Investigating Barriers in Green Supply Chain Management

Jasneet Kaur

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By: Jasneet Kaur

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Signed by the final examining committee:

Dr. Jamal Bentahar Chair

Dr. Amin Hammad Internal Examiner

Dr. Anjali Agarwal External Examiner

Dr. Anjali Awasthi Supervisor

Approved by _____
Chair of Department or Graduate Program Director

February 4, 2015 _____
Dean of Faculty

ABSTRACT

Investigating Barriers to Green Supply Chain Management

Jasneet Kaur

Green supply chain management has emerged as a trending topic of discussion for organizations thriving for enhanced competitive advantages, increased customer satisfaction, improved brand image, and of course minimum adverse impacts on the environment. It differs from traditional supply chain management in terms of consideration of environmental impacts of all the processes involved in a typical supply chain and intends to minimize their negative consequences. It involves going green from start to the end of the supply chain i.e. green design, green purchasing, green manufacturing, green packaging, green logistics, and green marketing. On one side, pressure from regulatory authorities, customer expectations, financial benefits, community groups, and media involvement act as potential drivers for adoption of green supply chain practices, there is still a long way to go considering the larger number of barriers currently being faced by organizations involved in corporate sustainability initiatives.

In this thesis, we present a DEMATEL based approach for investigating barriers in green supply chain management. The preliminary list of barriers is extracted from the literature review and classified into six categories namely Multiple M's, Supply Chain Processes, Stakeholders of Supply Chain, Sustainability Area, Organizational Hierarchy, and Others. Expert opinions are solicited to collect data on the identified barriers and DEMATEL is applied to identify the relationship between the barriers and their sub-categories.

The results of our study show that complexity of design to reuse/recycle products, lack of technical expertise, difficulty in identifying environmental opportunities, lack of training, lack of awareness on the environmental impacts of business, lack of corporate social responsibility, complexity in identifying third parties to recollect used products and lack of R&D capability on GSCM practices are the prominent barriers. Actions are therefore required by business organizations interested in corporate sustainability initiatives to eliminate or minimize the effect of these barriers.

Keywords: Green supply chain management, Barrier classification, DEMATEL, Pareto analysis

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I would also like to express my appreciation for all the professors and administrative staff members of the Concordia University for teaching me with the best knowledge and education in all the courses that I successfully passed as they proved to be fundamental in my thesis work as well.

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List of Acronyms

AHP - Analytical Hierarchy Process

APICS - American Production and Inventory Control Society

CSR - Corporate Social Responsibility

GSCM - Green Supply Chain Management

GTMA - Graph Theoretic and Matrix Approach

ISM - Interpretive Structural Modelling

R&D - Research & Development

RE - Renewable Energy

SCM - Supply Chain Management

SME's - Small and Medium Enterprises

SSPS - Statistical Package for Social Sciences

Chapter 1

Introduction

1.1 Background

Ever since the advent of the notion of Supply Chain Management (SCM) in the 1970's, Green Supply Chain management (GSCM) has captured the eyes of all. Today, we are in an era where sustainability has become a fundamental part of every business organization, be it of any size or nature. Thus, GSCM has been integrated into the strategic planning of every organization. It is considered as one of the main efforts aiming to integrate environmental parameters within the supply chain management systems (Jung, 2011). One example of this is the incorporation of Corporate Social Responsibility (CSR) concept in a number of legal and ethical frameworks which govern the functionality of the organizations in the society (Emmet & Sood, 2010). Under this idea, organizations are now expected to take complete responsibility of all the impacts of the actions of every member of their supply chain.

As in case of all radical innovations, barriers or challenges are also expected to be present in the case of GSCM adoption. These are the obstacles which come in the way of transition from traditional SCM to GSCM (Zhu, et al., 2005). Thus, it is essential for organizations to isolate these barriers and establish approaches for their successful eradication.

1.2 Thesis Objectives/ Thesis Statement

The primary objective of this research is to perform analysis on the green supply chain barriers and prioritize the most impactful ones. The barriers are extracted using literature review of research papers addressing similar objectives in countries like India, China,

Taiwan, and Malaysia etc. Six different categories of classification are developed to analyze the barriers.

1.3 Thesis Contribution

This study presents a list of 54 barriers to GSCM identified from the literature review of studies performed in manufacturing and construction industries in the Asian and Middle-Eastern countries. We classified these barriers into six different categories to see their effect on each other and which categories stand out to be the most influential ones. The results of the study lay emphasis on which category/sub-category is responsible for most number of barriers and where improvement procedures must be undertaken for successful implementation of GSCM. The categorization of the green supply chain barriers has been formulated using the knowledge of the supply chain management and quality systems. The relationships between the barrier categories of classification as well as the most pertinent barriers is developed using DEMATEL technique. The six categories are Multiple M's (Man, Machine, Method, Material, Money, Measurement, Market and Motivation), Supply Chain Processes (Design, Purchasing, Production, Testing & Inspection, Packaging, Transportation, Warehousing, After Sales Service and Recycling), Stakeholders (Employees, Customers, Suppliers, Government/Regulatory and NGO's), Sustainability Areas (Societal, Economic, Environmental and Technical), Organizational Hierarchy (Top Management/Executive Level, Middle Management/Departmental Level and Worker/Supervisory Level) and Others (Psychological, Technological, Knowledge and Strategical). Our study also sets the path for future studies for drawing more results and conclusions on the inter-relationships between the barriers and the six categories.

1.4 Thesis Organization

The rest of the report is organized as follows:

Chapter 2 provides a literature review of SCM, GSCM and barriers to GSCM

Chapter 3 presents the methodology including classification categories, Direct Ranking, Pareto analysis and DEMATEL.

Chapter 4 presents the numerical application of the proposed framework for barrier analysis and provides its results.

Chapter 5 presents the conclusions and future scope of this research summarizing the outcomes of the numerical analysis and gives recommendations for future works.

Chapter 2

Literature Review

2.1 Supply Chain Management

2.1.1 Introduction to Supply Chain Management

The concept of SCM has grown in its scope ever since its advent. From the process of outsourcing, manufacturing and delivery of goods to customers in the end, it has taken all the processes of generation and distribution of goods into its tide (Mentzer, et al., 2001). Some of the key drivers for the evolution of SCM include greater environmental concerns, globalization of sources, on time delivery to customers, increased market value and increased emphasis on quality worldwide. It is no longer considered just a competitive advantage but a necessity to remain in the market. In order to decrease the number of defective products, integration of quality control measures and collaborative efforts both by manufacturers and suppliers are needed. Also, as globalization of the outsourcing has increased, it has become more and more difficult for organizations to monitor supplier standards and activities. With SCM, it has become easier for organizations to be closely involved with their global suppliers in setting mutual goals, engage in training, and information sharing systems. Another reason for the emergence of the concept of SCM is the increased customer expectations and market uncertainty. Customers' increased demands for faster deliveries of goods and quality and defect free products have worked as pressures on organizations to build better networks with its alliances. Constantly changing technology and customer choices have also put immense pressures to integrate flexibility and information sharing with its suppliers and distributers.

2.1.2 Definitions of Supply Chain and SCM

The APICS Dictionary defines supply chain as “the processes linked with the generation of the initial raw materials to the ultimate consumption of the finished product across supplier-user companies” and “the functions within and outside a company that enable the value chain to make products and provide services to the customer” (Lummus & Vokurka, 1999). Thus, supply chain includes all the activities involved in the generation of products from raw materials to its delivery to the final customer including sourcing of raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, delivery to the customer, and the use of information systems necessary to monitor these activities.

According to the members of The Global Supply Chain Forum, SCM can be defined as “the integration of key business processes from end users through original suppliers that provide products, services, and information that add value for customers and other stakeholders” (Lambert, Cooper, & Pagh, 1998). Therefore, SCM basically means integration and coordination of all supply chain processes and stakeholders involved in the whole process. Figure 1 shows the general scheme of SCM where the physical flow shows the movement of products and money and informative flow refers to activities like order placing, delivery status updates, statistics etc.

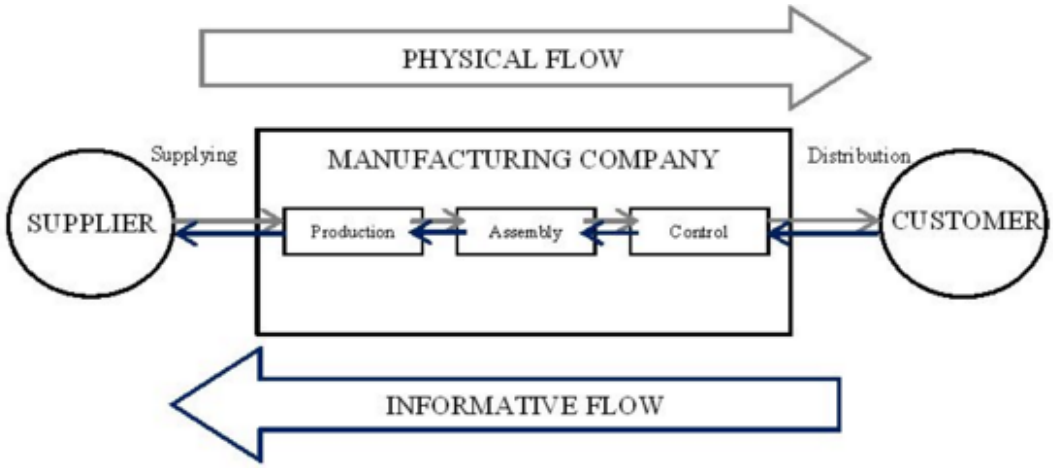

Figure 1 General Scheme of Supply Chain Management (Source: Regattieri & Santarelli , 2013)

2.2 Green Supply Chain Management

As defined by (Emmet & Sood, 2010), in comparison to traditional Supply chain, "Green Supply Chains consider the environmental effects of all processes of supply chain from the extraction of raw materials to the final disposal of goods." Hence, there is enhanced focus on end-to-end supply chain costs with greater visibility and information sharing between the various players of the supply chain. Each member of the supply chain motivates the other member to adapt green practices and provides guidance and support through different supplier development programs and customer support. Figure 2 shows the general green supply chain framework depicting green initiatives adopted in designing, sourcing, manufacturing, distribution and product recovery.

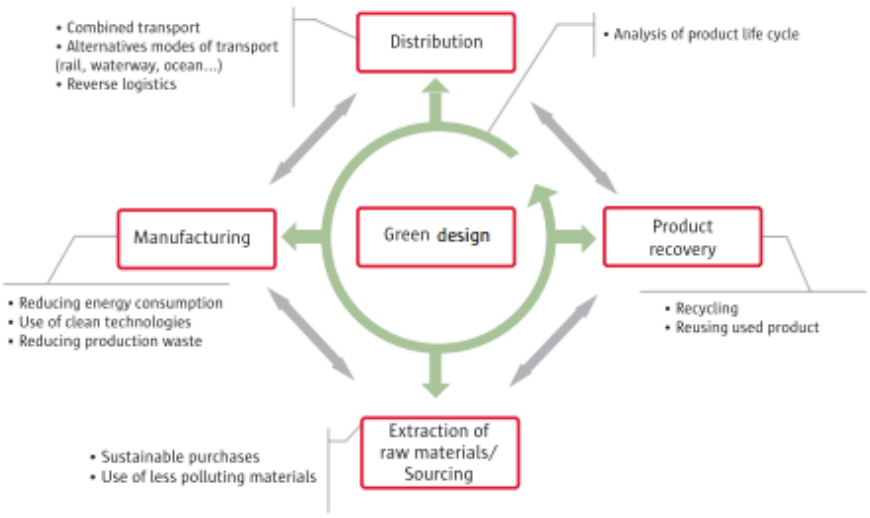

Figure 2 General Green Supply Chain Framework (Source: 2008 Supply Chain Monitor "How mature is the Green Supply Chain?", 2008)

2.3 Barriers to GSCM

Due to the prominent dominance of small and medium enterprises (SME's) in the Indian subcontinent and their significant impact on the economy and development, they enact a great impact on the environment (Govindan, et al., 2014). Moreover, in review of the research papers, it has been found that the implementation of GSCM in the SME's is encountering more hurdles as compared to those in the larger enterprises. A series of studies has confirmed the hurried implementation of GSCM. Various studies have pointed towards different barriers faced by the industries in taking up environmental measures.

The approach for the extraction of these barriers involved literature reviews, surveys, expert opinions, brainstorming sessions etc. In the past, studies have laid emphasis on finding the most influential barriers by prioritizing them through techniques like, Interpretive Structure Modelling (ISM), Analytical Hierarchy Process (AHP), or Graph

Theoretic and Matrix Approach (GTMA) etc. (Mathiyazhagan & Haq, 2013). The organizations then work on the most significant barriers having the highest priority.

From the literature review of 17 research papers on barriers to GSCM, it has been found that most of the studies took place in Asian or Middle-Eastern countries. More details about them have been provided in Figure 3. Countries like India and China are found to be the front runners in research on barriers to GSCM.

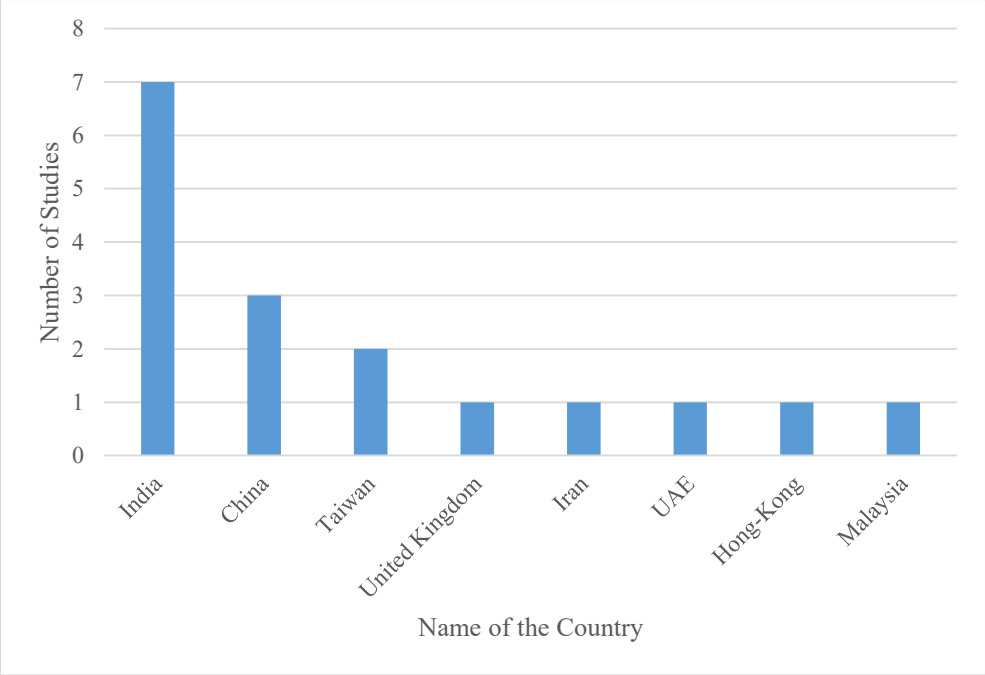

Figure 3 Countries of Research

It is seen Figure 4, that the research articles selected for the present study were mostly from recent years and only three of them were from years before 2010.

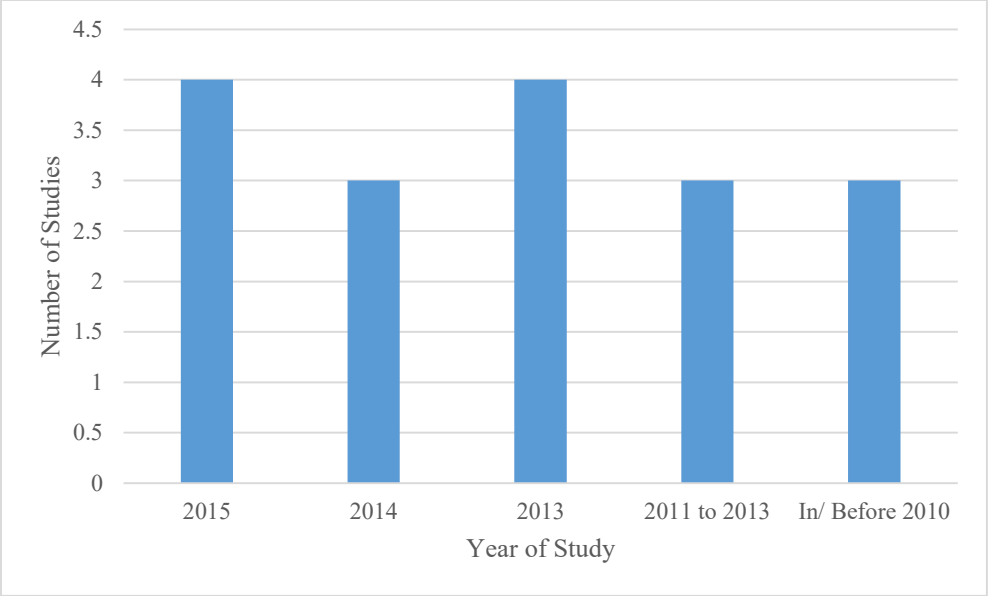

Figure 4 Years of Research

With respect to the methodologies adopted in the papers, it is found that most of the research papers implemented ISM for the prioritization of the barriers to GSCM as shown in Figure 5. Amongst the other methodologies were AHP, DEMATEL, Delphi Method and GTMA, Factor Analysis, and Statistical Package for Social Sciences (SSPS).

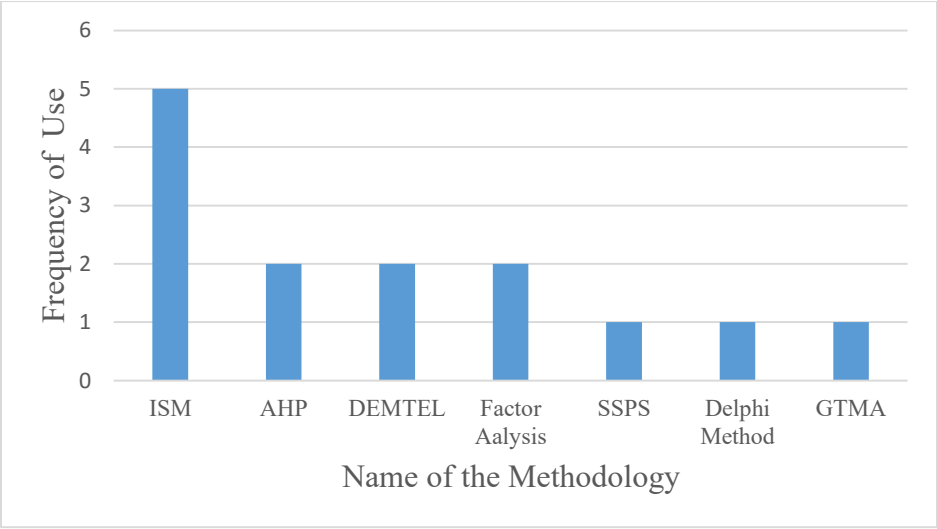

Figure 5 Methodologies of Research

Amongst the journals, Journal of Cleaner Production has published the highest number of studies on the subject. The names of all the journals with the number of papers in each of them is shown in Figure 6Figure 6.

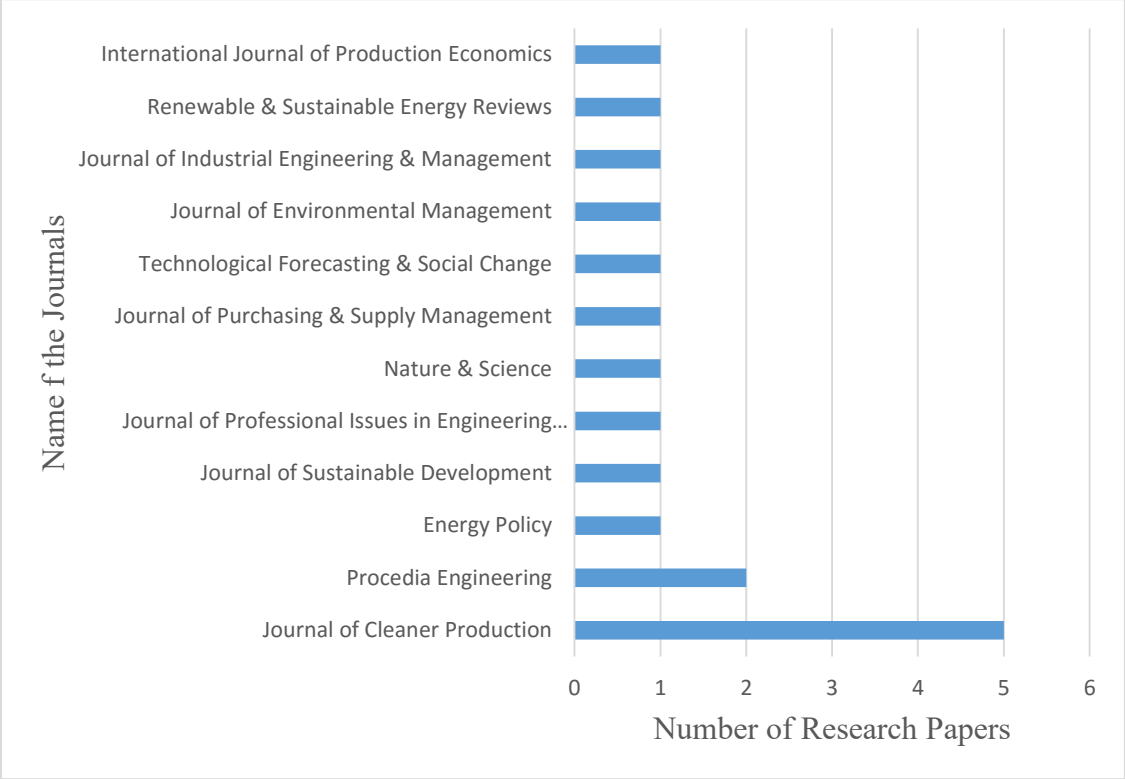

Figure 6 Journals of Research

Figure 7 depicts the various industries explored in the literature and the number of studies pertaining to each one of them.

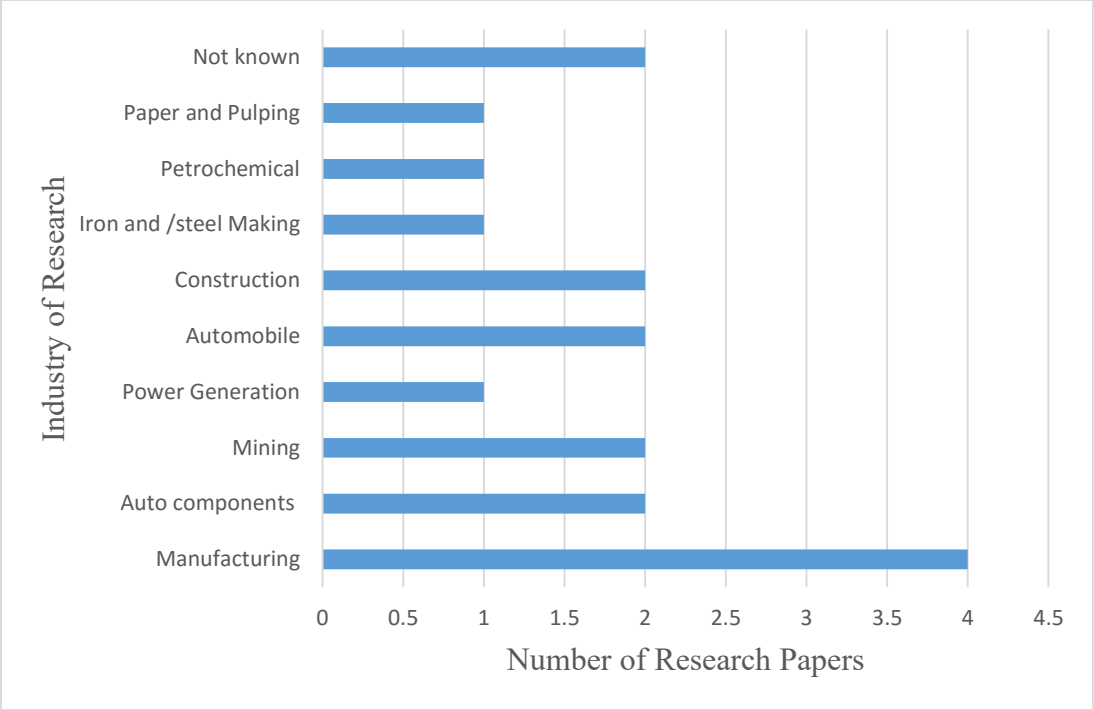

Figure 7 Industries of Research

2.4 Research Gap

The cited research papers provide an insightful background of the GSCM, consisting of its evolution, implementation and barriers. As many other research papers focus on the evolution and drivers of the GSCM, this particular set of papers has its focus on the barriers to GSCM.

The review of these papers points out a research gap in the studies and analysis of GSCM barriers, especially in the context of Indian and Chinese SME's. It has been found that only limited number of studies have been done on this topic and from limited number of industrial perspectives. As each industry and country differs in its opinions and judgments about the GSCM adoption, it is more than essential to take into account as many perspectives as possible. Most of the studies in the past have taken only limited number of barriers for analysis, this paper takes a step ahead by considering 54 different barriers in

total. The complete list of these barriers with their discoverer/researcher and subsequent research paper from which they have been extracted has been shown in Table 1 at the end of this chapter.

It was found that there exists a gap in the categorization of these barriers. A knowledge based methodology of SCM would be useful for their categorization. We propose six different categories based on Multiple M's (8 M's), Supply Chain Processes (Design, Purchasing, Production, Testing & Inspection, Packaging, Transportation, Warehousing, After Sales Service, and Recycling), Stakeholders (Employees, Customers, Suppliers, Government/Regulatory, and NGO's), Sustainability Areas (Societal, Economic, Environmental, Technical), Organizational Hierarchy (Top Management/Executive Level, Middle Management/Departmental Level, Worker/Supervisory Level) and Others (Psychological, Technological, Knowledge, and Strategical). Each barrier is then classified under each category on the knowledge basis

Table 1 Barrier Sources

Barrier No.	Barrier Name	Sources	Industry	Country
a1	Lack of government support to towards Environmental friendly policies	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Jayant & Azhar, 2014), (Luthra, Kumar, Kumar, & Haleem, 2011), (Jalalifar, Hafshejani, & Movahedi, 2013), (Liu, 2014), (Xia, Govindan, & Zhu, 2015), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Automobile, Automotive parts remanufacturing	India, China, Malaysia
a2	Market competition and uncertainty	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Jayant & Azhar, 2014), (Luthra, Kumar, Kumar, & Haleem, 2011), (Balasubramanian, 2012), (Lam, Chan, Chau, Poon, & Chun, 2009), (Liu, 2014), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Automobile, Construction	India, Hong-Kong, China, Malaysia
a3	Lack of support and guidance from regulatory authorities	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Jayant & Azhar, 2014), (Li, Pan, Kim, Linn, & Chiang, 2015), (Walker, Sisto, & McBain, 2008), (Liu, 2014), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Iron and steel making, Petrochemical, Paper and Pulping, Mining, Iron and steel making, Petrochemical, Paper and Pulping, Mining, Manufacturing	India, Taiwan, United Kingdom, China, Malaysia
a4	Changing regulations due to changing political climate	(Muduli, Govindan, Barve, & Geng, 2013), (Li, Pan, Kim, Linn, & Chiang, 2015), (Liu, 2014)		India, Taiwan, China
a5	Lack of government enforcement and corruption due to poor legislation	(Muduli, Govindan, Barve, & Geng, 2013), (Walker, Sisto, & McBain, 2008), (Ghazilla, et al., 2015)		India, United Kingdom, Malaysia

a6	Problem in maintaining environmental suppliers	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Jayant & Azhar, 2014), (Luthra, Kumar, Kumar, & Haleem, 2011), (Lam, Chan, Chau, Poon, & Chun, 2009), (Xia, Govindan, & Zhu, 2015)	Manufacturing (Auto components), Automobile, Construction, Automotive parts remanufacturing	India, Hong-Kong, China
a7	Complexity in measuring and monitoring suppliers environmental practices	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Ravi & Shankar, 2005), (Balasubramanian, 2012)	Manufacturing (Auto components), Automobile, Construction,	India, UAE
a8	Lack of an environmental partnership with suppliers	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Zhu & Geng, 2013), (Luthra, Kumar, Kumar, & Haleem, 2011)	Manufacturing, Automobile	India, China
a9	Products potentially conflict with laws	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Ravi & Shankar, 2005)	Manufacturing, Automobile	India
a10	Complexity of design to reuse/recycle used products	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Jayant & Azhar, 2014), (Balasubramanian, 2012), (Xia, Govindan, & Zhu, 2015)	Manufacturing (Auto components), Construction, Automotive parts remanufacturing	India, UAE, China
a11	Complexity of design to reduce consumption of resource/energy	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Muduli, Govindan, Barve, & Geng, 2013), (Ghazilla, et al., 2015)	Manufacturing, Mining	India, Malaysia

a12	Poor supplier commitment/ unwilling to exchange information	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Zhu & Geng, 2013), (Luthra, Kumar, Kumar, & Haleem, 2011), (Walker, Sisto, & McBain, 2008), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Mining, Construction, Automotive parts remanufacturing	India, China, United Kingdom , Malaysia
a13	High investments and less return-on investments	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Zhu & Geng, 2013), (Muduli, Govindan, Barve, & Geng, 2013), (Jayant & Azhar, 2014), (Jalalifar, Hafshejani, & Movahedi, 2013), (Balasubramanian, 2012), (Xia, Govindan, & Zhu, 2015), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Automobile, Construction, Automotive parts remanufacturing	India, China, UAE, China, Malaysia
a14	Expenditure in collecting and recycling used products	(Govindan, Kaliyan, Kannan, & Haq, 2014)	Manufacturing	India
a15	Cost of environment friendly packaging	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Zhu & Geng, 2013)	Manufacturing	India, China
a16	Non-availability of bank loans to encourage green products/processes	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Jayant & Azhar, 2014), (Li, Pan, Kim, Linn, & Chiang, 2015), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Iron and steel making, Petrochemical, Paper and Pulping	India, Hong-Kong, Taiwan, Malaysia
a17	High cost of hazardous waste disposal	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Zhu & Geng, 2013), (Jayant & Azhar, 2014), (Mathiyazhagan, Diabat, Al-Refaie, & Xu, 2015)	Manufacturing (Auto components), Mining and Mineral	India, China

a18	Cost of switching to new system, maintenance and operations costs of the improved system	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Zhu & Geng, 2013), (Wee, Yang, Chou, & Padilan , 2012), (Li, Pan, Kim, Linn, & Chiang, 2015), (Ravi & Shankar, 2005), (Walker, Sisto, & McBain, 2008), (Lam, Chan, Chau, Poon, & Chun, 2009), (Liu, 2014), (Ghazilla, et al., 2015)	Manufacturing, Power generation, Iron and steel making, Petrochemical, Paper and Pulping, Automobile, Construction	India, China, Taiwan, United Kingdom , Hong-Kong, Malaysia
a19	Lack of economies of scale, Unequal government subsidies/taxes	(Wee, Yang, Chou, & Padilan , 2012)	Power generation	Taiwan
a20	Fear of failure	(Govindan, Kaliyan, Kannan, & Haq, 2014) (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Jayant & Azhar, 2014), (Lam, Chan, Chau, Poon, & Chun, 2009)	Manufacturing (Auto components), Construction	India, Hong-Kong
a21	Difficulty in transforming positive environmental attitudes into action	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Muduli, Govindan, Barve, & Geng, 2013), (Luthra, Kumar, Kumar, & Haleem, 2011), (Lam, Chan, Chau, Poon, & Chun, 2009)	Manufacturing, Mining, Automobile	India, United Kingdom , Malaysia
a22	Lack of technical expertise	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Zhu & Geng, 2013), (Muduli, Govindan, Barve, & Geng, 2013), (Jayant & Azhar, 2014), (Luthra, Kumar, Kumar, & Haleem, 2011), (Jalalifar, Hafshejani, & Movahedi, 2013), (Balasubramanian, 2012), (Xia, Govindan, & Zhu, 2015), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Mining, Automobile, Construction, Automotive parts remanufacturing	India, China, UAE, Malaysia

a23	Lack of awareness about reverse logistics adoption	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013) (Jayant & Azhar, 2014), (Ravi & Shankar, 2005)	Manufacturing (Auto components), Automobile	India
a24	Disbelief about environmental benefits	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Muduli, Govindan, Barve, & Geng, 2013), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Mining	India, Malaysia
a25	Perception of "out of responsibility" zone	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Muduli, Govindan, Barve, & Geng, 2013), (Balasubramanian, 2012), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Mining, Construction	India, UAE, Malaysia
a26	Difficulty in identifying environmental opportunities	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Muduli, Govindan, Barve, & Geng, 2013)	Manufacturing, Mining	India
a27	Lack of Eco-literacy amongst supply chain members	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Jayant & Azhar, 2014), (Ravi & Shankar, 2005), (Balasubramanian, 2012), (Lam, Chan, Chau, Poon, & Chun, 2009)	Manufacturing (Auto components), Automobile, Construction	India, UAE, Hong-Kong
a28	Lack of environmental knowledge	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Muduli, Govindan, Barve, & Geng, 2013), (Jayant & Azhar, 2014), (Jalalifar, Hafshejani, & Movahedi, 2013), (Balasubramanian, 2012), (Lam, Chan, Chau, Poon, & Chun, 2009), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Mining, Construction	India, UAE, Hong-Kong, Malaysia
a29	Lack of information of Renewable Energy (RE) resources	(Zhu & Geng, 2013), (Wee, Yang, Chou, & Padilan , 2012), (Jalalifar, Hafshejani, & Movahedi, 2013)	Manufacturing, Power generation	India, Taiwan

a30	Lack of green system exposure to professionals	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Zhu & Geng 2013), (Balasubramanian, 2012)	Manufacturing (Auto components), Power Generation	India, China, UAE
a31	Complexity in identifying third parties to recollect used products	(Govindan, Kaliyan, Kannan, & Haq, 2014)	Manufacturing	India
a32	Difficulty in obtaining information on potential environmental improvements	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Zhu & Geng, 2013), (Muduli, Govindan, Barve, & Geng, 2013), (Li, Pan, Kim, Linn, & Chiang, 2015), (Xia, Govindan, & Zhu, 2015), (Ghazilla, et al., 2015)	Manufacturing, Mining, Iron and steel making, Petrochemical, Paper and Pulping, Automotive parts remanufacturing	India, China, Taiwan, China, Malaysia
a33	Hesitation/fear to convert to new systems	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Muduli, Govindan, Barve, & Geng, 2013), (Jayant & Azhar, 2014), (Luthra, Kumar, Kumar, & Haleem, 2011), (Ravi & Shankar, 2005), (Balasubramanian, 2012), (Lam, Chan, Chau, Poon, & Chun, 2009), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Mining, Automobile, Construction	India, UAE, Hong-Kong
a34	Lack of R&D capability on GSCM practices	(Zhu & Geng, 2013), (Xia, Govindan, & Zhu, 2015), (Ghazilla, et al., 2015)	Manufacturing, Automotive parts remanufacturing	China, Malaysia
a35	Lack of employee awareness about occupational health hazards	(Muduli, Govindan, Barve, & Geng, 2013)	Mining	India
a36	Risk in hazardous material inventory	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Jayant & Azhar, 2014)	Manufacturing (Auto components),	India

a37	Lack of training courses/consultancy/institutions to train, monitor/mentor progress specific to each industry	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Zhu & Geng, 2013), (Jayant & Azhar, 2014), (Ravi & Shankar, 2005), (Walker, Sisto, & McBain, 2008), (Balasubramanian, 2012), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Automobile, Construction	India, China, United Kingdom, UAE, Malaysia
a38	Lack of customer awareness and pressure about GSCM	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Muduli, Govindan, Barve, & Geng, 2013), (Jayant & Azhar, 2014), (Luthra, Kumar, Kumar, & Haleem, 2011), (Balasubramanian, 2012), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Automobile, Construction	India, UAE, Malaysia
a39	Lack of awareness of the environmental impacts on business	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Li, Pan, Kim, Linn, & Chiang, 2015), (Ghazilla, et al., 2015)	Manufacturing, Iron and steel making, Petrochemical, Paper and Pulping	India, Taiwan, Malaysia
a40	No proper training/reward system for suppliers	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Luthra, Kumar, Kumar, & Haleem, 2011), (Jalalifar, Hafshejani, & Movahedi, 2013), (Balasubramanian, 2012)	Manufacturing, Automobile, Construction	India, UAE
a41	No clear statement for responsibilities from management	(Zhu & Geng, 2013), (Walker, Sisto, & McBain, 2008), (Jalalifar, Hafshejani, & Movahedi, 2013), (Balasubramanian, 2012)	Manufacturing, Construction	China, United Kingdom, UAE

a42	Lack of effective environmental measures	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Luthra, Kumar, Kumar, & Haleem, 2011), (Jalalifar, Hafshejani, & Movahedi, 2013), (Balasubramanian, 2012), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Automobile, Construction	India, UAE, Malaysia
a43	Lack of human resources	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Muduli, Govindan, Barve, & Geng, 2013), (Luthra, Kumar, Kumar, & Haleem, 2011), (Jalalifar, Hafshejani, & Movahedi, 2013), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Mining, Automobile	India, Malaysia
a44	Current practice lacks flexibility to switch over to new system	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Lam, Chan, Chau, Poon, & Chun, 2009), (Liu, 2014), (Ghazilla, et al., 2015)	Manufacturing, Construction	India, Hong-Kong, China, Malaysia
a45	Lack of new technology, materials and processes	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Zhu & Geng, 2013), (Jayant & Azhar, 2014), (Luthra, Kumar, Kumar, & Haleem, 2011), (Li, Pan, Kim, Linn, & Chiang, 2015), (Ravi & Shankar, 2005), (Jalalifar, Hafshejani, & Movahedi, 2013), (Balasubramanian, 2012), (Lam, Chan, Chau, Poon, & Chun, 2009), (Xia, Govindan, & Zhu, 2015), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Automobile, Iron and steel making, Petrochemical, Paper and Pulping, Construction, Automotive parts remanufacturing	India, China, Taiwan, UAE, Hong-Kong, Malaysia
a46	Lack of infrastructure for suitability of waste management or disposal methods	(Muduli, Govindan, Barve, & Geng, 2013), (Luthra, Kumar, Kumar, & Haleem, 2011) (Balasubramanian, 2012)	Mining, Automobile, Construction	India, UAE

a47	No specific environmental goals	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Ravi & Shankar, 2005), (Jalalifar, Hafshejani, & Movahedi, 2013), (Balasubramanian, 2012), (Lam, Chan, Chau, Poon, & Chun, 2009)	Manufacturing, Automobile, Construction	India, UAE, Hong-Kong
a48	Lack of corporate social responsibility	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Jayant & Azhar, 2014), (Jalalifar, Hafshejani, & Movahedi, 2013), (Balasubramanian, 2012), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Construction	India, China, UAE, Malaysia
a49	Not much involvement in environmental related programs/meetings	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013)	Manufacturing (Auto components)	India
a50	Restrictive company policies towards product/process stewardship	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Ravi & Shankar, 2005), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Automobile	India, Malaysia
a51	Lack of inter-departmental co-operation in communication	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Zhu & Geng, 2013), (Muduli, Govindan, Barve, & Geng, 2013), (Jalalifar, Hafshejani, & Movahedi, 2013), (Balasubramanian, 2012), (Lam, Chan, Chau, Poon, & Chun, 2009), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Construction, Mining	India, China, UAE, Hong-Kong, Malaysia

a52	Lack of involvement of top management in adopting GSCM	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Mathiyazhagan, Govindan, NoorulHaq, & Geng, 2013), (Zhu & Geng, 2013), (Jayant & Azhar, 2014), (Luthra, Kumar, Kumar, & Haleem, 2011), (Ravi & Shankar, 2005), (Walker, Sisto, & McBain, 2008), (Jalalifar, Hafshejani, & Movahedi, 2013), (Balasubramanian, 2012), (Lam, Chan, Chau, Poon, & Chun, 2009), (Ghazilla, et al., 2015)	Manufacturing (Auto components), Construction, Automobile	India, China, United Kingdom , UAE, Hong-Kong, Malaysia
a53	Failure to market the benefits/results of GSCM	(Wee, Yang, Chou, & Padilan , 2012)	Power generation	India, China
a54	Inadequate management capacity	(Govindan, Kaliyan, Kannan, & Haq, 2014), (Jalalifar, Hafshejani, & Movahedi, 2013), (Liu, 2014)	Manufacturing	India

Chapter 3

Research Methodology

The proposed research methodology comprises of four main steps. In the first step, we list all the barriers identified from the literature review and a total of 54 barriers are identified. In the second step, we assign the 54 barriers to six categories of classification and their sub-categories. A separate table for each category and sub-categories of the barriers is shown in Appendix A. Step 3 begins with the assignment of "1"s in every cell for which a barrier and a sub-category bears any relationship. This step is repeated for each of the six categories. In the subsequent steps, column-wise totals of all the "1's" and row-wise totals of all the "1's" for every category is performed. The column-wise totals give the important sub-categories that has the most impactful barriers. The row-wise totals give the most important barriers in every category. Step 4 includes the application of DEMATEL and Pareto analysis on the barriers generated in the step 3. Figure 8 shows the flowchart explaining the four steps involved the methodology.

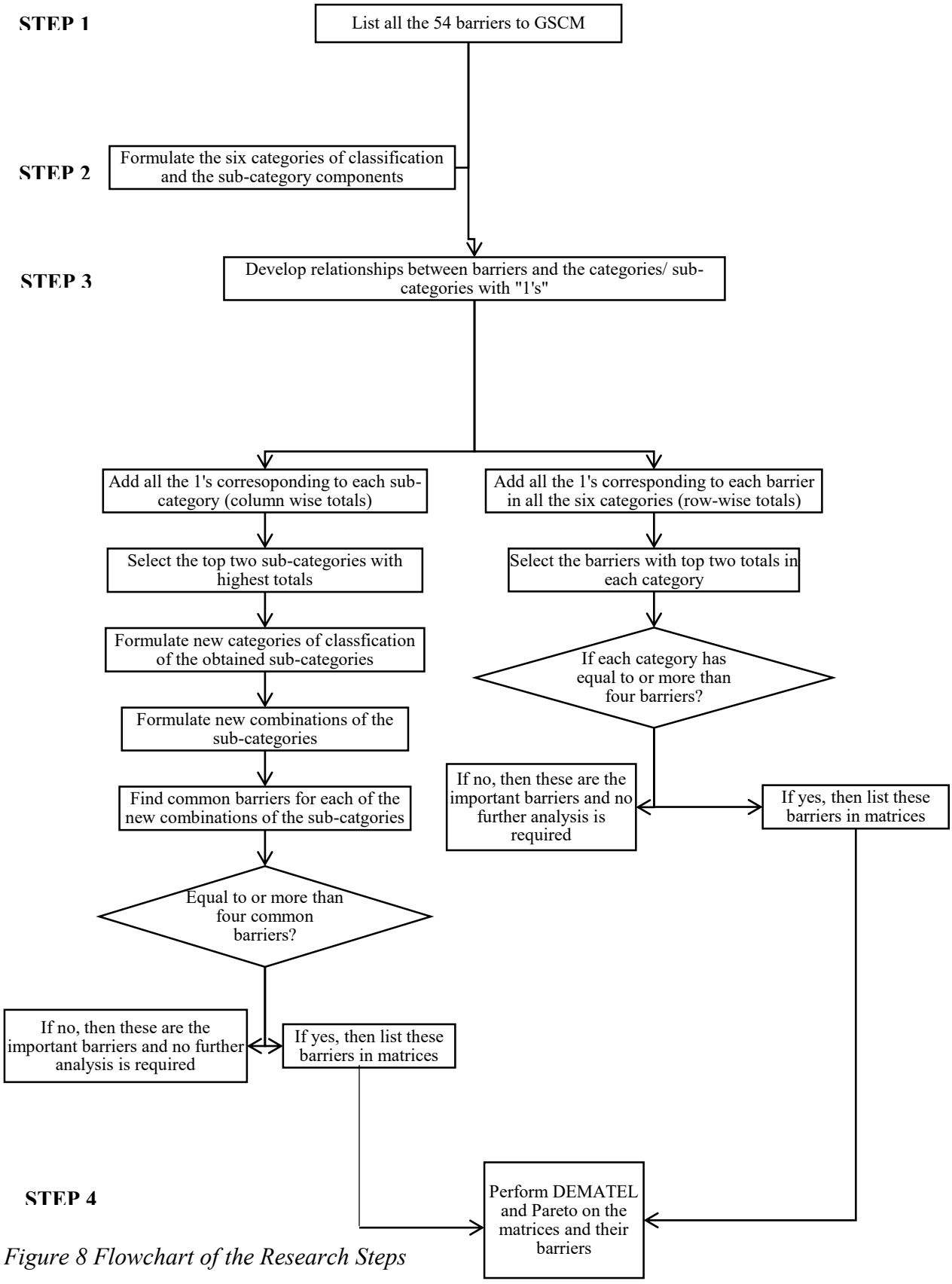

Figure 8 Flowchart of the Research Steps

3.1 Classification Categories

The six different categories of classification are explained in detail in the following sections. Table 2 gives the list of all the categories/sub-categories of classification.

Table 2 Classification Categories

Multiple M's	Supply Chain Processes	Stakeholders	Sustainability Area	Organizational Hierarchy	Others
Man	Design	Employees	Societal	Top Management	Psychological
Machine	Purchasing	Customers	Economic	Middle Management	Technological
Method	Production	Suppliers	Environmental	Workers	Knowledge
Material	Testing & Inspection	Government/ Regulatory	Technical		Strategical
Money	Packaging	NGO's			
Measurement	Transportation				
Market	Warehousing				
Motivation	After Sales Service				
	Recycling				

3.1.1 Multiple M's

Multiple M's technique of classifying the problems has been widely used in continuous process improvement and six sigma projects. Fishbone method, introduced by Kaoru Ishikawa uses this for developing the cause-and-effect diagram. It is used to construct the causes or problems on the "bones" which lead to the effect or the problem itself (Evans & Lindsay, 2005). The causes are often classified into 5 M's like, Man, Machine, Method, Material and Measurement etc. However, it is possible to have multiple M's according to the nature of the problem. In a research performed on the use of corporate six sigma

performance-improvement strategies for reducing the incidences of catheter related bloodstream infections in a surgical ICU, 6 M's i.e. Mother nature (patient factors here), Manpower (registered nurse and physician factors), Measurement (culture technique), Materials (catheter issues), Methods (sterile training and technique), and Machines (NA) were used in the cause-and-effect diagram (Frankel et al., 2005). In the present study, we have considered 8 M's, i.e. Man, Machine, Method, Material, Money, Measurement, Market and Motivation for classifying the barriers to GSCM.

3.1.2 Supply Chain Processes

For this category, the barriers to GSCM are classified under different supply chain processes/operations such as, Design, Purchasing, Production, Testing & Inspection, Packaging, Transportation, Warehousing, After Sales Service and Recycling (Bozarth & Handfield, 2008).

Design: Being the first step, it plays the most important role in any supply chain. If the organizations offer more focus on environmental concerns in their design phase, the supply chains could be made more sustainable.

Procurement: Also known as buying, sourcing, or purchasing, procurement is the process through which the raw materials and suppliers are generally selected by any organization (Emmet & Sood, 2010). Greening the procurement process would lead to waste minimization, cost savings, process improvement, image improvement and better compliance with the environment regulations.

Production: As manufacturing process has a significant impact on the environment, it is extremely important to move the focus towards green manufacturing, which involves the

use of better technology, eco-friendly materials, safe working conditions, and lower harmful emissions etc.

Testing & Inspection: This process involves checking if the product/service conforms to the specifications and regulations set by the related authorities. It usually falls under the quality control of the organization and is done just before the packaging process. GSCM barriers like "a9" (product usually conflict with laws) and "a22" (Lack of technical expertise) are contributed through this process.

Packaging: It has been found out to be the front runner amongst the sources of environmental pollution and degradation (Emmet & Sood, 2010) and thus, has become another focus of improvement for the organizations. Consumers have now become more environmentally aware than before and judge an organization's awareness as well.

Transportation: As the logistics operations enormously contribute to the greenhouse gases and deterioration of the environment, greening the supply chains through this activity has become a central point for the freight industry. Increased customer expectations and high penalties for non-compliances with the legislative regulations has acted as a pertinent driver for this supply chain process.

Warehousing: As defined by (Bozarth & Handfield, 2008), it refers to "any operation that stores, repackages, stages, sorts, or centralizes goods or materials". Thus, this process is important from the financial and time perspective for an organization. Often, an organization hesitates from going green in warehousing their products due to barriers like "a36" (Risk in hazardous material inventory).

After Sales Service: It refers to the support provided by the organization after the sale of its product/service. The examples of such services includes technical support, exchange service, easy and timely returns, warranty claims etc. It is to be noted though, that none of the barriers listed in the Appendix A related to this supply chain process.

Recycling: Reverse Logistics adoption is one of the most important activities required in order to implement GSCM successfully. With increased pressures for reverse logistics from both the customers and the government regulations, organizations are facing many challenges related to recycling process (Govindan, et al., 2012). Complexity of design and financial constraints are amongst those few challenges.

3.1.3 Stakeholders in Supply Chain

Stakeholders play a pivotal role in the case of collaborative supply chain and each one of them contributes significantly to their assigned roles (Kumar, Luthra, & Haleem, 2013) . In a typical case, the prominent stakeholders in a supply chain includes Suppliers, Manufacturers, Wholesalers, Retailers and Customers (Angerhofer & Angelides, 2006). In the present study, we could not identify any barriers related to the Retailers and the Wholesalers in the GSCM, so they are not included. At the same time, it was found that a lot of barriers were related to the regulatory authorities and government policies. Therefore, this category takes into account the different stakeholders of a supply chain namely, Employees (Organizational), Customers, Suppliers, Government and NGO's.

3.1.4 Sustainability Area

In this category, the supply chain has been segmented into four sustainability areas i.e. Societal, Economic, Environmental and Technical. Sustainability refers to the progress and advancements being made in the present without compromising with the needs of the future

generations (Seuring & Müller, 2008). Triple bottom line is a widely used approach in diverse number of frameworks related to sustainability. It basically states that at the intersection of these three facets (Social, Economic and Environment) of sustainability, organizations can engage in activities which are not only beneficial for environment and society, but also provides economic perks (Carter & Rogers, 2008). For the present study, along with the core of the sustainability which is this triple bottom line concept, another area that is considered is the technical aspect of sustainability.

3.1.5 Organizational Hierarchy

In this category, the supply chain has been split into three different levels of an organization i.e. Top level, Middle level and Worker level. Goals which are the top most objectives of an organization, are converted to managerial level objectives through strategic planning which are further converted into departmental level objectives through operational planning, and finally, execution involves the implementation of operational goals in real practice. The top management, referred to as the executive level, is involved in the goal setting and strategic planning of an organization. The Middle Management, referred to as the managerial level, works on the operational planning and the worker/supervisory level of an organization performs the execution of the objectives set by the middle management.

3.1.6 Others

There were few categories of classifications which do not fit into the above categories and are individualistic. But they require a separate category of classification for contributing to the study. Hence, these are listed under the sixth and the final category called as Others. Psychological, Technological, Knowledge and Strategical are the four sub-categories of this category.

3.2 DEMATEL

3.2.1 Introduction and Objective

The Decision Making and Trial Evaluation Laboratory (DEMATEL) technique is reported to have originated from the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976 (Tzeng, Chiang, & Li, 2007). It was believed that it would aid in understanding a particular problem by developing and using DEMATEL as a scientific research method (Chen, 2012). It is considered to be pertinent in solving problems involving group decision making by highlighting the most important variables in the problem. It is particularly helpful in systems involving complex and intertwined situations (Awasthi & Grzybowska, 2014). One of the very important characteristic of this methodology is that it can be applied to problems involving a large number of variables to develop inter-relationships between them (Chung-Wei & Gwo-Hshiung, 2009).

3.2.2 Literature Review and Applicability

DEMATEL technique is found to be a vast and diverse approach with respect to its applicability in solving complex and intertwined problems (Awasthi & Grzybowska, 2014). It is worth mentioning some of the case studies and applications performed by the researchers using DEMATEL in diverse criteria, structures, sectors, industries, countries etc. that has helped organizations/government agencies in process improvement and problem solving. Therefore, in this section, its applicability and diversity is presented through accounts of some research studies performed so far.

DEMATEL was used in developing a carbon management model for allowing the organizations to select suppliers having competence in carbon management in GSCM

(Hsu, et al., 2013). In this particular study, about thirteen criteria with three different dimensions of carbon management were studied and structural relations were developed to study the cause-and-effect relationships between them. In another study conducted on Taiwan's Employment Service Outreach Program, the performance criteria of the outreach personnel was evaluated using DEMATEL which helped in the identification of the main causes under job-seeking service category (Wu, Chen, & Shieh, 2010).

In order to identify key organizational and management factors that play a crucial role in aviation related accidents, DEMATEL was performed on the data obtained from one of the Taiwan's civil aviation industry. It showed that fuzzy DEMATEL has been useful in visualizing the structural relations and in identifying key factors in a complex system such as Safety Management Systems for airlines (Liou, Yen, & Tzeng, 2008). Nearly seventeen barriers faced by business organizations in the supply chain integration were identified in another study through experts in Poland and Canada and top five barriers were identified using DEMATEL (Awasthi & Grzybowska, 2014).

In another context where DEMATEL has been practiced is for improving the medical tourism industry in Taiwan (Chen, 2012). The eleven criteria identified were sub-divided into five different levels and group decision making was performed using responses from fifteen tourists and physicians. Consequently, the results suggested that Taiwan should focus on criteria like "internet marketing" and "network information".

DEMATEL has also been actively implemented in research areas focused on GSCM, whether it is for evaluating the most influential factors for successful implementation of GSCM (Gandhi, et al., 2015), evaluation of current GSCM practices (Lin, 2013), or finding the effective barriers in the implementation of GSCM (Jalalifar, Hafshejani, & Movahedi,

2013). The real life applicability is evident through the empirical case studies performed on different industries.

This technique is often combined with other methods such as Analytical Network Process (ANP), Analytical Hierarchical Process (AHP), fuzzy logic, grey based theory, Multiple Criteria Decision Making (MCDM), factor analysis etc. for better understanding of problems involving numerous criteria and levels (Lee, et al., 2013). A research on supply chain based barriers in the truck-engine remanufacturing in China incorporated grey-based DEMATEL for the purpose of eliminating any uncertainty arising from dealing with 19 variables and performed sensitivity analysis by changing the weights assigned to the responses received from different experts (Zhu, et al.,2014). The grey-based DEMATEL approach was also used in evaluating green supplier development programs (GSDP) by a telecommunications provider (Fu, et al., 2012). Fuzzy logic and DEMATEL have been combined in few environments involving vague and imprecise judgements. This includes development of global managers' competencies (Wu & Lee, 2007), evaluation of GSCM practices (Lin , 2013) and development of supplier selection criteria (Chang, Chang, & Wu, 2011), to name a few. In another hybrid model presented for evaluating the intertwined effects in the e-learning programs (Tzeng, Chiang, & Li, 2007), the independent relations of criteria were evaluated using MCDM model and factor analysis and the dependent relations were evaluated through DEMATEL in a fuzzy environment.

3.2.3 Technique

This techniques is synonymous to mind mapping in a way that the responses obtained for the variables (which are barriers in this case) from the experts are organized in kind of a visual impact-map that determine the actions taken in the direction of the problem in the

real world. It has been found to be commonly used method for modeling relationships between variables. In DEMATEL, cause and effect are two important factors which are considered for separating the variables into two different quadrants (cause and effect) and directional relationships are then drawn between them (Awasthi & Grzybowska, 2014).

(Fu, et al., 2012) Summarize the procedures of this technique into following four important stages:

- Stage 1. Development of pair-wise direct relations matrix between the system variables by obtaining the relationships developed by the experts
- Stage2. Determining the initial influence matrix by normalizing the direct-relation matrix obtained in the stage 1.
- Stage 3. Determining the total relation matrix.
- Stage 4. Determining the prominence-causal diagram and the relative strengths of the variables.

The different steps followed for the calculations are shown below (Chen, 2012) (Awasthi & Grzybowska, 2014):

Step 1: Generation of the Direct Relation/Average Matrix: Let there be *n* variables (i.e. barriers in this case) and a total of *m* experts who provided their responses for determining all the binary relationships between the variables as well as the strength of relationships.

Suppose A_k is the *n x n* matrix obtained from k^{th} expert using the notations given below for filling the matrix entries, i.e. the entry $a_{ij(k)}$ in the matrix gives the level of influence of the barrier a_i on the barrier *aj* as given by the k^{th} expert. Five levels of influence are defined below:

0: No influence (if barrier a_i have no influence over a_j)

1: Somewhat influence (if barrier a_i have somewhat influence over a_j)

2: Medium influence (if barrier a_i have medium over a_j)

3: High influence (if barrier a_i have high influence over a_j)

4: Very high influence (if barrier a_i have very high influence over a_j)

$$A_k = \begin{array}{c|ccccc} & E_1 & \dots & E_j & . & E_n \\ E_1 & 0 & \dots & a_{1j(k)} & . & a_{1n(k)} \\ : & : & \dots & : & . & : \\ E_i & a_{i1(k)} & \dots & a_{ij(k)} & . & a_{in(k)} \\ : & : & \dots & : & . & : \\ E_n & a_{n1(k)} & \dots & a_{nj(k)} & . & 0 \end{array}$$

Matrix entries represent these relationships and the *n x n* average matrix *Z* is obtained by finding the average of all the responses provided by "*m"* different experts for each relationship in the matrix. These matrix entries basically give the influence scores for the various variables (barriers to GSCM in this case) over each other obtained from the expert ratings on a scale of 0 to 4.

$$Z = \begin{vmatrix} 0 & \dots & Z_{1j} & . & Z_{1n} \\ : & \dots & : & . & : \\ Z_{i1} & \dots & Z_{ij} & . & Z_{in} \\ : & \dots & : & . & : \\ Z_{n1} & \dots & Z_{nj} & . & 0 \end{vmatrix}$$

Step 2: Normalized Direct Relation Matrix: The *n x n* normalized direct relation matrix *X* is found from the direct relation matrix obtained in the step 1 by dividing the direct relation matrix *Z* by *S,* where *S* is calculated as below:

$S = \max\left(\sum_{j=1}^{n} \text{Zij}, \sum_{i=1}^{n} \text{Zij}\right)$, $X = Z/S$ and $X = [x_{ij}]_{n \times n}$ where $0 \leq x_{ij} \leq 1$

It is found that the principal diagonal elements of *X* are all equal to zero.

Step 3: Total Relation Matrix: As the normalized direct relation matrix indicates only the direct relations, the total relation matrix *T* gives both direct and indirect influence exerted between the variables on each other. It is given by the following equation:

$$T = X(I - X)^{-1}$$

Where, *I* is the *n x n* Identity matrix.

Step 4: Prominence and Net cause-and-effect Values: Let D_i and *Ej* represent the sum of the i^{th} row (causal influence) and the sum of the j^{th} column (effect influence) respectively of the total relation matrix *T*, where $i = j = k = 1, 2, 3 \ldots\ldots n$. Now $D_k + E_k$ is defined as the prominence value representing the degree of influence and being influenced of the k^{th} variable. A variable with high prominence value is an important variable which can both affect and be affected by the other variables (Zhu, et al., 2014). $D_k - E_k$ is defined as the net cause-and-effect value of the k^{th} variable where the positive $D - E$ value variables are called the cause variables and the negative $D - E$ value variables are called as the effect variables.

Step 5: Threshold and Structural Relations: For the purpose of filtering out the variables having negligible effects from the total relation matrix *T*, a threshold or benchmark value

is chosen. The values lower than the threshold value are then omitted from the matrix T in order to obtain the inner dependency matrix. An impact-relations map is then developed for further analyzing and decision making. It is essential to choose an appropriate threshold value (∂) for obtaining more accurate results for the problem. This is because if the ∂ value is too low then the structural relations will be very complex and will include variables having less influence on the problem and if the ∂ value is too high then a lot of important impact relations will be missing from the picture.

It is discovered that different researchers use different methods for setting the threshold value for the process. For example, discussion with experts, averaging the values of the T matrix (Awasthi & Grzybowska, 2014), adding two standard deviations to the mean (Zhu, et al., 2014), Maximum Mean De-Entropy Algorithm (Chung-Wei & Gwo-Hshiung, 2009) are chosen by the decision maker.

3.2.4 Limitations

- It is witnessed that in many real life scenarios it is easier for human beings to respond to their preferences and expectations qualitatively rather than in exact numbers. As there is no such provision in the traditional DEMATEL approach, the results are not always certain and precise in a fuzzy environment (Shahraki & Paghaleh, 2011).

3.3 Direct Ranking

3.3.1 Importance Scale

In the present study, we chose the variable for measurement as “importance of the barriers to GSCM”. As this variable represents an intrinsic meaning i.e. “importance”, hence it can be treated as an ordinal variable and a qualitative ranking scale can be used in this case.

We used the importance scale of 1 to 10 to obtain the importance scores for the barriers to GSCM. A score of "10" for a barrier illustrated the most importance and a score of "1" demonstrated the least importance in the list of barriers achieved from developing relationships with different sub-category components in the classification. We asked the respondents to assign an importance score for each barrier in the list of barriers achieved from the initial relationship analysis.

3.3.2 Pareto Analysis

As the aim of the study is to identify the "vital few" from the "trivial many", Pareto analysis was used. This technique was named after an Italian economist Vilfredo Pareto by Joseph Juran as he observed that 80% of the effects resulted due to the 20% of the causes (Evans & Lindsay, 2005). A Pareto diagram is a simple histogram of the data entries sorted from largest to lowest frequency and a cumulative frequency curve is obtained. Pareto analysis is widely used as a statistical tool by employees undertaking improvement projects in numerous organizations in order to isolate the most impactful problems from relatively larger number of problems. As a result, the problems which are most significant stand out and provide opportunities for improvements.

In the present study, we employed Pareto analysis for ranking barriers in each of the nine matrices achieved after classification, so as to detect the most impactful barriers in GSCM. The numerical analysis is presented in the following chapter.

Chapter 4

Numerical Analysis and Findings

Findings of the Step 3 and Step 4 of the research methodology (Figure 8), are presented in this chapter.

4.1 Column-wise Totals

Table 3 presents the column-wise totals of all the "1's" for the Category 1 (Multiple M's).

Table 3 Column-wise Totals for Category 1

Sub-category Names	Column-wise Totals
Man	**26**
Machine	5
Method	**54**
Material	6
Money	7
Measurement	1
Market	2
Motivation	2

It is found that Method and Man have the highest totals and hence, they are the most influential sub-categories and barriers related to these two should be given consideration.

Table 4 shows the column-wise totals of all the "1"s related to the Category 2 (Supply Chain Processes) of classification and shows highest totals for Design and Purchasing sub-categories.

Table 4 Column-wise Totals for Category 2

Sub-Category Names	Column-wise Totals
Design	**5**
Purchasing	**9**
Production	3
Testing & Inspection	3
Packaging	2
Transportation	2
Warehousing	3
After sales service	0
Recycling	**5**

Table 5 shows the column-wise totals for Category 3 (Stakeholders of Supply Chain) and it is found that Employees, Suppliers and Government are the sub-categories which are contributing to the highest number of barriers.

Table 5 Column-wise Totals for Category 3

Sub-Category Names	Column-wise Totals
Employees	**25**
Customers	2
Suppliers	**6**
Government	**6**
NGO's	2

Table 6 shows the column-wise totals for the Category 4 (Sustainability Area) and it is found that Societal and Environment are the most important sub-categories.

Table 6 Column-wise Totals for Category 4

Sub-Category Names	Column-wise Totals
Societal	**21**
Economic	8
Environmental	**34**
Technical	17

Table 7 shows the column-wise totals for all the barriers in Category 5 (Organizational Hierarchy) and it is found that most of the barriers are related to Top Management and Middle Management.

Table 7 Column-wise Totals for Category 5

Sub-Category Names	Column-wise Totals
Top Management/ Executive Level	**19**
Middle Management/ Departmental Level	**18**
Workers/ Supervisory Level	3

Table 8 shows the column-wise totals for Category 6 (Others) and it is found that Knowledge, Technological and Strategical sub-categories have the highest totals.

Table 8 Column-wise Totals for Category 6

Sub-Category Names	Column-wise Totals
Psychological	4
Technological	**8**
Knowledge	**22**
Strategical	**8**

For the purpose of prioritizing we have selected the top two sub-categories in each of the six categories of classification. For example, for the category 1 (Multiple M's), "Man" and "Method" are selected as the two most pertinent "M's" in the category 1 for further analysis. Table 9 gives the list of important sub-categories after the column-wise totals.

Table 9 List of Pertinent Sub-Categories

Category No.	Category Name	Sub-Categories with top two highest totals
1.	Multiple M's	Man, Method
2.	Supply Chain Processes	Design, Purchasing, Recycling
3.	Stakeholders of Supply Chain	Employees, Suppliers, Government
4.	Sustainability Area	Environment, Social, Technical
5.	Organizational Hierarchy	Executives, Middle Management
6.	Others	Knowledge, Technological, Strategic

4.1.1 Further Classification and Removal of Redundant Categories

As it is evident, there are some redundant sub-category components identified in the Table 9 above and they are eliminated by identifying them into further new and broader categories. So, Executives, Middle Management, Suppliers and Government were classified under the category **"Man"** and the Employees were wrapped under middle management and executives. Design, Purchasing and Recycling are identified under the category **"Method"**. Knowledge, Strategic and Technological are identified under the category **"Technical"**. Environment and Societal are identified under the category **"Sustainability"**. Figure 9 shows the new categories of classification.

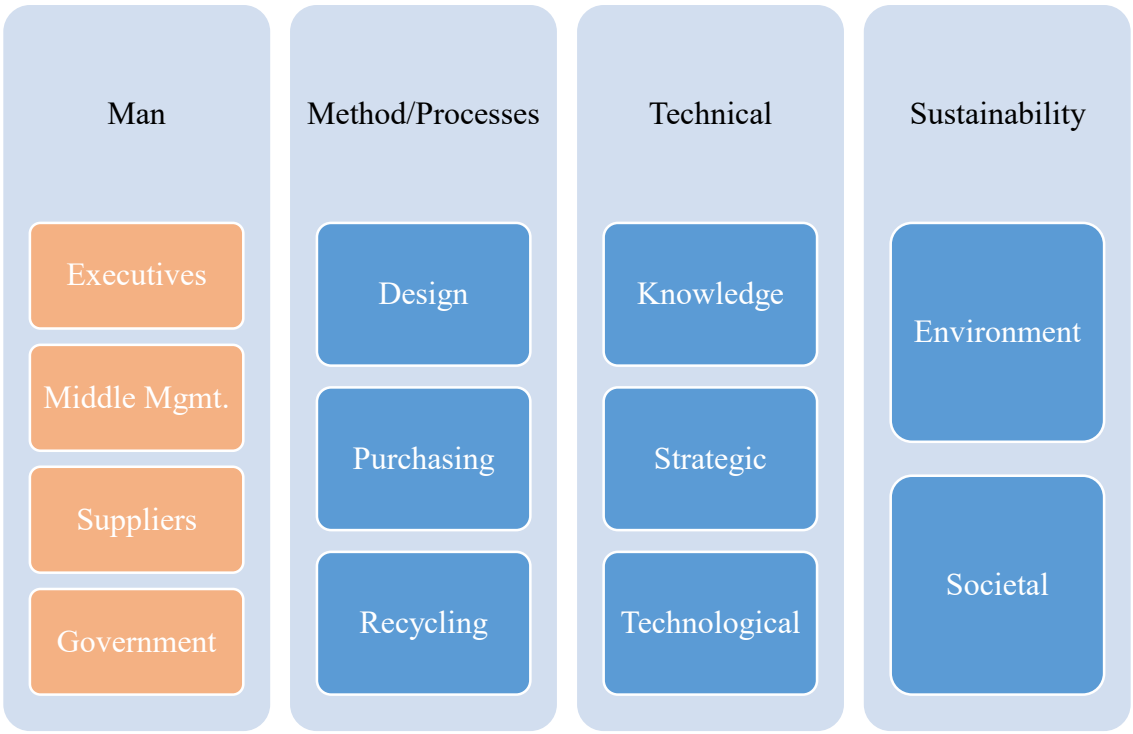

Figure 9 New Classification of Sub-Category Components

4.1.2 New Combinations and Common Barriers

In the next step, we developed relationships between these new four sub-categories components of the category Man i.e. Executives, Middle Management, Suppliers and Government, and other sub-categories components of the remaining three new categories i.e. Method, Technical and Sustainability.

Executives of the organization have influence over the sub-categories of Sustainability i.e. Environment & Social and also over sub-categories of Technical i.e. Knowledge and Strategic. Based on these relationships, we have formulated four combinations inspired by executives of an organization with other sub-category components. Table 10 shows the combinations of different sub-categories with Executives and their common barriers.

Table 10 Combinations of Different Sub-Categories with Executives and Common Barriers

Combination. No.	Combinations			Common Barriers
1.	Executives	Environment	Strategic	**a47,a48, a49,a50**
2.	Executives	Environment	Knowledge	**a21,a23,a26,a34,a39, a53,a48**
3.	Executives	Social	Strategic	x
4.	Executives	Social	Knowledge	**a21, a23,a26, a34 a39**

Then, we identified the barriers which are common in each of these combinations of sub-categories from the relationships developed in the Step 3 of the proposed methodology. For combination 1 (Executives, Environment and Strategic) we found out four common barriers i.e. a47, a48, a49 and a50, for combination 2 (Executives, Environment and knowledge) we found out seven common barriers i.e. a21, a23, a26, a34, a39, a53 and a48, for combination 3 (Executives, Social and Strategic) we found out no common barriers and for combination 4 (Executives, Social and Knowledge) we found out five common barriers i.e. a21, a23, a26, a34 and a39. Therefore, three out of these four combinations need further analysis i.e. DEMATEL and Direct Ranking.

Similarly, it is believed that the ***Middle Management*** has influence over all the remaining three category components. Middle management plays a vital role in Processes like Design, Purchasing and Recycling, Sustainability areas like Environment and Social and Technical aspects like Knowledge and Technological. Thus, we obtained twelve different combinations related to middle management. Table 11 lists all the combinations of the middle management with the other sub-categories and their common barriers.

Table 11 Combinations of Different Sub-Categories with Middle Management and Common Barriers

Combination No.	Combinations				Common Barriers
1.	Middle Management	Design	Environment	Knowledge	**a34**
2.	Middle Management	Design	Environment	Technological	x
3.	Middle Management	Purchasing	Environment	Knowledge	**a31**
4.	Middle Management	Purchasing	Environment	Technological	**a31**
5.	Middle Management	Recycling	Environment	Knowledge	x
6.	Middle Management	Recycling	Environment	Technological	x
7.	Middle Management	Design	Social	Knowledge	**a34**
8.	Middle Management	Design	Social	Technological	x
9.	Middle Management	Purchasing	Social	Knowledge	x
10.	Middle Management	Purchasing	Social	Technological	x
11.	Middle Management	Recycling	Social	Knowledge	x
12.	Middle Management	Recycling	Social	Technological	x

It is found that only Combinations 1, 3, 4 and 7 had one common barrier each i.e. barrier "a34" (Complexity in identifying third parties to recollect used products) for combination 1 and 7, and barrier "a31" (Lack of R&D capability on GSCM practices) for combination 3 and 4. Thus, these two barriers are the most impactful barriers under middle management and the managers of organizations should focus on finding ways to eradicate these barriers.

As no other combination had more than four common barriers, thus no further analysis is required.

In the same way, we developed combinations for ***Suppliers*** with other sub-category components. Suppliers tend to have impact on the supply chain processes like Purchasing, which have affect over sustainability areas like Environment and Social and Technical aspects like Knowledge and Technological. Table 12 lists the four combinations formed with these sub-category components and it is found that none of the combinations has any common barriers.

Table 12 Combinations of Different Sub-Categories with Suppliers and Common barriers

Combination No.	Combinations				Common Barriers
1.	Suppliers	Purchasing	Environment	Knowledge	x
2.	Suppliers	Purchasing	Environment	Technological	x
3.	Suppliers	Purchasing	Social	Knowledge	x
4.	Suppliers	Purchasing	Social	Technological	x

The last component under "Man", i.e. ***Government,*** has influence over Sustainability areas like Environment and Social and Technical aspects like Strategic. Hence, we developed the two combinations listed in Table13, for which no common barriers are found.

Table 13 Combinations of Different Sub-Categories with Government and Common Barriers

Combination No.	Combinations			Common Barriers
1.	Government	Environment	Strategic	x
2.	Government	Social	Strategic	x

4.2 Row-wise Totals

In order to identify the barriers which have impacts on more than one sub-category of each category, we calculated the row wise totals of all the "1's" for each barrier (refer to Appendix A) in the next step. For example, in the Category 1 (Multiple M's), for the barrier "a10" (Complexity of design to reuse/recycle used products), we gave "1" in the each cell corresponding to Machine, Man and Material. So, the row wise sum of all the "1's" for the barrier a10 resulted to be "3". In this way, we calculated the sum of all the "1's" for each barrier in all the six categories of classification and selected those barriers with top two totals in each category. The barriers with highest two totals in their corresponding categories are listed separately in the Table 14.

Table 14 Pertinent Barriers in Each Category

Category No.	Category Name	Barriers with top two highest totals
1.	Multiple M's	a10, a15, a17, a18, a21, a40, a45, a50, a53
2.	Supply Chain Processes	a15, a17, a22, a23, a45
3.	Stakeholders of Supply Chain	a3, a16, a25, a27
4.	Sustainability Area	a2, a14, a15, a16, a17, a21, a23, a25, a26, a27, a28, a29, a30, a31, a32, a34, a36, a37, a38, a39, a42, a50, a53
5.	Organizational Hierarchy	a22, a23, a25,a34,a35,a39,a54
6.	Others	a10, a11, a33, a34, a36

4.3 Matrices for Direct Ranking and DEMATEL Analysis

In order to further prioritize the three set of barriers to GSCM obtained in the section 4.1 and the other six set of barriers to GSCM obtained in the section 4.2, we used Direct

Ranking and DEMATEL techniques explained in the Chapter 3. The combined list of these barriers formed nine different matrices are listed in the Table 15.

Table 15 Final Nine Matrices and their Barriers

Matrix No.	Matrix Name	Barriers
Matrix 1	Executives/Environment/Strategic	a47,a48, a49,a50
Matrix 2	Executives/Environment/Knowledge	a21,a23, a26,a34,a39 a53,a48
Matrix 3	Executives/Social/Knowledge	a21, a23,a26, a34 a39
Matrix 4	Multiple M's	a10, a15, a17, a18, a21, a40, a45, a50, a53
Matrix 5	Supply Chain Processes	a15, a17, a22, a23, a45
Matrix 6	Stakeholders of Supply Chain	a3, a16, a25, a27
Matrix 7	Sustainability	a2, a14, a15, a16, a17, a21, a23, a25, a26, a27, a28, a29, a30, a31, a32, a34, a36, a37, a38, a39, a42, a50, a53
Matrix 8	Organizational Hierarchy	a22, a23, a25,a34,a35,a39,a54
Matrix 9	Others	a10, a11, a33, a34, a36

4.4 Data Collection

According to the step 4 for performing Direct Ranking and DEMATEL techniques on the barriers shortlisted in the step 3 of the proposed research methodology, importance scores for Direct Ranking and entries for the direct relation matrix in DEMATEL were required. For this purpose, seven professionals working in the industry/academia were contacted. Out of the seven, four industry professionals and one academician had replied.

4.5 Direct Ranking

After achieving the importance scores from five respondents, we performed the Pareto Analysis.

4.5.1 Pareto Analysis and Results

Figure 10 depicts the Pareto diagram of the matrix 1. It can be seen that three out of four GSCM barriers are important according to the 80-20 rule.

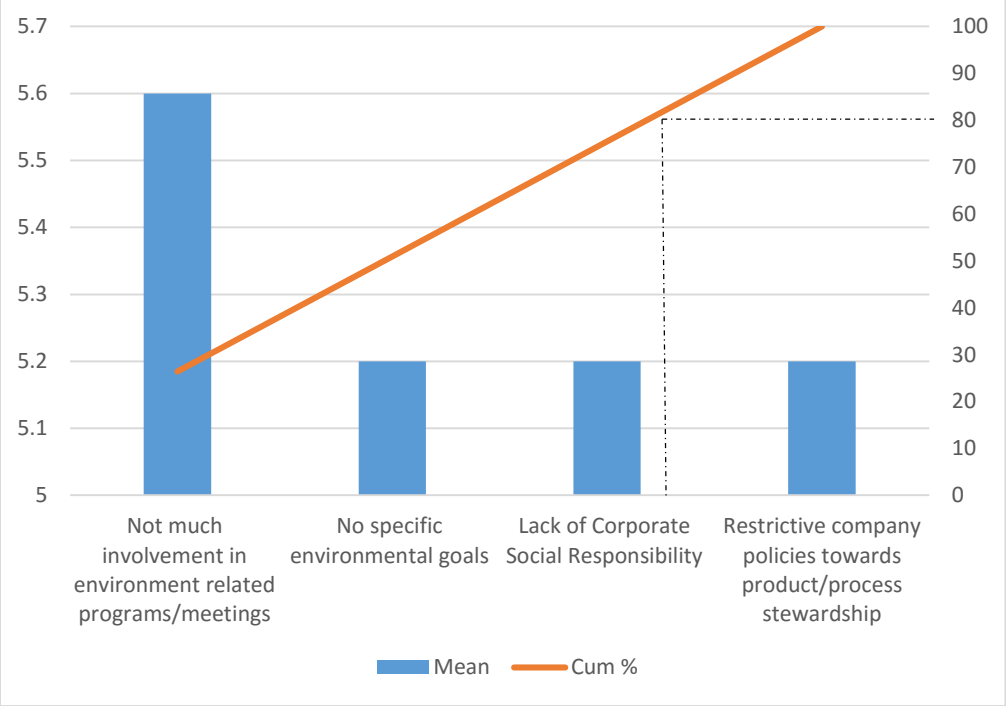

Figure 10 Matrix 1 Pareto Diagram

Table 16 presents the mean and cumulative % of the barriers identified in Figure 10.

Table 16 Matrix 1 Pareto Analysis

Barrier No.	Barrier Name	Mean	Cumulative Number	Cumulative %
a49	**Not much involvement in environment related programs/meetings**	**5.6**	**5.6**	**26.41**
a47	**No specific environmental goals**	**5.2**	**10.8**	**50.94**
a48	**Lack of Corporate Social Responsibility**	**5.2**	**16**	**75.47**

a50	Restrictive company policies towards product/process stewardship	5.2	21.2	100

It can be seen that barrier "a49" (Not much involvement in environment related programs/meetings) is the most important barrier as it has the highest mean value of the importance scores given by the respondents. Hence, the Executives should plan more initiatives in order to participate more in programs/meetings related to environmental improvements.

Figure 11 shows the Pareto diagram for matrix 2 and shows that five out of seven barriers (a34, a23, a21, a48, a39) are the important ones according to the 80-20 rule.

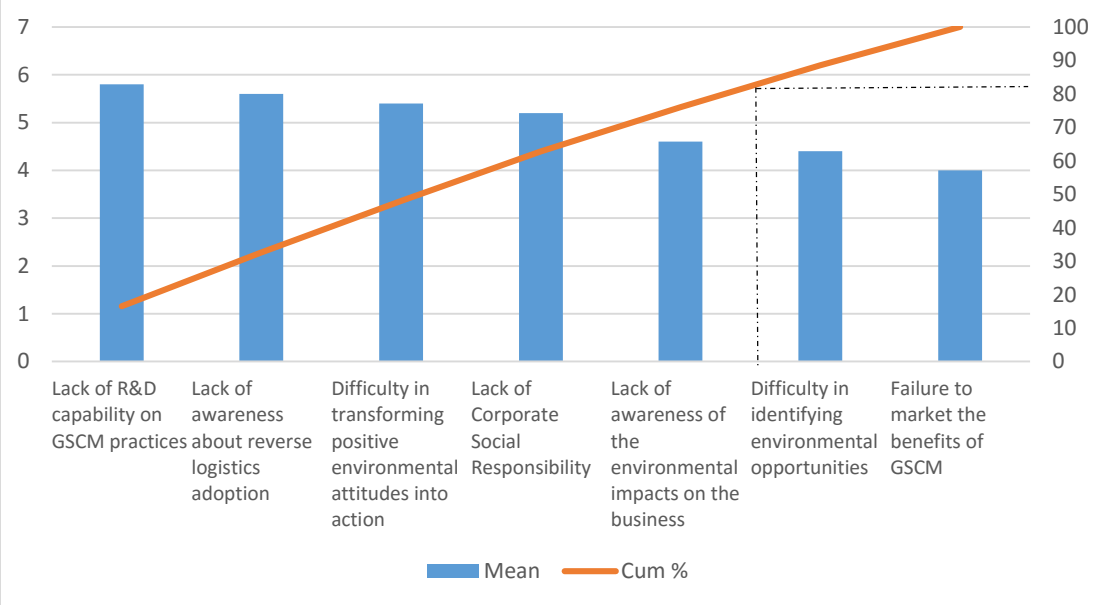

Figure 11 Matrix 2 Pareto Diagram

Table 17 shows the means and cumulative % of the barriers in matrix 2. It is seen that barrier "a34" (Lack of R&D capability on GSCM practices) has the highest mean value

and hence, the Executives of an organization should enhance their knowledge by investing more on the R&D capabilities which would ultimately improve the environment.

Table 17 Matrix 2 Pareto Analysis

Barrier No.	Barrier Name	Mean	Cumulative Number	Cumulative %
a34	**Lack of R&D capability on GSCM practices**	**5.8**	**5.8**	**16.57**
a23	**Lack of awareness about reverse logistics adoption**	**5.6**	**11.4**	**32.57**
a21	**Difficulty in transforming positive environmental attitudes into action**	**5.4**	**16.8**	**48**
a48	**Lack of Corporate Social Responsibility**	**5.2**	**22**	**62.85**
a39	**Lack of awareness of the environmental impacts on the business**	**4.6**	**26.6**	**76**
a26	Difficulty in identifying environmental opportunities	4.4	31	88.57
a53	Failure to market the benefits of GSCM	4	35	100

Figure 12 shows the Pareto diagram for the matrix 3 and shows that the barriers which could be considered responsible for cause for the 80% of the barriers in this matrix are “a34”, “a23” and “a21”.

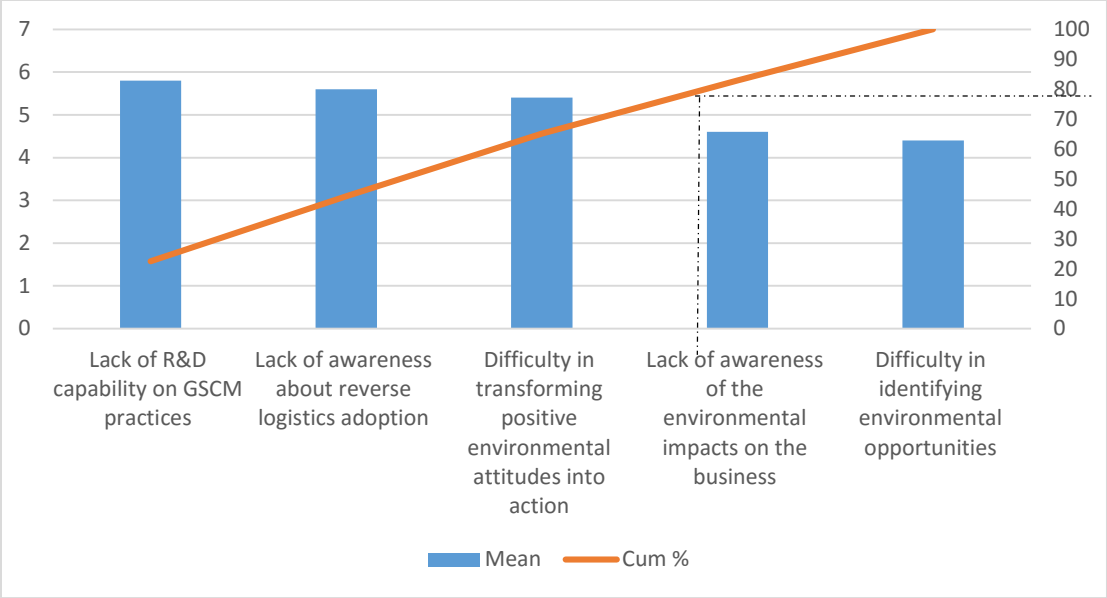

Figure 12 Matrix 3 Pareto Diagram

Table 18 shows the mean and cumulative % of all the barriers in the matrix 3.

Table 18 Matrix 3 Pareto Analysis

Barrier No.	Barrier Name	Mean	Cumulative Number	Cumulative %
a34	**Lack of R&D capability on GSCM practices**	**5.8**	**5.8**	**22.48**
a23	**Lack of awareness about reverse logistics adoption**	**5.6**	**11.4**	**44.18**
a21	**Difficulty in transforming positive environmental attitudes into action**	**5.4**	**16.8**	**65.11**
a39	Lack of awareness of the environmental impacts on the business	4.6	21.4	82.94
a26	Difficulty in identifying environmental opportunities	4.4	25.8	100

The results show that the barrier “a34” is the most important barrier again. Hence, it can be concluded that this barrier is the most important barrier affecting both the environment

and social areas of sustainability and the executives should undertake more initiatives so as to improve the knowledge on GSCM practices by investing more in the R&D facilities.

Figure 13 depicts the Pareto diagram for matrix 4 and it is seen that six out of nine barriers are important according to the 80-20 rule.

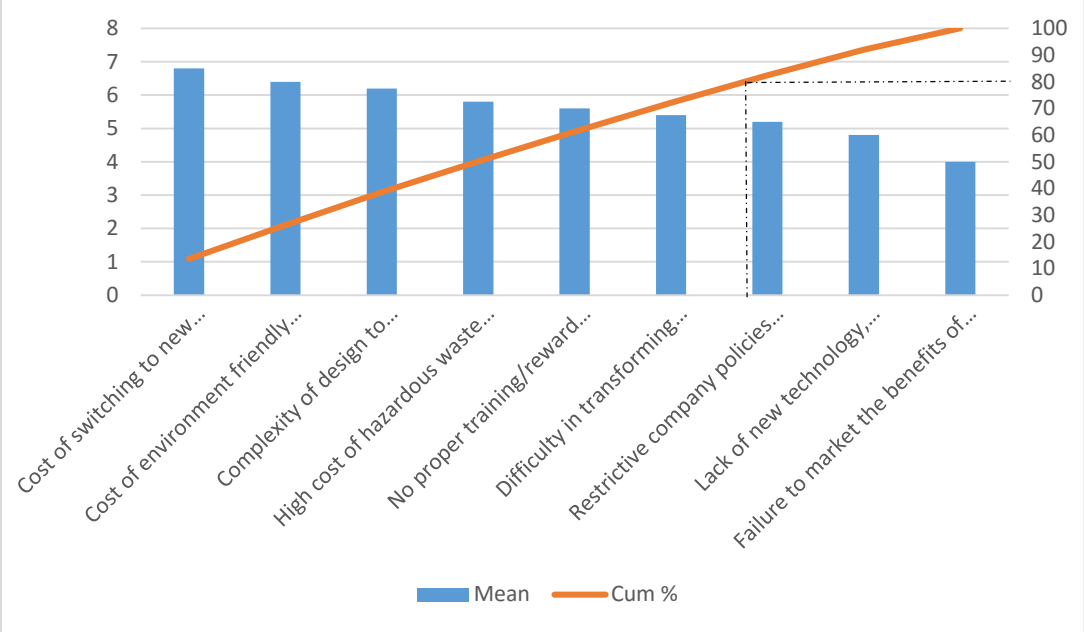

Figure 13 Matrix 4 Pareto Diagram

Table 19 shows the mean and cumulative % for the matrix 4 barriers representing the most pertinent barriers from the Category 1 (Multiple M's).

Table 19 Matrix 4 Pareto Analysis

Barrier No.	Barrier Name	Mean	Cumulative Number	Cumulative %
a18	**Cost of switching to new system, maintenance and operations costs of the improved system**	**6.8**	**6.8**	**13.54**
a15	**Cost of environment friendly packaging**	**6.4**	**13.2**	**26.29**

a10	**Complexity of design to reuse/recycle used products**	**6.2**	**19.4**	**38.64**
a17	**High cost of hazardous waste disposal**	**5.8**	**25.2**	**50.19**
a40	**No proper training/reward system for suppliers**	**5.6**	**30.8**	**61.35**
a21	**Difficulty in transforming positive environmental attitudes into action**	**5.4**	**36.2**	**72.11**
a50	Restrictive company policies towards product/process stewardship	5.2	41.4	82.47
a45	Lack of new technology, materials and processes	4.8	46.2	92.03
a53	Failure to market the benefits of GSCM	4	50.2	100

It can be seen that the barrier "a18" (Cost of switching to new system, maintenance and operations costs of the improved system) is the most important barrier. It has the highest mean value as shown in the Table 19. This barrier is related to the sub-categories like "Machine", "Method" and "Money" as shown in the Appendix 1 and hence, organizations should focus on finding ways to eradicate these three "M's" for successful GSCM adoption. This can be achieved by finding alternative methods and machines which aide the easy adoption into new and improved systems but do not add much to the financial constraints at the same time.

Figure 14 shows the Pareto diagram for the matrix 5 and it can be seen that barrier "a15", "a17" and "a23" are the important barriers according to the 80-20 rule.

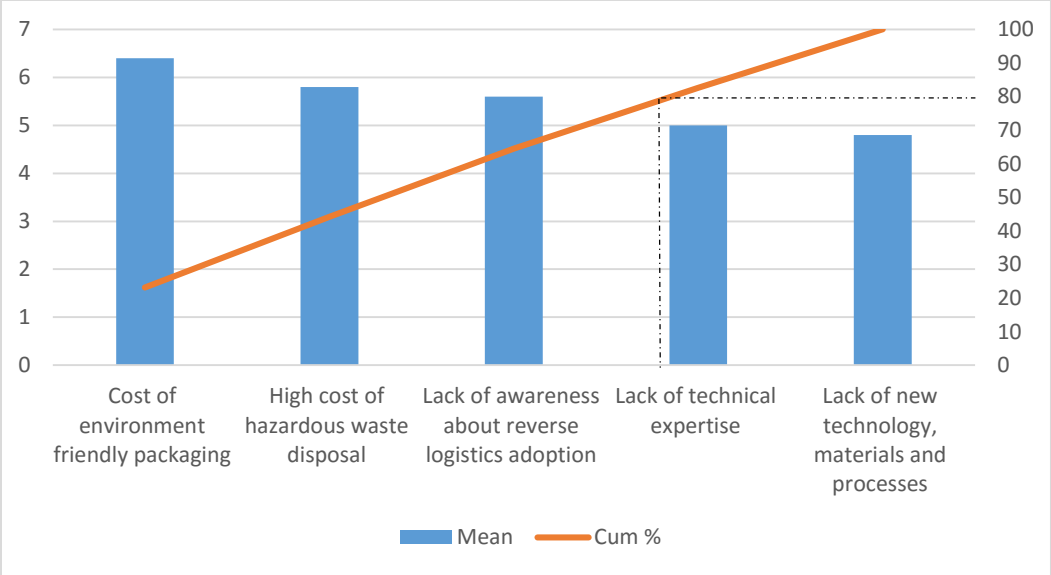

Figure 14 Matrix 5 Pareto Diagram

Table 20 shows the mean and cumulative % for the Matrix 5, representing the most pertinent barriers for Category 2 (Supply Chain Processes).

Table 20 Matrix 5 Pareto Analysis

Barrier No.	Barrier Name	Mean	Cumulative Number	Cumulative %
a15	**Cost of environment friendly packaging**	**6.4**	**6.4**	**23.18**
a17	**High cost of hazardous waste disposal**	**5.8**	**12.2**	**44.20**
a23	**Lack of awareness about reverse logistics adoption**	**5.6**	**17.8**	**64.49**
a22	Lack of technical expertise	5	22.8	82.60
a45	Lack of new technology, materials and processes	4.8	27.6	100

It can be seen that the barrier "a15" (Cost of environment friendly packaging) is the most important barrier with the highest mean value shown in Table 20. This barrier is related to the Purchasing and Packaging processes of the supply chain as shown in Appendix A.

Hence, the organizations should consider GSCM adoption initiatives while making the Purchasing and Packaging decisions such that the costs related to them can be reduced.

Figure 15 shows the Pareto diagram for the matrix 6 and shows that “a3” and “a25” are the most important barriers according to the 80-20 rule.

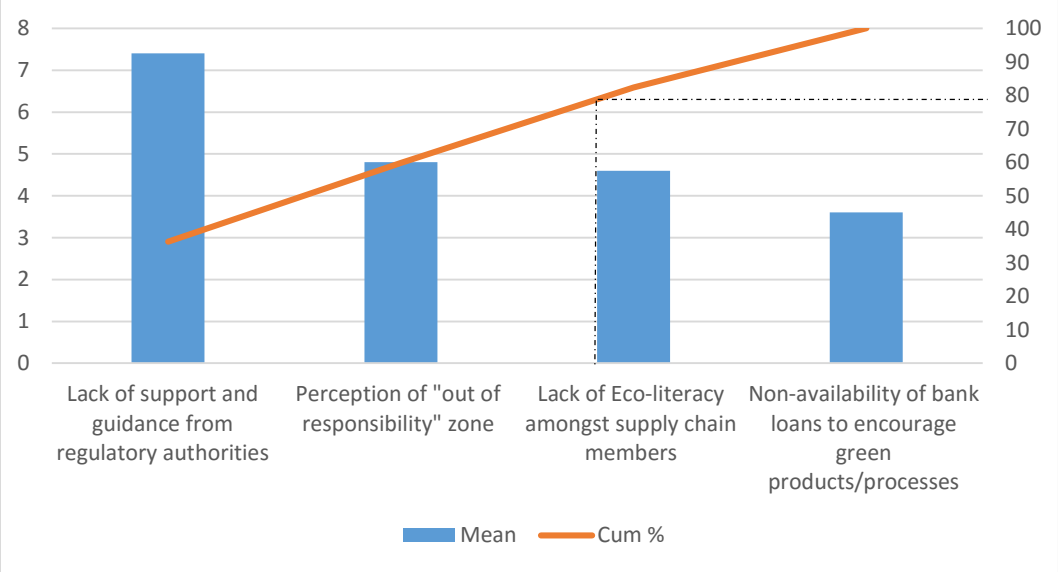

Figure 15 Matrix 6 Pareto Diagram

Table 21 gives the mean and cumulative % for the matrix 6 barriers for Category 3 (Stakeholders of Supply Chain).

Table 21 Matrix 6 Pareto Diagram

Barrier No.	Barrier Name	Mean	Cumulative Number	Cumulative %
a3	**Lack of support and guidance from regulatory authorities**	**7.4**	**7.4**	**36.27**
a25	**Perception of "out of responsibility" zone**	**4.8**	**12.2**	**59.80**
a27	Lack of Eco-literacy amongst supply chain members	4.6	16.8	82.35

a16	Non-availability of bank loans to encourage green products/processes	3.6	20.4	100

It can be seen that the barrier "a3" (Lack of support and guidance from regulatory authorities) is the most important barrier with the highest mean value shown in Table 21. This barrier is related to the sub-category of Government in Table 4.3. Hence, the regulatory authorities should extend more support to the organizations considering GSCM adoption benefits.

Figure 16 shows the Pareto diagram of the matrix 7 and shows that eighteen out of twenty four barriers are most important according to the 80-20 rule.

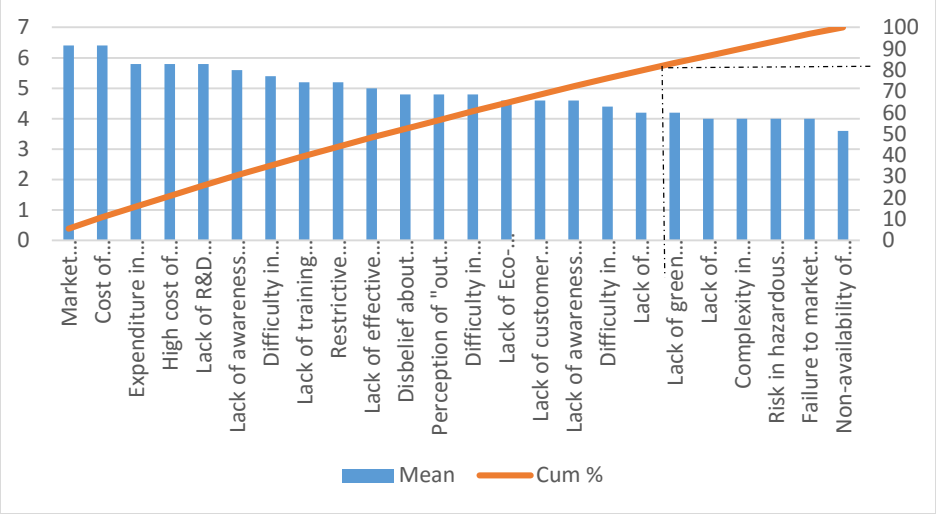

Figure 16 Matrix 7 Pareto Diagram

Table 22 shows the mean and cumulative % of the barriers in matrix 7, representing the most pertinent barriers from the Category 4 (Sustainability Areas).

Table 22 Matrix 7 Pareto Analysis

Barrier No.	Barrier Name	Mean	Cumulative Number	Cumulative %
a_2	**Market competition and uncertainty**	**6.4**	**6.4**	**5.46**
a_{15}	**Cost of environment friendly packaging**	**6.4**	**12.8**	**10.92**
a_{14}	**Expenditure in collecting and recycling used products**	**5.8**	**18.6**	**15.87**
a_{17}	**High cost of hazardous waste disposal**	**5.8**	**24.4**	**20.81**
a_{34}	**Lack of R&D capability on GSCM practices**	**5.8**	**30.2**	**25.76**
a_{23}	**Lack of awareness about reverse logistics adoption**	**5.6**	**35.8**	**30.54**
a_{21}	**Difficulty in transforming positive environmental attitudes into action**	**5.4**	**41.2**	**35.15**
a_{37}	**Lack of training courses/consultancy/institutions to train, monitor/mentor progress specific to each industry**	**5.2**	**46.4**	**39.59**
a_{50}	**Restrictive company policies towards product/process stewardship**	**5.2**	**51.6**	**44.02**
a_{42}	**Lack of effective environmental measures**	**5**	**56.6**	**48.29**
a_{24}	**Disbelief about environmental benefits**	**4.8**	**61.4**	**52.38**
a_{25}	**Perception of "out of responsibility" zone**	**4.8**	**66.2**	**56.48**
a_{32}	**Difficulty in obtaining information on potential environmental improvements**	**4.8**	**71**	**60.58**
a_{27}	**Lack of Eco-literacy amongst supply chain members**	**4.6**	**75.6**	**64.50**
a_{38}	**Lack of customer awareness and pressure about GSCM**	**4.6**	**80.2**	**68.43**
a_{39}	**Lack of awareness of the environmental impacts on the business**	**4.6**	**84.8**	**72.35**
a_{26}	**Difficulty in identifying environmental opportunities**	**4.4**	**89.2**	**76.10**
a_{28}	**Lack of environmental knowledge**	**4.2**	**93.4**	**79.69**
a_{30}	Lack of green system exposure to professionals	4.2	97.6	83.27
a_{29}	Lack of information of Renewable Energy (RE) resources	4	101.6	86.68

a_{31}	Complexity in identifying third parties to recollect used products	4	105.6	90.10
a_{36}	Risk in hazardous material inventory	4	109.6	93.51
a_{53}	Failure to market the benefits of GSCM	4	113.6	96.92
a_{16}	Non-availability of bank loans to encourage green products/processes	3.6	117.2	100

It can be seen that the barrier "a2" (Market Competition and Uncertainty) is the most important barrier with the highest mean value shown in Table 22. This barrier is related to the Economic and Technical aspects of Sustainability as shown in Appendix A. So, the organizations are unaware about the future of the GSCM initiatives and are apprehensive about their success in terms of both profit and customer response. Also, they are lacking technical expertise for understanding the market competition better and therefore, this barrier tops the chart for this category of classification and suggests that economic and technical perspectives hinder the successful GSCM adoption.

Figure 17 shows the Pareto diagram for the matrix 8 and shows that five out of seven barriers are important according to the 80-20 rule.

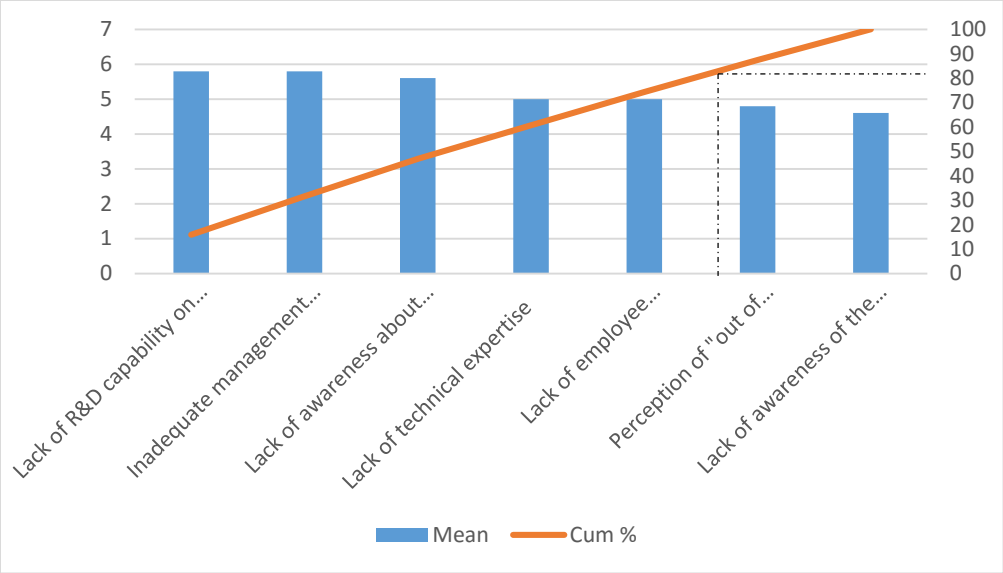

Figure 17 Matrix 8 Pareto Diagram

Table 23 gives the mean and cumulative % of all the barriers in matrix 8, representing the most pertinent barriers from the Category 5 (Organizational Hierarchy).

Table 23 Matrix 8 Pareto Analysis

Barrier No.	Barrier Name	Mean	Cumulative Number	Cumulative %
a_{34}	**Lack of R&D capability on GSCM practices**	**5.8**	**5.8**	**15.84**
a_{54}	**Inadequate management capacity**	**5.8**	**11.6**	**31.69**
a_{23}	**Lack of awareness about reverse logistics adoption**	**5.6**	**17.2**	**46.99**
a_{22}	**Lack of technical expertise**	**5**	**22.2**	**60.65**
a_{35}	**Lack of employee awareness about occupational health hazards**	**5**	**27.2**	**74.31**
a_{25}	Perception of "out of responsibility" zone	4.8	32	87.43
a_{39}	Lack of awareness of the environmental impacts on the business	4.6	36.6	100

It can be seen that the barrier “a34” (Lack of R&D capability on GSCM practices) is the most important barrier with the highest mean value shown in Table 23. This barrier is related to the Top Management/Executives and Middle Management of the organization. This indicates the need for the executives and managers of the organization to improve their R&D capabilities in order to find new and innovative practices for green supply chains.

Figure 18 shows the Pareto diagram for matrix and shows that six out of eight barriers are the most important barriers according to the 80-20 rule.

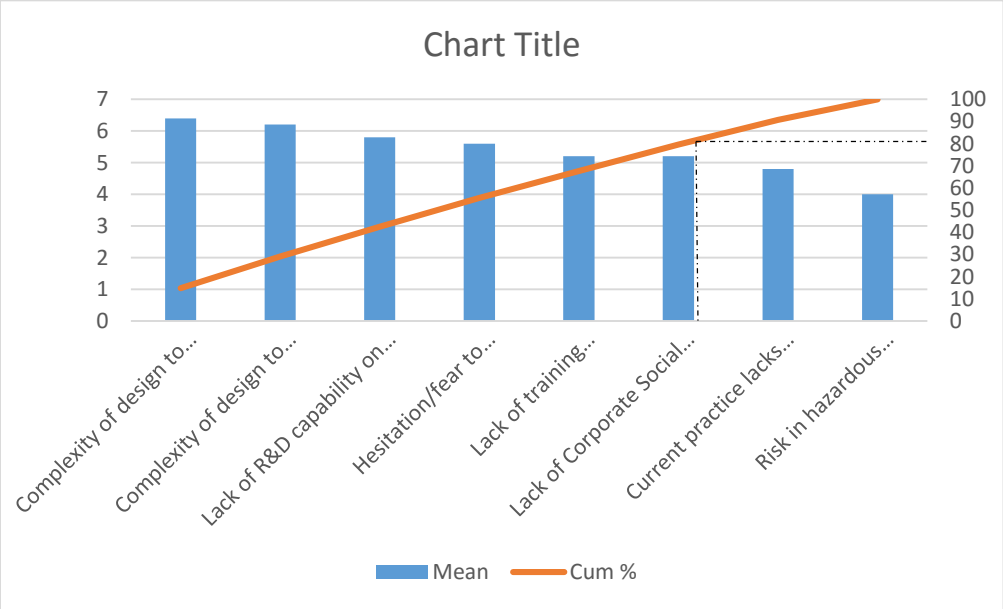

Figure 18 Matrix 9 Pareto Diagram

Table 24 gives the mean and cumulative % of all the barriers in matrix 9, representing the most pertinent barriers from the Category 6 (Others).

Table 24 Matrix 9 Pareto Analysis

Barrier No.	Barrier Name	Mean	Cumulative Number	Cumulative %
a_{11}	**Complexity of design to reduce consumption of resource/energy**	**6.4**	**6.4**	**14.81**
a_{10}	**Complexity of design to reuse/recycle used products**	**6.2**	**12.6**	**29.16**
a_{34}	**Lack of R&D capability on GSCM practices**	**5.8**	**18.4**	**42.59**
a_{33}	**Hesitation/fear to convert to new systems**	**5.6**	**24**	**55.55**
a_{37}	**Lack of training courses/consultancy/institutions to train, monitor/mentor progress specific to each industry**	**5.2**	**29.2**	**67.59**
a_{48}	**Lack of Corporate Social Responsibility**	**5.2**	**34.4**	**79.62**
a_{44}	Current practice lacks flexibility to switch over to new system	4.8	39.2	90.74
a_{36}	Risk in hazardous material inventory	4	43.2	100

It can be seen that the barrier "a11" (Complexity of design to reduce consumption of resource/energy) is the most important barrier with the highest mean value shown in Table 18. This barrier is found to be related to the Technological and Knowledge sub-categories. This indicates the need for organizations to make technological and knowledge advancements so as to reduce the difficulties in designing the processes and products which minimize the use of resources affecting the environment.

4.6 DEMATEL

The results of DEMATEL analysis are discussed for each of the nine matrices highlighting the most impactful (cause and effect) barriers to GSCM corresponding to different sub-categories of classification. The analysis is presented under six steps for each matrix followed by the findings and the impact diagram for each matrix. For the purpose of understanding, calculations involved in the six steps are shown only for the first matrix and for rest of the matrices, calculations are presented in the Appendix B.

4.6.1 DEMATEL for Matrix 1 (Executive/Environment/Strategic)

Step 1. Average Matrix, Z

0	1.8	2.6	2
2.8	0	2.5	1.4
2	1.6	0	2.6
1.6	2.4	2.2	0

Step 2. S = max (sum of rows, sum of columns) = max (7.3, 6.7), S = 7.3, 1/S = 0.136

Step 3. Normalized Initial Direct Relation Matrix, X= Z/S

0	0.246	0.356	0.273
0.383	0	0.342	0.191
0.273	0.219	0	0.356
0.219	0.328	0.301	0

Step 4. Total Relation Matrix, T

1.535	1.618	1.971	1.707
1.881	1.473	2.033	1.714
1.708	1.570	1.663	1.718
1.689	1.641	1.903	1.455

Step 5. Total Cause and Effect for barriers

	a47	a48	a49	a50
D-E	0.018	0.799	-0.912	0.094
D+E	13.64	13.40	14.23	13.28

Threshold value (average of Matrix T) ∂ = 1.705

Step 6. Inner Dependence Matrix

a47	a48	a49	a50
		1.971	**1.707**
1.881		**2.033**	**1.714**
1.708			**1.718**
		1.903	

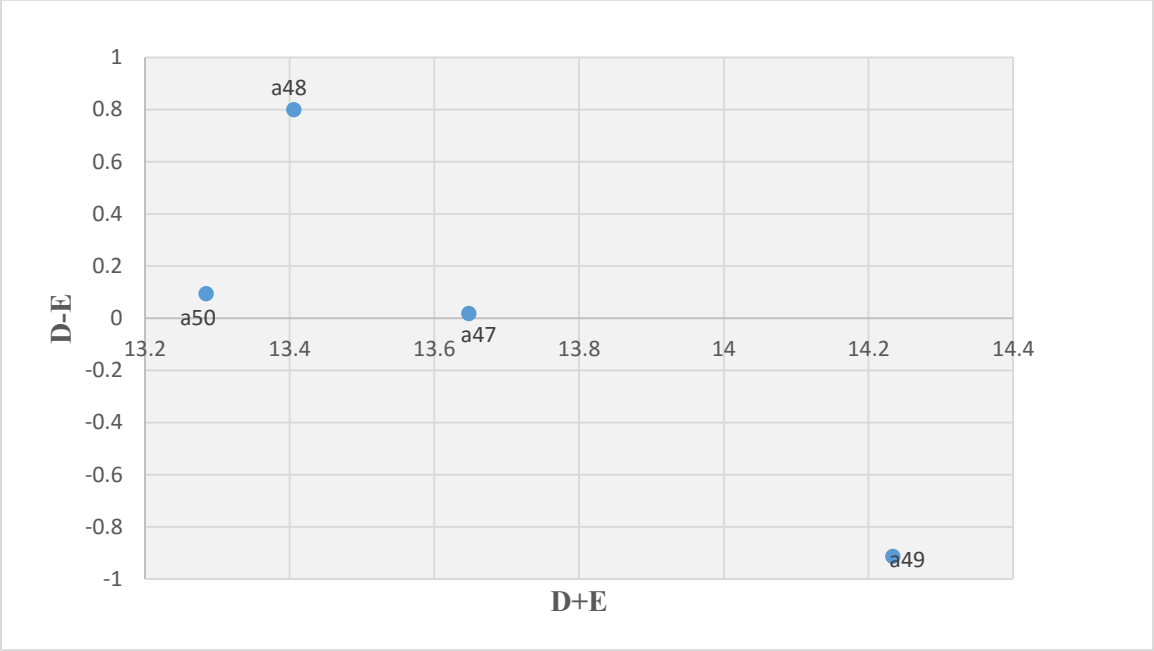

Figure 19 Matrix 1 DEMATEL Prominence-Causal Diagram

Findings:

- a47, a48 and a50 are the cause barriers and are effecting the other barriers.
- a49 is the effect barrier.
- a49 (Not much involvement in environment related programs and meetings) is the highest impact barrier and has the highest degree of influence on the other barriers

- From the inner dependency matrix, it is found that a49 is mostly caused by a48, a47 and a50, so these barriers should be given consideration. Out of these three, a48 has the highest impact value, so it should be given highest importance.
- So, it is concluded that barrier a48 (Lack of Corporate Social Responsibility) is the most influential barrier which is the main cause for the barrier a49 (Not much involvement in environment related programs and meetings).
- Hence, the top executives of an organization should work on the strategies that they develop which effects the sustainability area i.e. Environment.

4.6.2 DEMATEL for Matrix 2 (Executives/Environment/Knowledge)

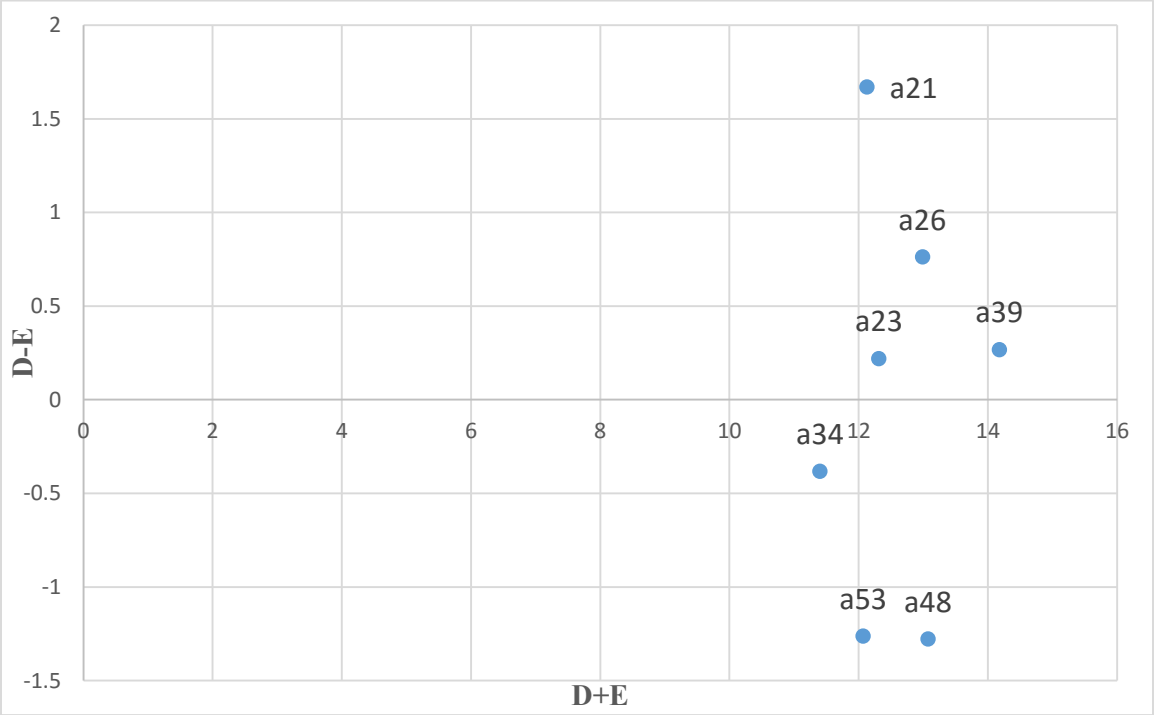

Figure 20 Matrix 2 DEMATEL Prominence-Causal Diagram

Findings:

- a21, a26, a39 and a23 are the cause barriers and are effecting the other barriers.

- a48, a53 and a34 are the effect barriers.
- a39 and a48 are the highest impact barriers and has the highest degree of influence on the other barriers.
- From the inner dependency matrix, it is found that a39 is caused by all other barriers except the barrier a34. So these barriers should be given consideration. Out of these, a26 has the highest impact value, so it should be given the highest importance. Also, a48 is caused by other barriers except a53 and a48 itself. For a48, a39 is the highest impact (cause) barrier and hence importance should be given to a39 as well.
- So, it is concluded that barrier a26 (Difficulty in identifying environmental opportunities) is the most influential barrier which is the main cause for the barrier a39 (Lack of awareness of the environmental impacts on the business) and a39 is the main cause for the a48 (Lack of corporate social responsibility).
- Hence, the top executives of an organization should work on eliminating these knowledge and environment barriers for the successful implementation of GSCM.

4.6.3 DEMATEL for Matrix 3 (Executives/Social/Knowledge)

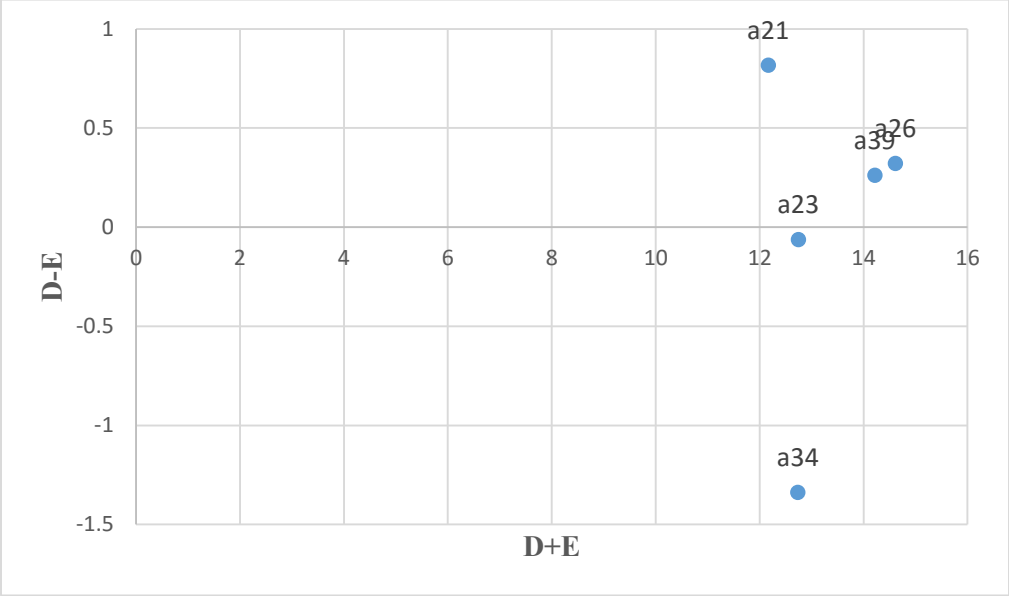

Figure 21 Matrix 3 DEMATEL Prominence-Causal Diagram

Findings:

- a21, a26 and a39 are the cause barriers and are effecting the other barriers.
- a34 and a23 are the effect barriers.
- a26 and a39 are the highest impact barriers and has the highest degree of influence on the other barriers.
- From the inner dependency matrix, it is found that a26 is caused by all other barriers except the barrier a34. So, these barriers should be given consideration. Out of these, a39 has the highest impact value, so it should be given the highest importance. Also, a39 is caused by other barriers except a34. For a39, a26 is the highest impact (cause) barrier and hence importance should be given to a26 as well.

- So, it is concluded that barrier a39 (Lack of awareness of the environmental impacts on the business) is the main cause for the a26 (Difficulty in identifying environmental opportunities) and vice versa.
- Hence, the top executives of an organization should work on eliminating these social and knowledge barriers for the successful implementation of GSCM.

4.6.4 DEMATEL for Matrix 4 (Multiple M's)

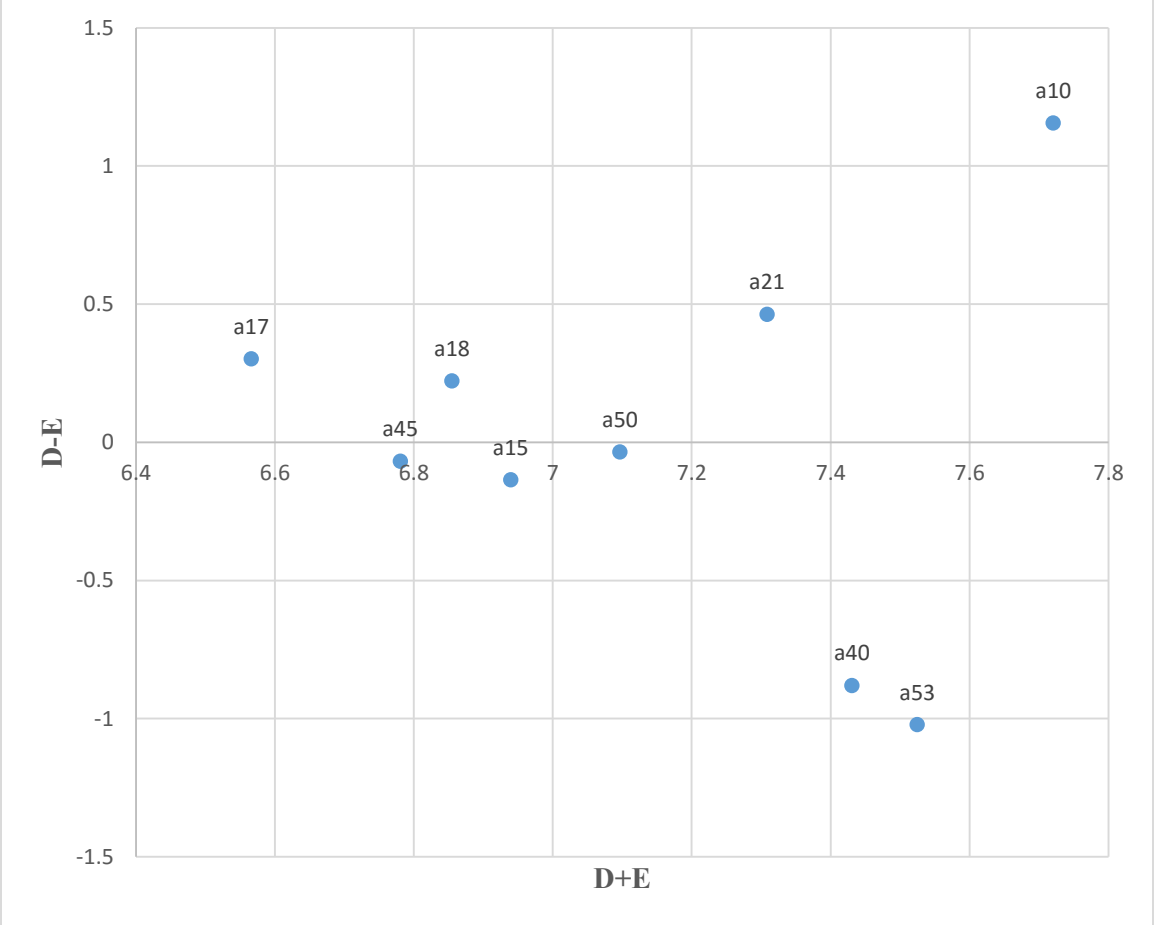

Figure 22 Matrix 4 DEMATEL Prominence-Causal Diagram

Findings:

- a10, a21, a17 and a18 are the cause barriers and are effecting the other barriers.

- a53, a40, a15, a45 and a50 are the effect barriers.
- a10, a53, a40 and a21 are the highest impact barriers and has the highest degree of influence on the other barriers.
- From the inner dependency matrix, it is found that a10 is caused by the barrier a 21. So this barrier should be given consideration. Also, a53 is caused by all other barriers, out of which, a10 has the highest impact value, so it should be given the highest importance. Another barrier a40 is caused by all other barriers, out of which a10 has the highest impact value again. The barrier a21 is caused by a10 and a50, out of which a50 has a higher impact value and hence it should be given consideration.
- So, it is concluded that barrier a21 (Difficulty in transforming positive environmental attitudes into action) is the most influential barrier which is the main cause for the barrier a10 (Complexity of design to reuse/recycle used products) and a10 is the main cause for the a53 (Failure to market the benefits/results of GSCM) and a40 (No proper training/reward system for suppliers). Last but not the least, a50 (Restrictive company policies towards product/process stewardship) is the main cause for a21.
- a50 causes a21, a21 causes a10 and a10 causes a53 and a40.
- a10 (Machine, Method and Material)
- a21 (Man, Method and Motivation)
- a40 (Man, Method and Motivation)
- a50 (Man, Method and Material)
- a53 (Man, Method and Market)

4.6.5 DEMATEL for Matrix 5 (Supply Chain Processes)

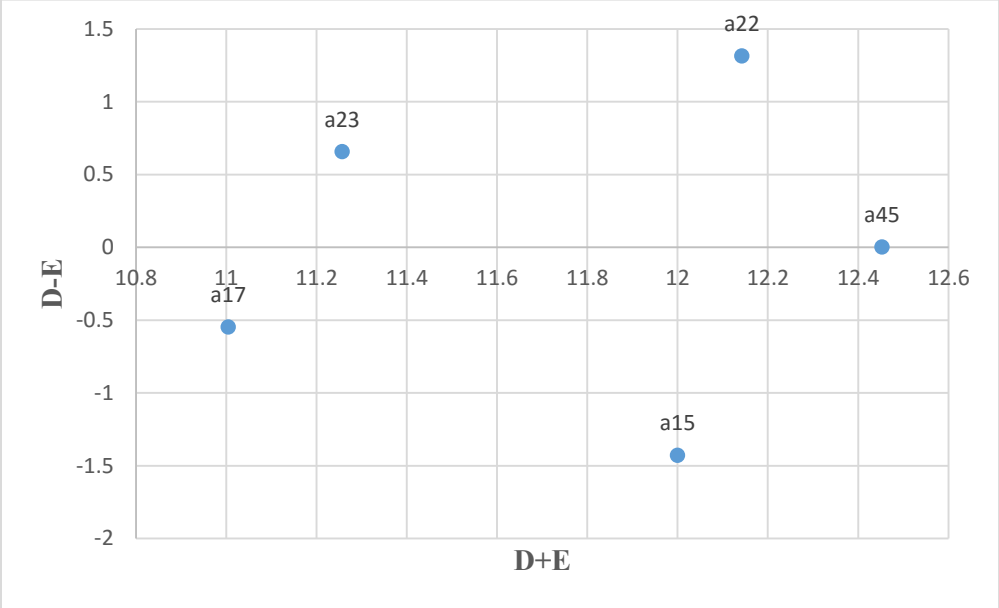

Figure 23 Matrix 5 DEMATEL Prominence-Causal Diagram

Findings:

- a22, a23 and a45 are the cause barriers and are effecting the other barriers.
- a15 and a17 are the effect barriers.
- a45 is the highest impact barrier and has the highest degree of influence on the other barriers.
- From the inner dependency matrix, it is found that a45 is caused by barriers a22 and a23. So these barriers should be given consideration. Out of these, a22 has the highest impact value, so it should be given the highest importance.
- So, it is concluded that barrier a22 (Lack of technical expertise) is the main cause for the barrier a45 (Lack of new technology, materials and processes).
- a22 (Design, Purchasing, Production, Testing & Inspection, Packaging, Transportation, Warehousing, After sales Service, Recycling).

- a45 (Production, Testing & Inspection)

4.6.6 DEMATEL for Matrix 6 (Stakeholders of Supply Chain)

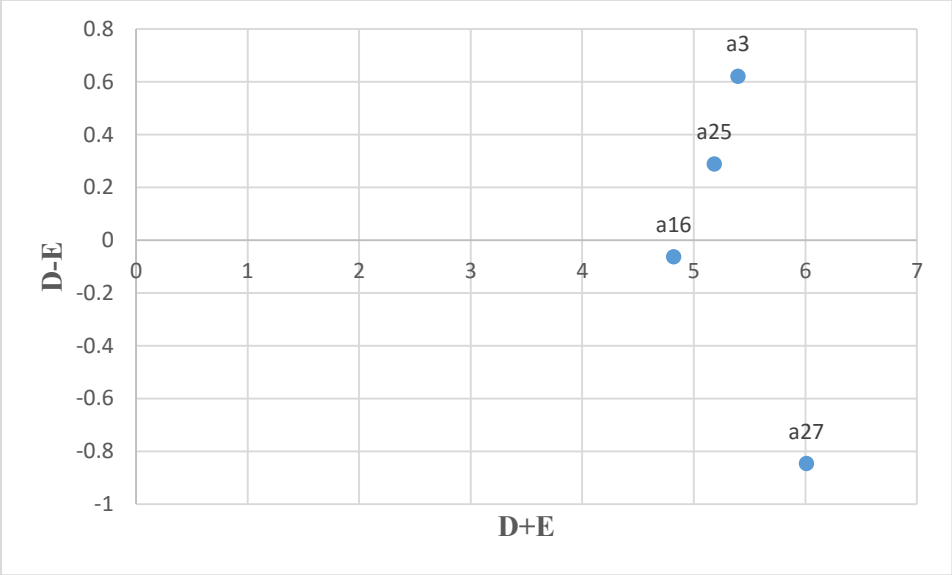

Figure 24 Matrix 6 DEMATEL Prominence-Causal Diagram

Findings:

- a3 and a25 are the cause barriers and are effecting the other barriers.
- a27 and a16 are the effect barriers.
- a27 (Lack of eco-literacy amongst supply chain members) is the highest impact barrier and has the highest degree of influence on the other barriers.
- From the inner dependency matrix, it is found that a27 is caused by all other barriers, so these barriers should be given consideration. Out of these three, a3 has the highest impact value, so it should be given highest importance.
- So, it is concluded that barrier a3 (Lack of support and guidance from regulatory authorities) is the most influential barrier which is the main cause for the barrier a27 (Lack of eco-literacy amongst supply chain members)

- a3 (Government and NGO's)
- a27 (Employees, Customers and Suppliers)

4.6.7 DEMATEL for Matrix 7 (Sustainability Area)

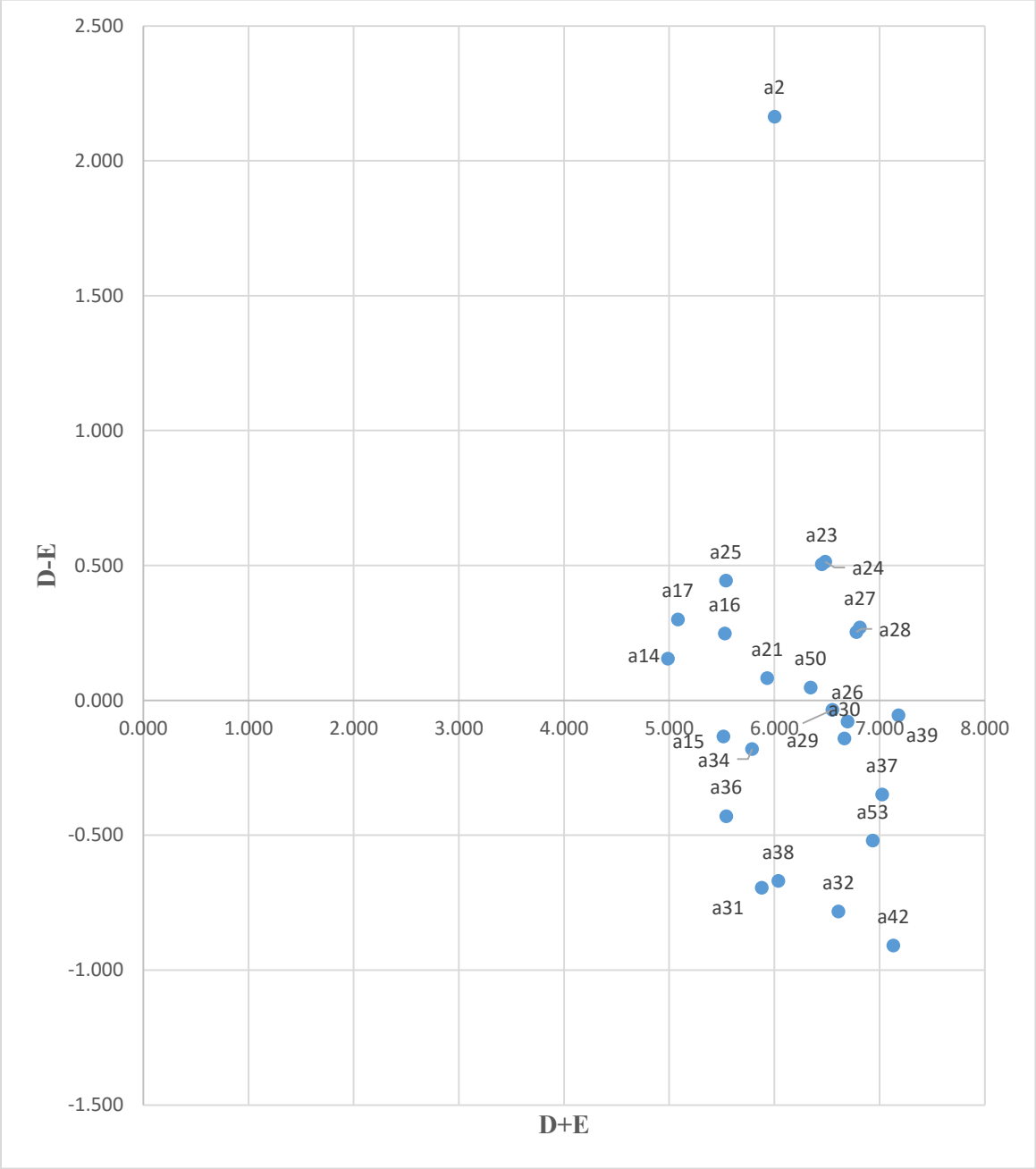

Figure 25 Matrix 7 DEMATEL Prominence-Causal Diagram

Findings:

- a11, a10, a37 and a44 are the cause barriers and are effecting the other barriers.
- a33, a36, a48 and a34 are the effect barriers.
- a33, a37, a10 and a11 are the highest impact barriers and has the highest degree of influence on the other barriers.
- From the inner dependency matrix, it is found that a33 is caused by all the barriers except a36, out of which a11 has the highest impact value, so barrier a11 should be given consideration. Also, a37 is caused by all other barriers except a34 and a36, out of which, a11 has the highest impact value again, so it should be given the highest importance. Another barrier a10 is having high cause value and it is caused by other barriers a11 and a37, out of which a11 has the highest influence value again. The barrier a11 is caused by a10, and a37, both of which should be given consideration.
- So, it is concluded that barrier a11 (Complexity of design to reduce consumption of resource/ energy) is the most influential barrier which is the main cause for the barrier a33 (Hesitation/fear to convert to new systems), a37 (Lack of training courses/consultancy/institutions to train, monitor/mentor progress specific to each industry) and a10 (Complexity of design to reuse/recycle used products). Also, a10 and a37 are causing a11.
- a10 (Technological, knowledge)
- a11 (Technological, knowledge)
- a33 (Psychological, Technological)
- a37 (knowledge and strategic)

4.6.8 DEMATEL for Matrix 8 (Organizational Hierarchy)

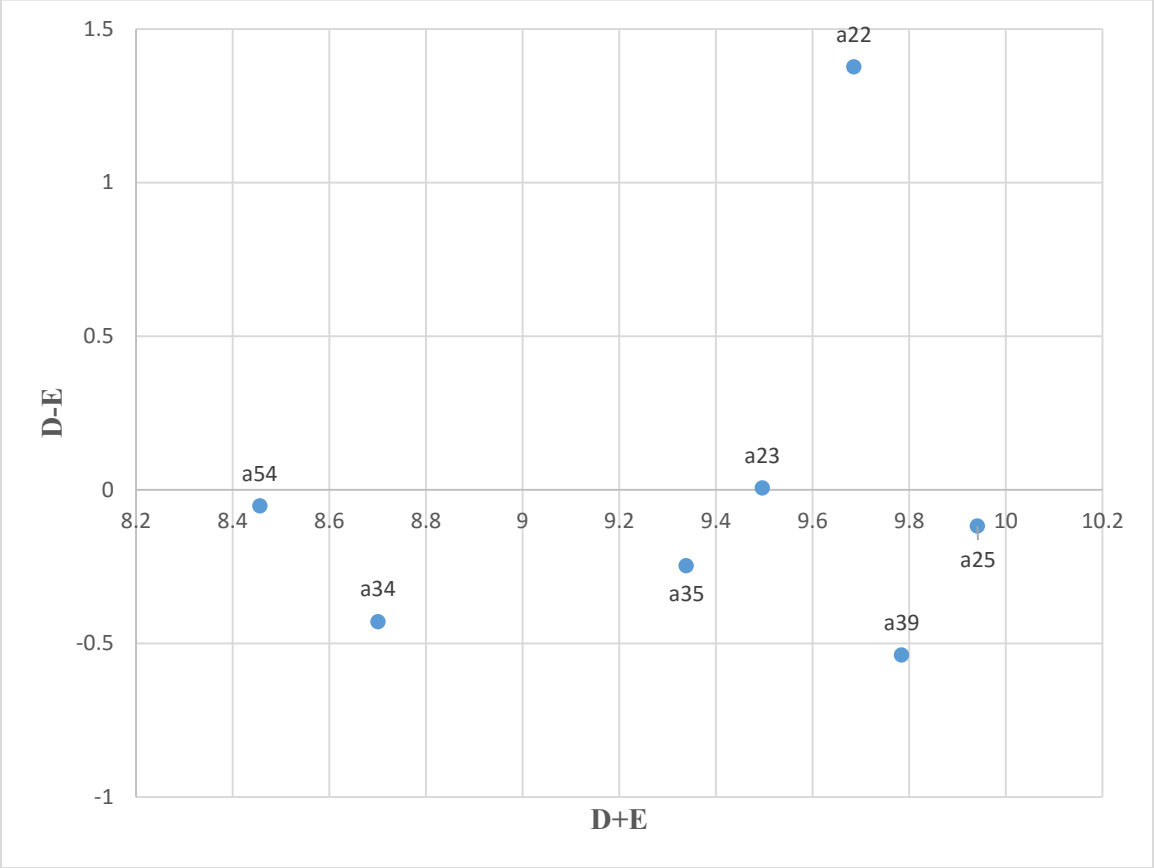

Figure 26 Matrix 8 DEMATEL Prominence-Causal Diagram

Findings:

- a22 and a23 are the cause barriers and are effecting the other barriers.
- a39, a34, a35, a25 and a54 are the effect barriers.
- a25, a39, a22 and a23 are the highest impact barriers and has the highest degree of influence on the other barriers.
- From the inner dependency matrix, it is found that a25 is caused by the barrier a22, a23, a35 and a39, out of which a22 has the highest impact value, so barrier a22 should be given consideration. Also, a39 is caused by all other barriers except a35, out of which, a22 has the highest impact value again, so it should

be given the highest importance. Another barrier a22 is having high cause value but it is not caused by any other barrier significantly. The barrier a23 is caused by a22, a25 and a39, out of which a22 has a higher impact value and hence it should be given consideration.

- So, it is concluded that barrier a22 (Lack of technical expertise) is the most influential barrier which is the main cause for the barrier a25 (Perception of "out of responsibility" zone), a39 (Lack of awareness of the environmental impacts on business) and a23 (Lack of awareness about reverse logistics adoption).
- a22 (Middle Management and worker level)
- a23 (Top Management, Middle Management and Worker Level)
- a25 (Top Management, Middle Management)
- a39 (Top Management, Middle Management)

4.6.9 DEMATEL for Matrix 9 (Others)

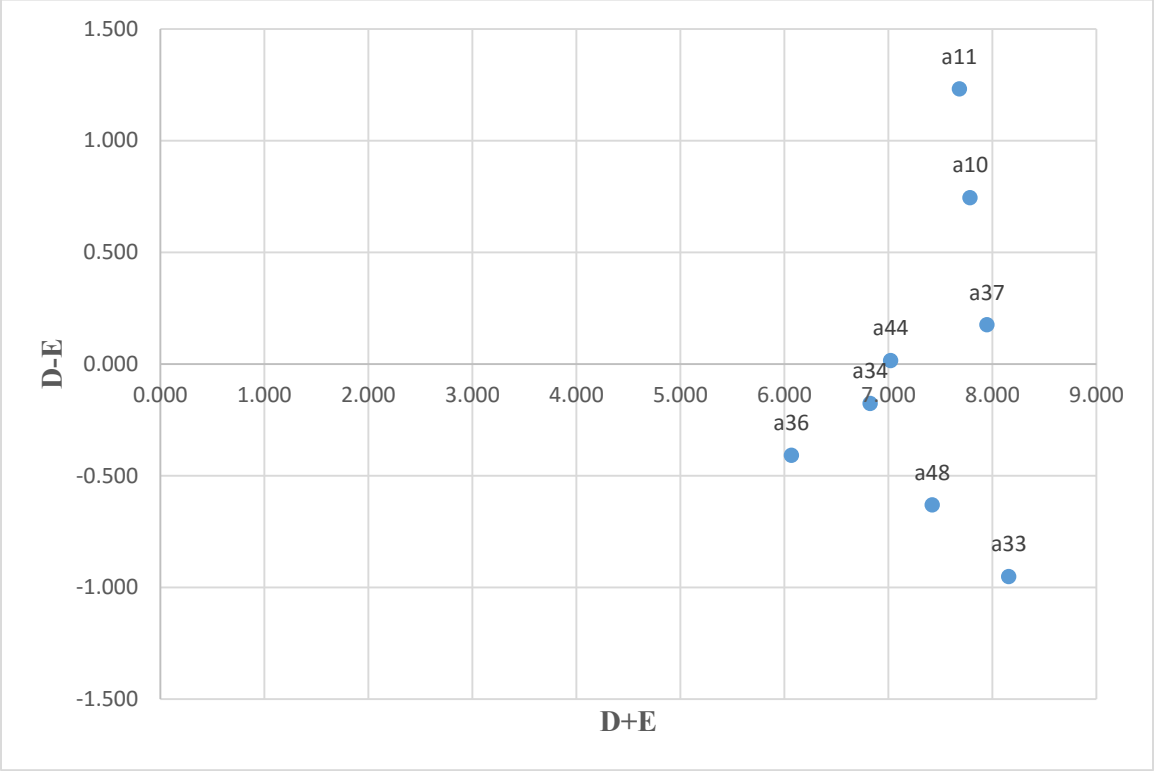

Figure 27 Matrix 9 DEMATEL Prominence-Causal Diagram

Findings:

- a11, a10, a37 and a44 are the cause barriers and are effecting the other barriers.
- a33, a36, a48 and a34 are the effect barriers.
- a33, a37, a10 and a11 are the highest impact barriers and has the highest degree of influence on the other barriers.
- From the inner dependency matrix, it is found that a33 is caused by all the barriers except a36, out of which a11 has the highest impact value, so barrier a11 should be given consideration. Also, a37 is caused by all other barriers except a34 and a36, out of which, a11 has the highest impact value again, so it should be given the highest importance. Another barrier a10 is having high

cause value and it is caused by other barriers a11 and a37, out of which a11 has the highest influence value again. The barrier a11 is caused by a10, and a37, both of which should be given consideration.

- So, it is concluded that barrier a11 (Complexity of design to reduce consumption of resource/energy) is the most influential barrier which is the main cause for the barrier a33 (Hesitation/fear to convert to new systems), a37 (Lack of training courses/consultancy/institutions to train, monitor/mentor progress specific to each industry) and a10 (Complexity of design to reuse/recycle used products). Also, a10 and a37 are causing a11.
- a10 (Technological, knowledge)
- a11 (Technological, knowledge)
- a33 (Psychological, Technological)
- a37 (knowledge and strategic)

4.7 DEMATEL and Direct Ranking Comparisons

For the purpose of validation, we compared the results of both DEMATEL and Direct Ranking. We listed all the barriers having the most impact through DEMATEL and barriers resulting from the 80-20 rule in the Pareto analysis in Direct Ranking. It is found that the results from both the techniques has common barriers in seven out of nine matrices. Table 25 shows the comparison in the findings of both DEMATEL and Direct Ranking.

Table 25 DEMATEL and Direct Ranking Comparisons

Matrix No.	DEMATEL	Direct Ranking
Matrix 1	**a48, a49**	a47, **a48, a49**
Matrix 2	a26, **a39, a48**	a21, a23, a34, **a39, a48**
Matrix 3	a26, a39	a21, a23, a34
Matrix 4	**a10, a21, a40,** a50, a53	**a10,** a15, a17, a18, **a21, a40**
Matrix 5	a22, a45	a15, a17, a23
Matrix 6	**a3,** a27	**a3,** a25
Matrix 7	**a2, a37,** a39, **a42**	**a2,** a14, a15, a17, a21, a23, a24, a25, a27, a32, a34, **a37, a42,** a50
Matrix 8	**a22, a23,** a25, a39	**a22, a23,** a34, a35,a54
Matrix 9	**a10, a11, a33, a37**	**a10, a11, a33,** a34, **a37,** a48

Through DEMATEL, we have identified 20 most impactful barriers out of the 38 barriers used in the analysis. All the pertinent barriers from DEMATEL technique and their presence in different matrices is given in the Table 26.

Table 26 Resulting Prominent Barriers

S. No.	Barrier No.	Barrier Name	Matrix No.
1	a2	Market competition and uncertainty	Matrix 7
2	a3	Lack of support and guidance from regulatory authorities	Matrix 6
3	**a10**	**Complexity of design to reuse/recycle used products**	**Matrix 4, Matrix 9**
4	a11	Complexity of design to reduce consumption of resource/energy	Matrix 9
5	a21	Difficulty in transforming positive environmental attitudes into action	Matrix 4
6	**a22**	**Lack of technical expertise**	**Matrix 5, Matrix 8**
7	a23	Lack of awareness about reverse logistics adoption	Matrix 8
8	a25	Perception of "out of responsibility" zone	Matrix 8

9	**a26**	**Difficulty in identifying environmental opportunities**	**Matrix 2, Matrix 3**
10	a27	Lack of Eco-literacy amongst supply chain members	Matrix 6
11	a33	Hesitation/fear to convert to new systems	Matrix 9
12	**a37**	**Lack of training courses/ consultancy/ institutions to train, monitor/mentor progress specific to each industry**	**Matrix 7, Matrix 9**
13	**a39**	**Lack of awareness of the environmental impacts on business**	**Matrix 2, Matrix 3, Matrix 7, Matrix 8**
14	a40	No proper training/reward system for suppliers	Matrix 4
15	a42	Lack of effective environmental measures	Matrix 7
16	a45	Lack of new technology, materials and processes	Matrix 5
17	**a48**	**Lack of corporate social responsibility**	**Matrix 1, Matrix 2**
18	a49	Not much involvement in environmental related programs/meetings	Matrix 1
19	a50	Restrictive company policies towards product/process stewardship	Matrix 4
20	a53	Failure to market the benefits/results of GSCM	Matrix 4

As it is seen, out of these 20 barriers, 6 barriers (a10, a22, a26, a37, a39 and a48) are found to be present in the most pertinent barriers for more than one matrix. Hence, they are the most influential barriers and must be taken care of.

Chapter 5

Conclusions and Future Scope

5.1 Conclusions

In this thesis, we investigated the barriers to GSCM. Literature review was conducted to identify the preliminary list of barriers. In order to understand the nature of the barriers, we classified them into different categories and sub-categories. These categories of classification are Multiple M's, Supply Chain Processes, Stakeholders of Supply Chain, Sustainability Area, Organizational Hierarchy, and Others. DEMATEL, Direct Ranking and Pareto analysis are used to identify the relationships between different barriers Responses from 5 experts are used in this thesis. The findings of the DEMATEL show that complexity of design to reuse/recycle products, lack of technical expertise, difficulty in identifying environmental opportunities, lack of training, lack of awareness on the environmental impacts of business, lack of corporate social responsibility, complexity in identifying third parties to recollect used products and lack of R&D capability on GSCM practices are the most prominent barriers. The comparisons with the Direct Ranking results support these findings as well.

5.2 Limitations

The main limitation of the present study is the lack of large number of respondents for the numerical analysis. With fewer number of respondents, a bias might exist with respect to one industry or their field of work.

5.3 Future Scope

- The number of respondents could be increased.

- In this study, six categories of classification were explored. Future studies may explore more categories for barrier classification.
- The literature review for the extraction of the barriers to GSCM comprised of mostly Asian and a few Middle-Eastern countries. The research can be extended to other countries.
- The present study compared the DEMATEL results with Pareto analysis. Future studies can include other statistical techniques.

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APPENDICES

Appendix A Barrier relationships with sub-categories

Category 1 relationships with barriers

Barrier No.	Barrier Name	Category 1(Multiple M's)								Row Total
		Man	Machine	Method	Material	Money	Measurement	Market	Motivation	
a1	Lack of government support to towards Environmental friendly policies			1						1
a2	Market competition and uncertainty			1				1		2
a3	Lack of support and guidance from regulatory authorities			1						1
a4	Changing regulations due to changing political climate			1						1
a5	Lack of government enforcement and corruption due to poor legislation			1						1
a6	Problem in maintaining environmental suppliers			1						1
a7	Complexity in measuring and monitoring suppliers environmental practices			1			1			2
a8	Lack of an environmental partnership with suppliers			1						1
a9	Products potentially conflict with laws			1						1
a10	Complexity of design to reuse/recycle used products		1	1	1					3

a11	Complexity of design to reduce consumption of resource/energy		1	1					2
a12	Poor supplier commitment/ unwilling to exchange information			1					1
a13	High investments and less return-on investments			1		1			2
a14	Expenditure in collecting and recycling used products			1		1			2
a15	Cost of environment friendly packaging			1	1	1			3
a16	Non-availability of bank loans to encourage green products/processes			1		1			2
a17	High cost of hazardous waste disposal			1	1	1			3
a18	Cost of switching to new system, maintenance and operations costs of the improved system		1	1		1			3
a19	Lack of economies of scale, Unequal government subsidies/taxes			1		1			2
a20	Fear of failure	1		1					2
a21	Difficulty in transforming positive environmental attitudes into action	1		1				1	3
a22	Lack of technical expertise	1		1					2
a23	Lack of awareness about reverse logistics adoption	1		1					2
a24	Disbelief about environmental benefits	1		1					2
a25	Perception of "out of responsibility" zone	1		1					2
a26	Difficulty in identifying environmental opportunities	1		1					2

a27	Lack of Eco-literacy amongst supply chain members	1	1			2
a28	Lack of environmental knowledge	1	1			2
a29	Lack of information of Renewable Energy (RE) resources		1			1
a30	Lack of green system exposure to professionals		1			1
a31	Complexity in identifying third parties to recollect used products		1			1
a32	Difficulty in obtaining information on potential environmental improvements		1			1
a33	Hesitation/fear to convert to new systems	1	1			2
a34	Lack of R&D capability on GSCM practices	1	1			2
a35	Lack of employee awareness about occupational health hazards	1	1			2
a36	Risk in hazardous material inventory		1	1		2
a37	Lack of training courses/consultancy/institutions to train, monitor/mentor progress specific to each industry	1	1			2
a38	Lack of customer awareness and pressure about GSCM	1	1			2
a39	Lack of awareness of the environmental impacts on business	1	1			2
a40	No proper training/reward system for suppliers	1	1		1	3
a41	No clear statement for responsibilities from management	1	1			2

a42	Lack of effective environmental measures			1						1
a43	Lack of human resources	1		1						2
a44	Current practice lacks flexibility to switch over to new system			1						1
a45	Lack of new technology, materials and processes		1	1	1					3
a46	Lack of infrastructure for suitability of waste management or disposal methods		1	1						2
a47	No specific environmental goals	1		1						2
a48	Lack of corporate social responsibility	1		1						2
a49	Not much involvement in environmental related programs/meetings	1		1						2
a50	Restrictive company policies towards product/process stewardship	1		1	1					3
a51	Lack of inter-departmental co-operation in communication	1		1						2
a52	Lack of involvement of top management in adopting GSCM	1		1						2
a53	Failure to market the benefits/results of GSCM	1		1				1		3
a54	Inadequate management capacity	1		1						2
	Column Total	26	5	54	6	7	1	2	2	

Category 2 relationships with barriers

Barrier No.	Barrier Name	Category 2(Supply chain processes)									Row Total
		Design	Purchasing	Production	Testing & Inspection (Quality Control)	Packaging	Transportation	Warehousing	After sales Service	Recycling	
a1	Lack of government support to towards Environmental friendly policies										
a2	Market competition and uncertainty										
a3	Lack of support and guidance from regulatory authorities										
a4	Changing regulations due to changing political climate										
a5	Lack of government enforcement and corruption due to poor legislation										
a6	Problem in maintaining environmental suppliers		1								1
a7	Complexity in measuring and monitoring suppliers environmental practices		1								1
a8	Lack of an environmental partnership with suppliers		1								1

a9	Products potentially conflict with laws			1					1
a10	Complexity of design to reuse/recycle used products	1							1
a11	Complexity of design to reduce consumption of resource/energy	1							1
a12	Poor supplier commitment/ unwilling to exchange information		1						1
a13	High investments and less return-on investments		1						1
a14	Expenditure in collecting and recycling used products							1	1
a15	Cost of environment friendly packaging		1			1			2
a16	Non-availability of bank loans to encourage green products/processes								
a17	High cost of hazardous waste disposal			1				1	2
a18	Cost of switching to new system, maintenance and operations costs of the improved system		1						1
a19	Lack of economies of scale, Unequal government subsidies/taxes								

a20	Fear of failure	1									1
a21	Difficulty in transforming positive environmental attitudes into action										
a22	Lack of technical expertise	1	1	1	1		1	1	1	1	8
a23	Lack of awareness about reverse logistics adoption							1	1	1	2
a24	Disbelief about environmental benefits										
a25	Perception of "out of responsibility" zone										
a26	Difficulty in identifying environmental opportunities										
a27	Lack of Eco-literacy amongst supply chain members										
a28	Lack of environmental knowledge										
a29	Lack of information of Renewable Energy (RE) resources										
a30	Lack of green system exposure to professionals										
a31	Complexity in identifying third parties to recollect used products		1								1

a32	Difficulty in obtaining information on potential environmental improvements				
a33	Hesitation/fear to convert to new systems				
a34	Lack of R&D capability on GSCM practices	1			1
a35	Lack of employee awareness about occupational health hazards				
a36	Risk in hazardous material inventory			1	1
a37	Lack of training courses/consultancy/institutions to train, monitor/mentor progress specific to each industry				
a38	Lack of customer awareness and pressure about GSCM				
a39	Lack of awareness of the environmental impacts on business				
a40	No proper training/reward system for suppliers				
a41	No clear statement for responsibilities from management				

a42	Lack of effective environmental measures						
a43	Lack of human resources						
a44	Current practice lacks flexibility to switch over to new system						
a45	Lack of new technology, materials and processes	1	1				2
a46	Lack of infrastructure for suitability of waste management or disposal methods					1	1
a47	No specific environmental goals						
a48	Lack of corporate social responsibility						
a49	Not much involvement in environmental related programs/meetings						
a50	Restrictive company policies towards product/process stewardship						
a51	Lack of inter-departmental co-operation in communication						
a52	Lack of involvement of top management in adopting GSCM						

a53	Failure to market the benefits/results of GSCM										
a54	Inadequate management capacity										
	Column Total	5	9	3	3		2	2	3	5	

Category 3 relationships with barriers

Barrier No.	Barrier Name	Category 3 (Stakeholders of supply chain)					Row Total
		Employees(Organizational)	Customers	Suppliers	Government(Regulatory)	NGO's(Community groups/environmental organizations)	
a1	Lack of government support to towards Environmental friendly policies				1		1
a2	Market competition and uncertainty						
a3	Lack of support and guidance from regulatory authorities				1	1	2
a4	Changing regulations due to changing political climate				1		1
a5	Lack of government enforcement and corruption due to poor legislation				1		1
a6	Problem in maintaining environmental suppliers			1			1

a7	Complexity in measuring and monitoring suppliers environmental practices		1			1
a8	Lack of an environmental partnership with suppliers		1			1
a9	Products potentially conflict with laws					
a10	Complexity of design to reuse/recycle used products					
a11	Complexity of design to reduce consumption of resource/energy					
a12	Poor supplier commitment/ unwilling to exchange information		1			1
a13	High investments and less return-on investments					
a14	Expenditure in collecting and recycling used products					
a15	Cost of environment friendly packaging					
a16	Non-availability of bank loans to encourage green products/processes			1	1	2
a17	High cost of hazardous waste disposal					
a18	Cost of switching to new system, maintenance and operations costs of the improved system					
a19	Lack of economies of scale, Unequal government subsidies/taxes			1		1
a20	Fear of failure	1				1

a21	Difficulty in transforming positive environmental attitudes into action	1				1
a22	Lack of technical expertise	1				1
a23	Lack of awareness about reverse logistics adoption	1				1
a24	Disbelief about environmental benefits	1				1
a25	Perception of "out of responsibility" zone	1		1		2
a26	Difficulty in identifying environmental opportunities	1				1
a27	Lack of Eco-literacy amongst supply chain members	1	1	1		3
a28	Lack of environmental knowledge	1				1
a29	Lack of information of Renewable Energy (RE) resources					
a30	Lack of green system exposure to professionals					
a31	Complexity in identifying third parties to recollect used products					
a32	Difficulty in obtaining information on potential environmental improvements					
a33	Hesitation/fear to convert to new systems	1				1
a34	Lack of R&D capability on GSCM practices	1				1
a35	Lack of employee awareness about occupational health hazards	1				1

a36	Risk in hazardous material inventory				
a37	Lack of training courses/consultancy/institutions to train, monitor/mentor progress specific to each industry	1			1
a38	Lack of customer awareness and pressure about GSCM		1		1
a39	Lack of awareness of the environmental impacts on business	1			1
a40	No proper training/reward system for suppliers	1			1
a41	No clear statement for responsibilities from management	1			1
a42	Lack of effective environmental measures				
a43	Lack of human resources	1			1
a44	Current practice lacks flexibility to switch over to new system				
a45	Lack of new technology, materials and processes				
a46	Lack of infrastructure for suitability of waste management or disposal methods				
a47	No specific environmental goals	1			1
a48	Lack of corporate social responsibility	1			1
a49	Not much involvement in environmental related programs/meetings	1			1

a50	Restrictive company policies towards product/process stewardship	1					1
a51	Lack of inter-departmental co-operation in communication	1					1
a52	Lack of involvement of top management in adopting GSCM	1					1
a53	Failure to market the benefits/results of GSCM	1					1
a54	Inadequate management capacity	1					
	Column Total	25	2	6	6	2	

Category 4 relationships with barriers

Barrier No.	Barrier Name	Category 4(Sustainability Area)				Row Total
		Societal	Economic	Environmental	Technical	
a1	Lack of government support to towards Environmental friendly policies			1		1
a2	Market competition and uncertainty		1		1	2
a3	Lack of support and guidance from regulatory authorities	1				1
a4	Changing regulations due to changing political climate	1				1
a5	Lack of government enforcement and corruption due to poor legislation	1				1
a6	Problem in maintaining environmental suppliers			1		1

a7	Complexity in measuring and monitoring suppliers environmental practices			1		1
a8	Lack of an environmental partnership with suppliers			1		1
a9	Products potentially conflict with laws			1		1
a10	Complexity of design to reuse/recycle used products			1		1
a11	Complexity of design to reduce consumption of resource/energy			1		1
a12	Poor supplier commitment/ unwilling to exchange information	1				1
a13	High investments and less return-on investments		1			1
a14	Expenditure in collecting and recycling used products		1	1		2
a15	Cost of environment friendly packaging		1	1		2
a16	Non-availability of bank loans to encourage green products/processes		1	1		2
a17	High cost of hazardous waste disposal		1	1		2
a18	Cost of switching to new system, maintenance and operations costs of the improved system		1			1
a19	Lack of economies of scale, Unequal government subsidies/taxes		1			1
a20	Fear of failure	1				1
a21	Difficulty in transforming positive environmental attitudes into action	1		1		2
a22	Lack of technical expertise				1	1
a23	Lack of awareness about reverse logistics adoption	1		1	1	3
a24	Disbelief about environmental benefits	1		1		2

a25	Perception of "out of responsibility" zone	1	1		2
a26	Difficulty in identifying environmental opportunities	1	1	1	3
a27	Lack of Eco-literacy amongst supply chain members	1	1	1	3
a28	Lack of environmental knowledge	1	1	1	3
a29	Lack of information of Renewable Energy (RE) resources	1	1		2
a30	Lack of green system exposure to professionals	1	1	1	3
a31	Complexity in identifying third parties to recollect used products		1	1	2
a32	Difficulty in obtaining information on potential environmental improvements		1	1	2
a33	Hesitation/fear to convert to new systems	1			1
a34	Lack of R&D capability on GSCM practices	1	1	1	3
a35	Lack of employee awareness about occupational health hazards	1			1
a36	Risk in hazardous material inventory	1	1		2
a37	Lack of training courses/consultancy/institutions to train, monitor/mentor progress specific to each industry	1		1	2
a38	Lack of customer awareness and pressure about GSCM	1	1		2
a39	Lack of awareness of the environmental impacts on business	1	1		2
a40	No proper training/reward system for suppliers				
a41	No clear statement for responsibilities from management				

a42	Lack of effective environmental measures			1	1	2
a43	Lack of human resources					
a44	Current practice lacks flexibility to switch over to new system					
a45	Lack of new technology, materials and processes				1	1
a46	Lack of infrastructure for suitability of waste management or disposal methods			1	1	2
a47	No specific environmental goals			1		1
a48	Lack of corporate social responsibility			1		1
a49	Not much involvement in environmental related programs/meetings			1		1
a50	Restrictive company policies towards product/process stewardship			1	1	2
a51	Lack of inter-departmental co-operation in communication					
a52	Lack of involvement of top management in adopting GSCM			1		1
a53	Failure to market the benefits/results of GSCM			1	1	2
a54	Inadequate management capacity				1	1
	Column Total	21	8	34	17	

Category 5 relationships with barriers

Barrier No.	Barrier Name	Category 5(Organizational Hierarchy)	Row Total

		Top Management/Executive Level	Middle/Departmental Level	Worker/Supervisory Level
a1	Lack of government support to towards Environmental friendly policies			
a2	Market competition and uncertainty			
a3	Lack of support and guidance from regulatory authorities			
a4	Changing regulations due to changing political climate			
a5	Lack of government enforcement and corruption due to poor legislation			
a6	Problem in maintaining environmental suppliers			
a7	Complexity in measuring and monitoring suppliers environmental practices			
a8	Lack of an environmental partnership with suppliers			
a9	Products potentially conflict with laws			
a10	Complexity of design to reuse/recycle used products			
a11	Complexity of design to reduce consumption of resource/energy			
a12	Poor supplier commitment/ unwilling to exchange information			
a13	High investments and less return-on investments			
a14	Expenditure in collecting and recycling used products			

a15	Cost of environment friendly packaging				
a16	Non-availability of bank loans to encourage green products/processes				
a17	High cost of hazardous waste disposal				
a18	Cost of switching to new system, maintenance and operations costs of the improved system				
a19	Lack of economies of scale, Unequal government subsidies/taxes				
a20	Fear of failure	1			1
a21	Difficulty in transforming positive environmental attitudes into action	1			1
a22	Lack of technical expertise		1	1	2
a23	Lack of awareness about reverse logistics adoption	1	1	1	3
a24	Disbelief about environmental benefits	1			1
a25	Perception of "out of responsibility" zone	1	1		2
a26	Difficulty in identifying environmental opportunities	1			1
a27	Lack of Eco-literacy amongst supply chain members		1		1
a28	Lack of environmental knowledge		1		1
a29	Lack of information of Renewable Energy (RE) resources		1		1
a30	Lack of green system exposure to professionals		1		1

a31	Complexity in identifying third parties to recollect used products		1		1
a32	Difficulty in obtaining information on potential environmental improvements		1		1
a33	Hesitation/fear to convert to new systems	1			1
a34	Lack of R&D capability on GSCM practices	1	1		2
a35	Lack of employee awareness about occupational health hazards		1	1	2
a36	Risk in hazardous material inventory				
a37	Lack of training courses/consultancy/institutions to train, monitor/mentor progress specific to each industry		1		1
a38	Lack of customer awareness and pressure about GSCM				
a39	Lack of awareness of the environmental impacts on business	1	1		2
a40	No proper training/reward system for suppliers	1			1
a41	No clear statement for responsibilities from management	1			1
a42	Lack of effective environmental measures		1		1
a43	Lack of human resources		1		1
a44	Current practice lacks flexibility to switch over to new system		1		1
a45	Lack of new technology, materials and processes	1			1

a46	Lack of infrastructure for suitability of waste management or disposal methods					
a47	No specific environmental goals	1				1
a48	Lack of corporate social responsibility	1				1
a49	Not much involvement in environmental related programs/meetings	1				1
a50	Restrictive company policies towards product/process stewardship	1				1
a51	Lack of inter-departmental co-operation in communication		1			1
a52	Lack of involvement of top management in adopting GSCM	1				1
a53	Failure to market the benefits/results of GSCM	1				1
a54	Inadequate management capacity	1	1			2
	Column total	19	18	3		

Category 6 relationships with barriers

Barrier No.	Barrier Name	Category 6(Others)				Row Total
		Psychological	Technological	Knowledge	Strategical	
a1	Lack of government support to towards Environmental friendly policies					
a2	Market competition and uncertainty					

a3	Lack of support and guidance from regulatory authorities			
a4	Changing regulations due to changing political climate			
a5	Lack of government enforcement and corruption due to poor legislation			
a6	Problem in maintaining environmental suppliers			
a7	Complexity in measuring and monitoring suppliers environmental practices			
a8	Lack of an environmental partnership with suppliers			
a9	Products potentially conflict with laws			
a10	Complexity of design to reuse/recycle used products	1	1	2
a11	Complexity of design to reduce consumption of resource/energy	1	1	2
a12	Poor supplier commitment/ unwilling to exchange information		1	1
a13	High investments and less return-on investments			
a14	Expenditure in collecting and recycling used products			
a15	Cost of environment friendly packaging			
a16	Non-availability of bank loans to encourage green products/processes			
a17	High cost of hazardous waste disposal			
a18	Cost of switching to new system, maintenance and operations costs of the improved system	1		1

a19	Lack of economies of scale, Unequal government subsidies/taxes				
a20	Fear of failure	1			1
a21	Difficulty in transforming positive environmental attitudes into action			1	1
a22	Lack of technical expertise				1
a23	Lack of awareness about reverse logistics adoption			1	1
a24	Disbelief about environmental benefits	1			1
a25	Perception of "out of responsibility" zone	1			1
a26	Difficulty in identifying environmental opportunities			1	1
a27	Lack of Eco-literacy amongst supply chain members			1	1
a28	Lack of environmental knowledge			1	1
a29	Lack of information of Renewable Energy (RE) resources			1	1
a30	Lack of green system exposure to professionals			1	1
a31	Complexity in identifying third parties to recollect used products			1	1
a32	Difficulty in obtaining information on potential environmental improvements			1	1
a33	Hesitation/fear to convert to new systems	1	1		**2**
a34	Lack of R&D capability on GSCM practices			1	**2**
a35	Lack of employee awareness about occupational health hazards			1	1

a36	Risk in hazardous material inventory	1	1		**2**
a37	Lack of training courses/consultancy/institutions to train, monitor/mentor progress specific to each industry		1	1	**2**
a38	Lack of customer awareness and pressure about GSCM		1		1
a39	Lack of awareness of the environmental impacts on business		1		1
a40	No proper training/reward system for suppliers			1	1
a41	No clear statement for responsibilities from management			1	1
a42	Lack of effective environmental measures			1	1
a43	Lack of human resources				
a44	Current practice lacks flexibility to switch over to new system	1	1		**2**
a45	Lack of new technology, materials and processes	1			1
a46	Lack of infrastructure for suitability of waste management or disposal methods	1	1		1
a47	No specific environmental goals			1	1
a48	Lack of corporate social responsibility		1	1	2
a49	Not much involvement in environmental related programs/meetings			1	1
a50	Restrictive company policies towards product/process stewardship			1	1
a51	Lack of inter-departmental co-operation in communication				

a52	Lack of involvement of top management in adopting GSCM					
a53	Failure to market the benefits/results of GSCM			1		1
a54	Inadequate management capacity					
	Column total	4	8	22	8	

Appendix B DEMATEL Calculations

DEMATEL Calculations for Matrix 2

Step 1. Average Matrix, Z

0	3.5	1.5	2.5	1.5	2.25	2
1	0	2.2	1.4	2.2	2.2	2.8
1.8	1.8	0	2.6	2.8	2	2
1	1.4	1.6	0	2	2.4	1.8
2	2	2.6	1.8	0	3	2.4
2.2	1.8	1.6	1.4	2.2	0	1.6
1.4	1	1.8	1.4	2.4	1.8	0

Step 2. S= max (sum of rows, sum of columns) = max (13.65, 13.25), S=13.65, 1/S = 0.073

Step 3. Normalized Initial Direct Relation Matrix, X= Z/S

0	0.256	0.109	0.183	0.109	0.164	0.146
0.073	0	0.161	0.102	0.161	0.161	0.205
0.131	0.131	0	0.190	0.205	0.146	0.146
0.073	0.102	0.117	0	0.146	0.175	0.131
0.146	0.146	0.190	0.131	0	0.219	0.175
0.161	0.131	0.117	0.102	0.161	0	0.117
0.102	0.073	0.131	0.102	0.175	0.131	0

Step 4. Total Relation Matrix, T

0.715	1.043	0.941	0.963	1.057	1.129	1.048
0.726	0.749	0.906	0.828	1.013	1.035	1.006
0.834	0.944	0.840	0.970	1.126	1.115	1.042
0.648	0.754	0.778	0.645	0.894	0.940	0.848
0.884	0.998	1.042	0.965	1.004	1.216	1.109
0.756	0.832	0.825	0.788	0.956	0.846	0.891
0.661	0.722	0.777	0.730	0.901	0.892	0.718

Step 5. Total Cause and Effect for barriers

	a21	a23	a26	a34	a39	a48	a53
D-E	1.671	0.219	0.763	-0.382	0.268	-1.277	-1.268
D+E	12.12	12.31	12.98	11.40	14.17	13.07	12.07

Threshold value (average of Matrix T), ∂ = 0.899

Step 6. Inner Dependency Matrix

a21	a23	a26	a34	a39	a48	a53
	1.043	**0.941**	**0.963**	**1.057**	**1.129**	**1.048**
		0.906		**1.013**	**1.035**	**1.006**
	0.944		**0.970**	**1.126**	**1.115**	**1.042**
					0.940	
	0.998	**1.042**	**0.965**	**1.004**	**1.216**	**1.109**
				0.956		
				0.901		

DEMATEL Calculations for Matrix 3

Step 1. Average Matrix, Z

0	2.75	1.5	2	1
1	0	2	1.6	2.2
1.8	1.6	0	2.4	2.6
1.2	1.2	1.8	0	1.8
2	1.6	2.6	1.8	0

Step 2. S= max (sum of rows, sum of columns) = max (7.9, 8.4) = 8.4, 1/S = 0.119

Step 3. Normalized Initial Direct Relation Matrix, X= Z/S

0	0.3271	0.178	0.238	0.119
0.119	0	0.238	0.190	0.261
0.214	0.190	0	0.285	0.309
0.142	0.142	0.214	0	0.214
0.238	0.190	0.309	0.214	0

Step 4. Total Relation Matrix, T

0.980	1.369	1.394	1.416	1.329
1.079	1.084	1.414	1.359	1.403
1.317	1.440	1.435	1.635	1.638
0.997	1.103	1.272	1.078	1.246
1.298	1.405	1.628	1.547	1.358

Step 5. Total Cause and Effect for barriers

	a21	a23	a26	a34	a39
D-E	0.816	-0.062	0.321	1.337	0.261
D+E	12.16	12.74	14.61	12.73	14.21

Threshold value (average of Matrix T) $\partial = 1.329$

Step 6. Inner Dependency Matrix

a21	a23	a26	a34	a39
	1.369	**1.394**	**1.416**	**1.329**
		1.414	**1.359**	**1.403**
	1.440	**1.435**	**1.635**	**1.638**
	1.405	**1.628**	**1.547**	**1.358**

DEMATEL Calculations for Matrix 4

Step 1. Average Matrix, Z

0	2.4	1.6	2.8	1.8	2.4	2.6	2.2	3.2
1.4	0	2	2.4	1.6	1.6	1	1.4	2.8
1.2	1.6	0	1.6	2	2.2	1.8	1.4	2.6
1.6	2	2.2	0	1.6	2	1.4	1.8	2.2
1.6	1.2	1.6	2	0	2.5	2.5	3	2
2.4	1.8	1	1	1.6	0	2	1.6	2
2.2	2.6	2	1.6	1.4	1.8	0	1.2	1
1.2	1.8	1	1.8	2.4	2.4	1.8	0	2.4
1.8	1.4	1.6	0.8	1.8	2.6	1.2	2.2	0

Step 2. S= max (sum of rows, sum of columns) = max (18.2, 19) =19, 1/S = 0.052

Step 3. Normalized Initial Direct Relation Matrix, X= Z/S

0	0.126	0.084	0.147	0.094	0.126	0.136	0.115	0.168
0.073	0	0.105	0.126	0.084	0.084	0.052	0.073	0.147
0.063	0.084	0	0.084	0.105	0.115	0.094	0.073	0.136
0.084	0.105	0.115	0	0.084	0.105	0.073	0.094	0.115
0.084	0.063	0.084	0.105	0	0.131	0.131	0.157	0.105
0.126	0.094	0.052	0.052	0.084	0	0.105	0.084	0.105
0.115	0.136	0.105	0.084	0.073	0.094	0	0.063	0.052
0.063	0.094	0.052	0.094	0.126	0.126	0.094	0	0.126
0.094	0.073	0.084	0.042	0.094	0.136	0.063	0.115	0

Step 4. Total Relation Matrix T=

0.364	0.504	0.425	0.494	0.464	0.571	0.497	0.497	0.617
0.346	0.297	0.361	0.391	0.368	0.431	0.339	0.372	0.493
0.342	0.378	0.267	0.357	0.387	0.460	0.378	0.374	0.484
0.366	0.406	0.380	0.291	0.380	0.462	0.369	0.400	0.481
0.396	0.403	0.378	0.414	0.332	0.519	0.449	0.483	0.505
0.382	0.376	0.306	0.323	0.356	0.339	0.376	0.369	0.444
0.378	0.419	0.358	0.358	0.354	0.432	0.286	0.356	0.411
0.350	0.396	0.325	0.375	0.413	0.478	0.387	0.315	0.486
0.353	0.354	0.327	0.309	0.365	0.459	0.339	0.394	0.347

Step 5. Total Cause and Effect for barriers

	a10	a15	a17	a18	a21	a40	a45	a50	a53
D-E	1.155	-0.135	0.301	0.222	0.462	-0.880	-0.068	-0.035	-1.021
D+E	7.720	6.939	6.565	6.854	7.308	7.430	6.780	7.096	7.524

Threshold value (average of Matrix T), ∂ = 0.396

Step 6. Inner Dependency Matrix

a10	a15	a17	a18	a21	a40	a45	a50	a53
	0.504	**0.425**	**0.494**	**0.464**	**0.571**	**0.497**	**0.497**	**0.617**
					0.431			**0.493**
					0.460			**0.484**
	0.406				**0.462**		**0.400**	**0.481**
0.396	**0.403**		**0.414**		**0.519**	**0.449**	**0.483**	**0.505**
								0.444
	0.419				**0.432**			**0.411**
				0.413	**0.478**			**0.486**
					0.459			

DEMATEL Calculations for Matrix 5

Step 1. Average Matrix, Z

0	2.25	2	1	1.25
1.6	0	1.4	1.8	1.6
1.8	2	0	2.2	2.6
2.4	0.8	1.6	0	2.6
2.8	2	1.6	1.6	0

Step 2. S= max (sum of rows, sum of columns) = max (8.6, 8.6) = 8.6, 1/S= 0.116

Step 3. Normalized Initial Direct Relation Matrix, X= Z/S

0	0.261	0.232	0.116	0.145
0.186	0	0.162	0.209	0.186
0.209	0.232	0	0.255	0.302
0.279	0.093	0.186	0	0.302
0.325	0.232	0.186	0.186	0

Step 4. Total Relation Matrix, T

1.054	1.127	1.044	0.948	1.111
1.207	0.901	0.987	1.001	1.130
1.528	1.350	1.088	1.271	1.489
1.423	1.126	1.124	0.938	1.342
1.499	1.270	1.167	1.139	1.151

Step 5. Total Cause and Effect for barriers

	a15	a17	a22	a23	a45
D-E	-1.427	-0.547	1.315	0.656	0.002
D+E	11.99	11.00	12.14	11.25	12.45

Threshold value (average of Matrix T) $\partial = 1.177$

Step 6. Inner Dependency Matrix

a15	a17	a22	a23	a45
1.207				
1.528	**1.350**		**1.271**	**1.489**
1.423				**1.342**
1.499	**1.270**			

DEMATEL Calculations for Matrix 6

Step 1. Average Matrix, Z

0	1.75	2.5	2.25
1.2	0	1.25	2.5
1.6	1.2	0	3
2	2	1.4	0

Step 2. S= max (sum of rows, sum of columns) = max (7.75, 6.5) = 7.75, 1/S= 0.129

Step 3. Normalized Initial Direct Relation Matrix, X= Z/S

0	0.225	0.322	0.290
0.154	0	0.161	0.322
0.206	0.154	0	0.387
0.258	0.258	0.180	0

Step 4. Total Relation Matrix, T

0.525	0.718	0.784	0.978
0.552	0.427	0.560	0.837
0.654	0.627	0.487	0.968
0.654	0.667	0.615	0.643

Step 5. Total Cause and Effect for barriers

	a3	a16	a25	a27
D-E	0.620	-0.062	0.289	-0.846
D+E	5.395	4.820	5.184	6.009

Threshold value (average of Matrix T), $\partial = 0.669$

Step 6. Inner dependency matrix

a3	a16	a25	a27
	0.718	**0.784**	**0.978**
			0.837
			0.968

DEMATEL Calculations for Matrix 7

Step 1. Average Matrix, Z

a2	a14	a15	a16	a17	a21	a23	a24	a25	a26	a27	a28	a29	a30	a31	a32	a34	a36	a37	a38	a39	a42	a50	a53
0	2.5	2.25	2.25	2.25	2.5	2.5	2	1.5	1.75	2.5	2.5	2.5	2.25	2.75	2.5	1.75	2	3	3	2.5	2.25	2.75	3
1.2	0	1.4	1.6	2	0.8	1.4	1.4	1.6	2	1.8	0.8	1	1.6	1.8	2	1.8	1.4	1.6	1	1.2	1.6	1.8	1.4
0.6	2.4	0	0.8	2	1.8	1	1.8	1.2	2	1	1.2	1	2	1.4	1.8	1.8	1.4	2	1.4	2	2	1.2	2.2
0.8	2	1.4	0	1.25	2	1	2	1.25	2	2.25	2	2.25	2	2.25	1	2	1.25	1.75	1.5	2	1.25	1.5	1.75
0.4	1	1.6	1.6	0	1.8	1.8	1.2	1.2	1.8	1	1.8	1.8	1.8	2.2	1.6	2.2	1.6	2.2	1.4	1.2	1.4	1.4	2
0.6	1.2	1.4	1.2	1.6	0	2.75	2.5	2.75	1.75	2.25	1.5	1	1	2	2	2.25	1	1.25	1.75	1.25	2.5	2.75	1.75
1	1.2	2.6	2	1	0.8	0	2.2	2.4	2.6	1.6	1.8	2	2	2.6	2	1.6	2.2	2.4	2.2	2.4	2.6	2.6	2.8
1.6	1.2	1.8	1.4	1.2	1.8	1.4	0	2.2	2.4	2.2	2	2.4	2	2.4	2.6	2.2	1.4	3.2	2.6	1.8	2.2	2	2.6
1.6	1.4	1.4	1	0.6	1.4	2	1.75	0	1.5	2.6	1.6	1.8	2	2.2	1.4	1.4	2	2	1.8	2	1.8	1.8	2.4
1	0.75	1.8	1.8	0.8	1.4	1.8	0.75	1.2	0	2	1.6	2.2	1.6	1.8	2.4	2.4	1.6	1.8	2.4	2.4	3	0.6	1.6
0.6	1.6	1.6	1.8	1.6	1.4	2.2	2.5	1.6	2.8	0	2.6	2.6	2	2.2	1.6	1.4	2.2	2.8	2.4	3	2.6	1.8	2.4
1.8	2.2	1.8	1.4	1.4	1.8	2	1.75	1.6	2.6	2.2	0	2.2	2.8	1.6	2.2	1.4	1.8	2.8	2.4	2.4	2.8	2	1.8
1	1.6	1.6	1.4	1.2	2.4	2.2	1.75	1.4	2	2.4	2	0	2.4	1.8	2.2	1.4	1.4	2.6	2	2.6	2.6	1.6	1.6
1.8	1.4	0.8	1.2	1.2	1.4	1.4	2	1.4	2.4	1.8	2.2	2.2	0	2.2	2	1.4	2	2.4	2.6	2.4	2.6	1.8	2.6
0.8	1.2	1.2	1.8	1	1.4	1.8	0.75	0.6	2.2	1.4	1.8	2.4	2.4	0	1.6	1.2	1.6	2	1.6	1.2	2	1.2	1.2
1	0.8	1.6	2	1.2	2	2	1	0.8	2.6	2	2.6	2.6	2.4	1.8	0	2.2	1.8	2.2	2.2	2.4	3.2	1.8	1.8
1.4	0.8	1.6	1	1.2	1.2	1.4	2	1.8	1.4	2.2	2	1.4	1.2	1.2	2.4	0	1.8	1.4	1.2	1.8	2.4	2.2	1.8
0.8	1.75	1.75	2.25	1.5	1.25	0.5	1.75	1	2	1.25	1.25	2	1.75	1	1.5	1.5	0	1.4	2	1.2	2	1.4	1.4
1	1.2	1.6	1.6	1.8	2	2.2	2	1.4	2.4	2.2	1.8	1.6	2.4	1.4	1.8	1.25	3	0	2	2.8	2	2	3
1	1	1	1	0.8	1.2	1.8	2	1.6	1.6	1.2	2	1.6	1	1.6	1.2	1.4	1.8	2	0	1.4	3	1.8	2.4
1.6	1.8	2	1.8	2	2.2	2.2	2.2	1.8	2.6	2.4	1.8	2	2	1.6	2.6	2	1.4	2	1.4	0	3	2.4	2.6
1.2	1.4	1.8	1	1.4	2	1.4	1.2	1.2	2.2	1.6	2.4	1.8	2.4	2	1.8	1.8	2.2	1.8	1.6	2.4	0	1.6	3.2

1	0.8	2	1.6	1	2.4	1.6	1.8	1	2.4	1.8	2.4	1.6	2.2	2.2	2.2	1.6	1.4	2.2	2.2	2.6	2	0	2.4
1.2	1.2	1.6	1.6	1.8	1.8	1.2	1.6	1.4	2	2	1.6	1.8	2	2.2	2.6	1.8	1.2	2.6	2	2.8	2.4	2.2	0

Step 2. S= max (sum of rows, sum of columns) = max (53.2, 54.75) = 54.75, 1/S = 0.018

Step 3. Normalized Initial Direct Relation Matrix X= Z/S

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
00	46	41	41	41	46	46	37	27	32	46	46	46	41	50	46	32	37	55	55	46	41	50	55
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	00	26	29	37	15	26	26	29	37	33	15	18	29	33	37	33	26	29	18	22	29	33	26
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	44	00	15	37	33	18	33	22	37	18	22	18	37	26	33	33	26	37	26	37	37	22	40
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	37	26	00	23	37	18	37	23	37	41	37	41	37	41	18	37	23	32	27	37	23	27	32
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
07	18	29	29	00	33	33	22	22	33	18	33	33	33	40	29	40	29	40	26	22	26	26	37
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	22	26	22	29	00	50	46	50	32	41	27	18	18	37	37	41	18	23	32	23	46	50	32
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	22	47	37	18	15	00	40	44	47	29	33	37	37	47	37	29	40	44	40	44	47	47	51
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	22	33	26	22	33	26	00	40	44	40	37	44	37	44	47	40	26	58	47	33	40	37	47
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	26	26	18	11	26	37	32	00	27	47	29	33	37	40	26	26	37	37	33	37	33	33	44
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	14	33	33	15	26	33	14	22	00	37	29	40	29	33	44	44	29	33	44	44	55	11	29
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	29	29	33	29	26	40	46	29	51	00	47	47	37	40	29	26	40	51	44	55	47	33	44
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	40	33	26	26	33	37	32	29	47	40	00	40	51	29	40	26	33	51	44	44	51	37	33
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	29	29	26	22	44	40	32	26	37	44	37	00	44	33	40	26	26	47	37	47	47	29	29

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	26	15	22	22	26	26	37	26	44	33	40	40	00	40	37	26	37	44	47	44	47	33	47
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	22	22	33	18	26	33	14	11	40	26	33	44	44	00	29	22	29	37	29	22	37	22	22
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	15	29	37	22	37	37	18	15	47	37	47	47	44	33	00	40	33	40	40	44	58	33	33
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	15	29	18	22	22	26	37	33	26	40	37	26	22	22	44	00	33	26	22	33	44	40	33
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	32	32	41	27	23	09	32	18	37	23	23	37	32	18	27	27	00	26	37	22	37	26	26
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	22	29	29	33	37	40	37	26	44	40	33	29	44	26	33	23	55	00	37	51	37	37	55
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	18	18	18	15	22	33	37	29	29	22	37	29	18	29	22	26	33	37	00	26	55	33	44
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	33	37	33	37	40	40	40	33	47	44	33	37	37	29	47	37	26	37	26	00	55	44	47
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	26	33	18	26	37	26	22	22	40	29	44	33	44	37	33	33	40	33	29	44	00	29	58
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	15	37	29	18	44	29	33	18	44	33	44	29	40	40	40	29	26	40	40	47	37	00	44
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	22	29	29	33	33	22	29	26	37	37	29	33	37	40	47	33	22	47	37	51	44	40	00

Step 4. Total Relation Matrix, T

0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.2
80	45	57	50	40	66	68	60	33	86	80	80	81	82	85	85	55	60	06	92	95	08	80	08
0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
72	63	99	98	98	91	03	03	95	33	18	01	05	18	18	24	10	04	25	06	17	34	14	23
0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
64	08	77	87	01	12	00	13	92	37	08	11	08	29	15	26	14	07	36	17	34	46	08	41
0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
71	07	08	78	93	22	06	24	98	45	37	31	37	36	36	18	23	10	40	26	42	41	19	40
0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
60	84	06	01	65	12	13	03	91	34	08	21	22	25	29	22	21	11	40	17	21	36	11	37

0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
70	95	12	02	01	89	40	36	27	45	40	28	19	23	37	39	31	10	36	34	34	68	45	46
0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
87	07	46	29	03	19	05	44	32	77	45	48	53	57	62	56	34	45	73	58	72	89	57	82
0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
97	07	33	19	07	37	32	07	30	74	56	53	60	57	59	67	45	32	88	66	62	83	48	79
0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
87	99	11	99	84	14	26	23	78	40	46	29	33	40	39	29	16	27	49	35	47	55	28	57
0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
75	86	16	10	86	12	20	03	97	10	33	26	37	30	29	43	31	18	41	42	50	73	05	40
0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
81	16	31	27	15	31	46	52	21	83	19	64	65	59	57	51	33	47	83	64	84	92	45	77
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
01	25	33	20	11	37	43	38	20	79	56	18	57	72	46	61	32	40	82	63	73	94	48	67
0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
82	09	22	13	01	40	38	31	10	59	51	44	10	56	41	52	24	25	68	47	67	80	34	53
0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
96	05	09	10	01	23	25	34	10	66	41	48	49	14	48	49	24	35	65	58	63	81	37	70
0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
65	85	96	02	81	02	11	93	78	37	12	19	30	33	87	18	00	08	33	18	18	42	04	20
0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
83	96	24	24	02	35	36	19	01	71	46	57	57	58	42	15	39	33	63	52	65	93	38	58
0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
80	84	10	94	90	06	10	21	05	31	33	30	20	20	16	40	86	18	31	18	36	58	29	39
0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1
65	94	04	08	89	99	87	09	84	32	08	08	21	20	04	15	05	78	21	23	16	40	06	22
0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
84	04	25	19	13	35	40	37	12	69	50	43	41	58	37	48	24	54	26	50	73	73	43	80
0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1
71	84	96	90	80	02	13	17	98	30	11	25	19	12	19	15	07	14	37	92	25	63	18	45
0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
98	19	38	28	22	46	47	47	25	80	61	51	55	59	48	69	44	34	70	47	33	99	57	82
0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
83	02	22	02	01	28	19	16	02	57	32	46	37	50	39	40	27	34	49	35	58	29	29	74
0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
81	93	27	14	96	38	26	29	01	63	39	49	36	50	46	50	26	23	59	49	64	68	03	64

0.0 84	0.1 00	0.1 21	0.1 15	0.1 10	0.1 28	0.1 20	0.1 26	0.1 08	0.1 57	0.1 43	0.1 36	0.1 40	0.1 47	0.1 46	0.1 57	0.1 30	0.1 20	0.1 66	0.1 45	0.1 68	0.1 75	0.1 42	0.1 23

Step 5. Total Cause and Effect for barriers

	D-E	D+E
a2	2.163	6.001
a14	0.154	4.986
a15	-0.134	5.516
a16	0.248	5.528
a17	0.299	5.081
a21	0.082	5.931
a23	0.504	6.451
a24	0.513	6.484
a25	0.443	5.539
a26	-0.782	6.608
a27	0.270	6.813
a28	0.252	6.779
a29	-0.034	6.550
a30	-0.141	6.665
a31	-0.694	5.879
a32	-0.079	6.695
a34	-0.180	5.786
a36	-0.430	5.542
a37	-0.349	7.024
a38	-0.669	6.037
a39	-0.055	7.179
a42	-0.909	7.130
a50	0.0471	6.344
a53	-0.520	6.934

Threshold value (average of Matrix T), $\partial = 0.129$

Step 6. Inner Dependence Matrix

a2	a14	a15	a16	a17	a21	a23	a24	a25	a26	a27	a28	a29	a30	a31	a32	a34	a36	a37	a38	a39	a42	a50	a53
	0.1	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.2**	**0.1**	**0.1**	**0.2**	**0.1**	**0.2**
	45	**57**	**50**	**40**	**66**	**68**	**60**	**33**	**86**	**80**	**80**	**81**	**82**	**85**	**85**	**55**	**60**	**06**	**92**	**95**	**08**	**80**	**08**
									0.1												**0.1**		
									33												**34**		
									0.1									**0.1**		**0.1**	**0.1**		**0.1**
									37									**36**		**34**	**46**		**41**
									0.1	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**				**0.1**		**0.1**	**0.1**		**0.1**
									45	**37**	**31**	**37**	**36**	**36**				**40**		**42**	**41**		**40**
									0.1									**0.1**			**0.1**		**0.1**
									34									**40**			**36**		**37**
						0.1	**0.1**		**0.1**	**0.1**				**0.1**	**0.1**	**0.1**		**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
						40	**36**		**45**	**40**				**37**	**39**	**31**		**36**	**34**	**34**	**68**	**45**	**46**
		0.1					**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
		46					**44**	**32**	**77**	**45**	**48**	**53**	**57**	**62**	**56**	**34**	**45**	**73**	**58**	**72**	**89**	**57**	**82**
		0.1			**0.1**	**0.1**		**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
		33			**37**	**32**		**30**	**74**	**56**	**53**	**60**	**57**	**59**	**67**	**45**	**32**	**88**	**66**	**62**	**83**	**48**	**79**
									0.1	**0.1**		**0.1**	**0.1**	**0.1**				**0.1**	**0.1**	**0.1**	**0.1**		**0.1**
									40	**46**		**33**	**40**	**39**				**49**	**35**	**47**	**55**		**57**
										0.1		**0.1**	**0.1**		**0.1**	**0.1**		**0.1**	**0.1**	**0.1**	**0.1**		**0.1**
										33		**37**	**30**		**43**	**31**		**41**	**42**	**50**	**73**		**40**
		0.1			**0.1**	**0.1**	**0.1**		**0.1**		**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
		31			**31**	**46**	**52**		**83**		**64**	**65**	**59**	**57**	**51**	**33**	**47**	**83**	**64**	**84**	**92**	**45**	**77**
		0.1			**0.1**	**0.1**	**0.1**		**0.1**	**0.1**		**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
		33			**37**	**43**	**38**		**79**	**56**		**57**	**72**	**46**	**61**	**32**	**40**	**82**	**63**	**73**	**94**	**48**	**67**
					0.1	**0.1**	**0.1**		**0.1**	**0.1**	**0.1**		**0.1**	**0.1**	**0.1**			**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
					40	**38**	**31**		**59**	**51**	**44**		**56**	**41**	**52**			**68**	**47**	**67**	**80**	**34**	**53**
							0.1		**0.1**	**0.1**	**0.1**	**0.1**		**0.1**	**0.1**		**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
							34		**66**	**41**	**48**	**49**		**48**	**49**		**35**	**65**	**58**	**63**	**81**	**37**	**70**
									0.1			**0.1**	**0.1**					**0.1**			**0.1**		
									37			**30**	**33**					**33**			**42**		
					0.1	**0.1**			**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**		**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
					35	**36**			**71**	**46**	**57**	**57**	**58**	**42**		**39**	**33**	**63**	**52**	**65**	**93**	**38**	**58**
									0.1	**0.1**	**0.1**				**0.1**			**0.1**		**0.1**	**0.1**		**0.1**
									31	**33**	**30**				**40**			**31**		**36**	**58**		**39**

				0.1													0.1		
				32													40		
		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		0.1		0.1	0.1	0.1	0.1	0.1
		35	40	37	69	50	43	41	58	37	48		54		50	73	73	43	80
					0.1									0.1			0.1		0.1
					30									37			63		45
0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
38		46	47	47	80	61	51	55	59	48	69	44	34	70	47	33	99	57	82
					0.1	0.1	0.1	0.1	0.1	0.1	0.1		0.1	0.1	0.1	0.1			0.1
					57	32	46	37	50	39	40		34	49	35	58			74
		0.1			0.1	0.1	0.1	0.1	0.1	0.1	0.1			0.1	0.1	0.1	0.1		0.1
		38			63	39	49	36	50	46	50			59	49	64	68		64
					0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		0.1	0.1	0.1	0.1	0.1	
					57	43	36	40	47	46	57	30		66	45	68	75	42	

DEMATEL Calculations for Matrix 8

Step 1. Average Matrix, Z

0	2.5	2.5	2.25	1.75	2	2.5
1	0	2.6	1.6	2.2	2.4	1.6
1.6	2.2	0	1.6	2	2.4	2
2	1.2	2	0	1.4	1.6	1.4
1.8	1.6	1.6	2.2	0	2.2	1.4
1.4	2.2	2	1.8	2.4	0	1.2
2	1.6	1.4	1.4	1.6	1.8	0

Step 2. S= max (sum of rows, sum of columns) = max (13.5, 12.4) = 13.5, 1/S = 0.074

Step 3. Normalized Initial Direct Relation Matrix, X= Z/S

0	0.185	0.185	0.166	0.129	0.148	0.185
0.074	0	0.192	0.118	0.162	0.177	0.118
0.118	0.162	0	0.118	0.148	0.177	0.148
0.148	0.088	0.148	0	0.103	0.118	0.103
0.133	0.118	0.118	0.162	0	0.162	0.103
0.103	0.162	0.148	0.133	0.177	0	0.088
0.148	0.118	0.103	0.103	0.118	0.133	0

Step 4. Total Relation Matrix, T

0.593	0.835	0.876	0.793	0.799	0.866	0.766
0.579	0.582	0.778	0.665	0.731	0.787	0.625
0.631	0.743	0.638	0.684	0.739	0.807	0.667
0.574	0.591	0.667	0.488	0.606	0.657	0.550
0.605	0.663	0.697	0.677	0.563	0.745	0.592
0.589	0.706	0.730	0.663	0.726	0.618	0.589
0.580	0.622	0.641	0.590	0.626	0.677	0.462

Step 5. Total Cause and Effect for Barriers

	a22	a23	a25	a34	a35	a39	a54
D-E	1.376	0.006	-0.117	-0.429	-0.246	-0.537	-0.052
D+E	9.685	9.496	9.941	8.700	9.338	9.784	8.456

Threshold value (average of Matrix T), $\partial = 0.667$

Step 6. Inner Dependency Matrix

a22	a23	a25	a34	a35	a39	a54
	0.835	**0.876**	**0.793**	**0.799**	**0.866**	**0.766**
		0.778		**0.731**	**0.787**	
	0.743		**0.684**	**0.739**	**0.807**	
		0.697	**0.677**		**0.745**	
	0.706	**0.730**		**0.726**		
					0.677	

DEMATEL Calculations for Matrix 9

Step 1. Average Matrix, Z

0	1.6	2.8	2.2	1.8	2.6	1.8	2.2
2	0	2.4	2.8	1.4	2.8	1.8	2.4
2	2	0	0.8	0.6	2.2	1.6	2.8
1.8	1.6	2.2	0	1.8	1.2	1.2	1.6
1.5	1.25	1.75	1.5	0	1.4	1.2	0.8
2	2	2.2	1.4	2.4	0	2.2	2.2
1.4	1.4	2.4	2	1.8	1.8	0	1.4
1.2	1	2	1.6	1.8	2.2	2	0

Step 2. S= max (sum of rows, sum of columns) = max (15.75, 15.6) = 15.75, 1/S = 0.063

Step 3. Normalized Initial Direct Relation Matrix, X= Z/S

0	0.101	0.177	0.139	0.114	0.165	0.114	0.139
0.126	0	0.152	0.177	0.088	0.177	0.114	0.152
0.126	0.126	0	0.050	0.038	0.139	0.101	0.177
0.114	0.101	0.139	0	0.114	0.076	0.076	0.101
0.095	0.079	0.111	0.095	0	0.088	0.076	0.050
0.126	0.126	0.139	0.088	0.152	0	0.139	0.139
0.088	0.088	0.152	0.126	0.114	0.114	0	0.088
0.076	0.063	0.126	0.101	0.114	0.139	0.126	0

Step 4. Total Relation Matrix, T

0.412	0.468	0.685	0.527	0.472	0.588	0.512	0.598
0.545	0.394	0.688	0.577	0.471	0.618	0.531	0.629
0.458	0.431	0.452	0.395	0.358	0.507	0.444	0.556
0.421	0.383	0.538	0.316	0.391	0.422	0.389	0.461
0.362	0.326	0.453	0.355	0.246	0.377	0.341	0.364
0.501	0.467	0.629	0.470	0.488	0.425	0.509	0.568
0.422	0.393	0.570	0.446	0.407	0.469	0.335	0.472
0.397	0.359	0.535	0.413	0.400	0.476	0.438	0.374

Step 5. Total cause and effect for barriers

	a10	a11	a33	a34	a36	a37	a44	a48
D-E	0.745	1.232	-0.952	-0.177	-0.408	0.176	0.015	-0.630
D+E	7.786	7.682	8.158	6.826	6.067	7.948	7.021	7.421

Threshold value (average of Matrix T), $\partial = 0.460$

Step 6. Inner Dependency Matrix

a10	a11	a33	a34	a36	a37	a44	a48
	0.468	**0.685**	**0.527**	**0.472**	**0.589**	**0.512**	**0.599**
0.545		**0.689**	**0.577**	**0.471**	**0.619**	**0.531**	**0.630**
					0.507		**0.556**
		0.539					**0.461**
0.501	**0.468**	**0.629**	**0.471**	**0.489**		**0.510**	**0.568**
		0.571			**0.470**		**0.473**
		0.536			**0.476**		