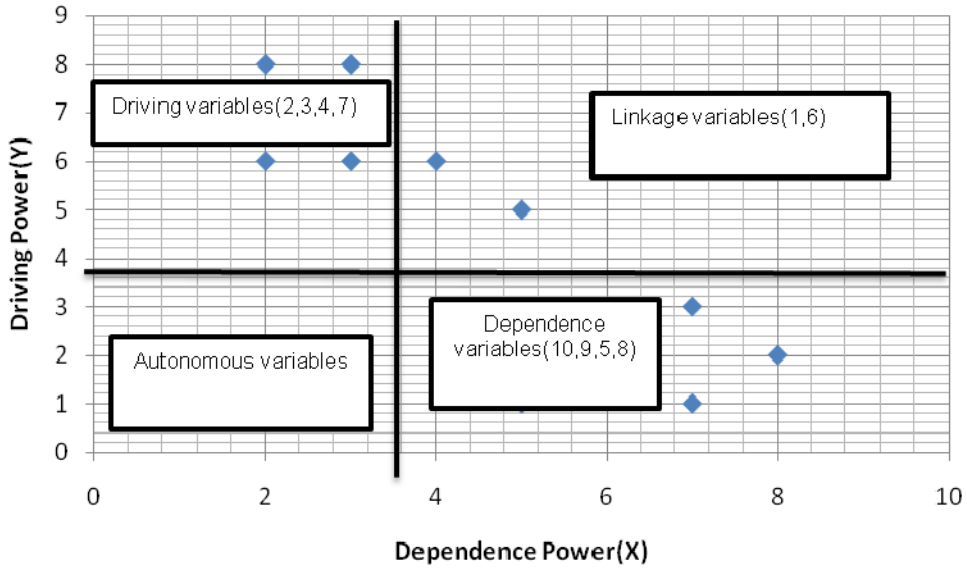


**Figure 3.** Output of MICMAC analysis.

green practices and the ultimate objective is to enhance export sales. Therefore, GSCM practice is identified as a central approach to enhance operational performance and thereby business performance.

3. The ISM Model yields a hierarchy in which Market Share and Profitability is at level 1 (the top level) followed by Reduction in carbon emission (level 2), Green technology adoption (level 3), Total quality environmental management (level 4), Supplier relationship management and Customer relationship management (level 5), Top management commitment (level 6), Regulatory pressures and market pressures are at bottom level (level 7).

4. Four variables are identified as driving variables and four variables as dependent variables using MICMAC analysis. Also there are two linkage variables but no autonomous variable emerged from the analysis.

5. Customer relationship management, Top management commitment, Regulatory pressures and Total quality environmental management have been identified as driving variables. The driving variables play a vital role in successful GSCM practices. They condition the rest of the system and are called independent variables or drivers.

6. The dependent variables characterize desired objectives for achieving success and identified from the analysis are Market pressures, Reduction in carbon emission, Market Share and Profit. These attributes are weak drivers but strongly dependent.

7. Linkage variables are very sensitive and unstable. Any action on these variables will trigger an effect on other variables and also a feedback on themselves. Supplier relationship management and Green Technology adoption have emerged as the linkage variable.

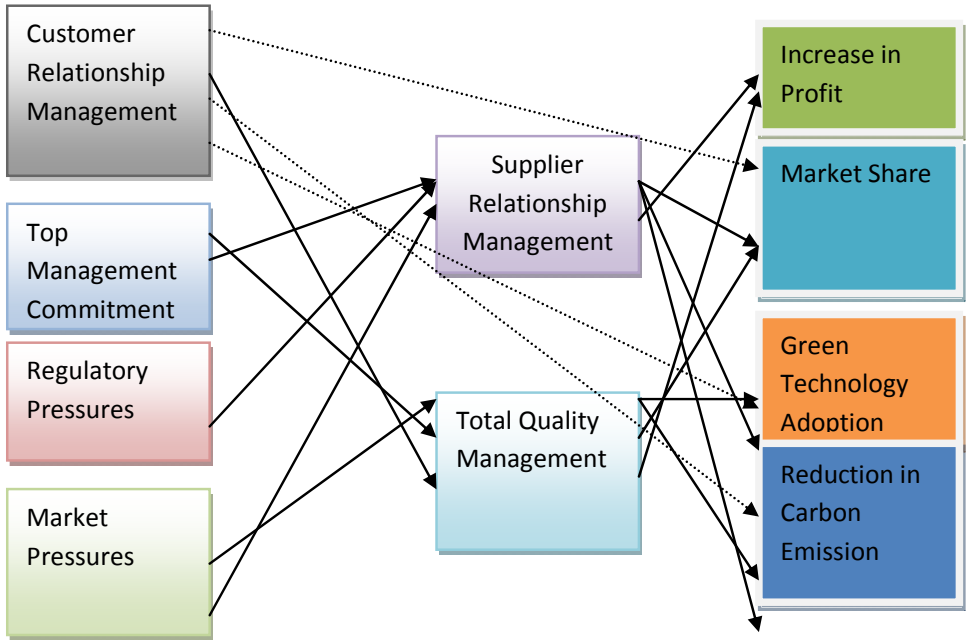


**Figure 4.** Conclusive GSCM model.

8. The model presented in this study may enable management and decisions-makers involved in rubber technology to identify and classify the enablers that have either strong dependence or strong driving power or both strong dependence and driving power that enhances the process of GSCM practices.

## Theoretical and managerial implications

Earlier works and reviews have limited focus and narrow perspective. They do not adequately cover all the aspects and facets of GSCM. Although rubber goods manufacturing sector is of national importance for the growth of Indian economy the lack of previous GSCM empirical studies related to this sector is the main reason for lack of GSCM knowledge and incidence of implementation failure. The Rubber Board of India is putting emphasis on enhancing export sales and showing interest in GSCM practices. Literature shows that without GSCM practices, it is impossible to develop competitiveness in the global market. Past research clearly reveals that there is a lack of GSCM model in the rubber goods manufacturing sector and due to which GSCM implementation is not popular in this sector. The model developed by us clearly explains the complex relationships among key variables and also show the direct and indirect relationships in a better fashion so that managers can easily understand the links and devise GSCM strategies successfully.

## Limitations

We understand that every management research has its own limitations; the present study also suffers from certain limitations. It is confined to a single sector and needs to be validated in other sectors and industries.

## Unique contributions

There are three important components of 'Unique Contributions' i.e., What, How and Why (Whetten, 1989). In the present study we have made effort to answer the three vital questions in terms of variables which we have identified from the synthesis of literature and experts opinion. We have developed a contextual relationships using ISM approach and further refined using MICMAC analysis. A conclusive model was developed which can be further tested using SEM. The GSCM model is unique as no such model exists for the rubber goods manufacturing sector and definitely the sector will be able to improve its performance after implementing the model and achieve sustainability.

### *Further research directions*

To eradicate the limitations of present research we propose to validate the model empirically in other sectors by using Exploratory factor analysis and further test using linear

multiple regression analysis and using SEM packages such as AMOS/LISREL. The ISM methodology can be extended using Total Interpretive Structural Modeling which can further nullify the limitation of ISM methodology.

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