

Implementation of the Sustainable Green Supply Chain Management in Hydraulic Fitting Solution Using ISM Method

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Abstract- Since last few years, Green Supply Chain Management (GSCM) has been gaining more popularity in industries and academia. It is an emerged and imperative research area for researchers and Supply Chain (SC) practitioners. As customers are becoming more environmental conscious and governments are making stricter environmental regulations, the industries need to reduce the environmental impact of their supply chain and the requirement of GSC increased. GSCM includes of the manufacturing process that minimizes waste and pollution. It also integrates environmental thinking into supply chain management; from conceptual product design to the delivery of final product to the customers, and also involves end-of-life management. GSCM implementation is supported by few factors which are known as GSCM drivers. These drivers could assist in adoption of Green supply chain management. The aim of this paper The key purpose of this study is to identified the GSCM drivers which affecting the implementation of the sustainable GSCM in Indian industries and to determine the relationship among the drivers. This study is also helpful in understanding mutual influences of drivers, and to identify the most significant drivers from the driver's list with the help of Interpretive Structural Modelling (ISM) technique. The classification of these drivers depending upon their driving and dependency power. In this study, drivers were identified by intensive literature survey. This study may play vital role to understand contextual relationships among the factors to implement GSCM in Indian manufacturing industry.

Keywords- Green Supply Chain Management, Interpretive Structural Modelling.

I. INTRODUCTION

Green Supply Chain Management has its roots from Green management and supply chain management. Srivastva (2007) defined Green supply chain management as "integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life". This indicates that the environmental aspects are considered in every process of the product life cycle. Johansson and Winroth (2009) stated that Green supply chain aims for continuous improvements of industrial processes and products to reduce or prevent pollution to air, water and land. They also suggested that by these improvements, there is possibility of minimizing risks to humans and other

species. There are some challenges that has been pointed out by Richards (1994) in associating with the Green manufacturing which are meeting the customer demands for environmentally sound products, development of recycling schemes, minimizing the materials use, and selecting the materials causing low environmental impacts.

Adding the concept of green to the supply chain invokes the consideration of natural environment in to the process. Similar to the supply chain, the green supply chain has its boundary and scope ranging from green procurement to integrated green supply chain to green distribution flowing from supplier to manufacturer to customer. Zhu and Sarkis (2004) even included the concept Reverse Logistics (RL) in to the Green Supply Chain Management.

Green Supply Chain Management is a broad term in which all the industries work with their suppliers and customers to improve their environmental performance. These environmental performances can be practiced by different focuses (Green Business Network, 2001). Focus on reducing or eliminating the excess materials used in the manufacturing processes or products.

- Focus on the supplier's environmental compliance status during the operations.
- Joint venture for developing the new materials, products and solutions for environmental issues.
- Requiring suppliers to implement and possibly certify environmental management systems.
- Educating the suppliers regarding the material use, prevention of pollution and tools of interest to the customer company.
- Refining the suppliers would help in developing new materials, parts and process with environmental concern.
- Auditing suppliers' compliance status.

Motives for green supply chain management

The Green supply chain is emerged as a response for long term trends in manufacturing industries. In the early 20th

century the manufacturing industries are characterized by consolidation of vertical integration i.e. the major components for the product is manufactured and assembled within the industry. In the later part of the 20th century it is characterized by outsourcing functions were the industries made to be more dependent on their suppliers for good and needed quality, promptly delivery of goods and to make the product in competitive prices. So the supplier's environmental impact can affect the any of those elements, so it is demanded that the suppliers should practice the green supply chain to help the organization to overcome the environmental challenges (Green Business Network, 2001). The green supply chain can be practiced in organization through several internal and external drivers. New Zealand Business Council for Sustainable Development (NZBCSD) as described in their practical guide for Business Guide to a Sustainable supply chain (2003) is that the supply chain is mainly focused on three areas as central:

- *Improving the performance of business's own operations.*
- *Ensuring that the goods and services provided by suppliers are sustainable and working with the suppliers increases the efficiency and competitiveness.*
- *Working effectively with customers and sales channel to design sustainable products and services.*

On against the backdrop of these general trends the companies mainly rely on the motivation factors which are classified as internal and external motivations. The primary motivations explained in the Green Business Network (2001) are risk management,, regulatory stance , enhanced brand image, international purchasing restrictions and customer pressure.

Table.I - Motivations for GSCM (Green Business Network 2001)

Primary motivations	
Internal motivations and possible effects	External motivations and possible effects
Risk management <ul style="list-style-type: none"> • Supply interruption • Long term risk to human and environment • Competitive disadvantage 	Enhanced brand image <ul style="list-style-type: none"> • Corporate culture of forecasting trends and moving proactively • Potential for harm to public image for environmental concern.
Regulatory stance <ul style="list-style-type: none"> • Desire to go beyond compliance • Suppliers knowingly or unknowingly provide problematic substances • Supplier non-compliance poses production risk 	International purchasing restrictions <ul style="list-style-type: none"> • Eco-labeling and product take back gaining momentum • May drive the creation of system for collection • Frequently focused on high-profile brands transport, disassembly or recycling
	Customer pressure <ul style="list-style-type: none"> • Often appear in conjunction with a threat to brand image • Regularly focusing on high-profile brands
Secondary motivations	
Cost reduction as suppliers apply pollution prevention	Increased innovation <ul style="list-style-type: none"> • Can result from supplier participation in new product development
Enhanced quality	

II. GREEN SUPPLY CHAIN MANAGEMENT THROUGHOUT THE PRODUCT LIFE CYCLE

According to Wang et al, (2003) Green supply chain is an effective way for manufacturers to manage the environmental strategies. The basic principle of Green supply chain management is to incorporate the concept of green into their product life cycle. Designing a supply chain concurrently with the product is a supply chain best practice and the supply chain would be made more eco friendly by implementing the concept of green in each process of their supply chain. Srivastva (2007) has review and through industry interaction.

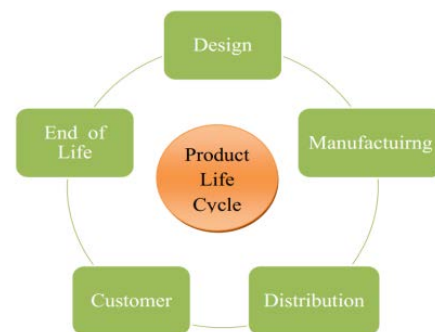


Fig. 1 Product Life Cycle classified the GSCM in three broad categories which are green design, green operations and green manufacturing.

III. PROBLEM DESCRIPTION

The Indian company under study is a firm that produces aluminium products in India. The company produces aluminium sheets, circles and kitchenware products such as aluminium, frying pans, pressure cookers, sauce pots and saucepans. The firm is well-known in India as a pressure cooker manufacturer and a supplier of aluminium. The manufactured product is distributed in and around the state and to other states through hantet work of distributors. Due to environment all the company is planning to implement green supply chain concept. Choosing the drivers that are important to implementing green supply chain management practices involves a literature review and a decision-making team which includes experts from the industry.

IV. OBJECTIVE OF THE STUDY

- To Identified the GSCM drivers.
- To determine the relationship among the drivers.
- To understand the mutual influences of drivers.
- To separate the drivers according to their priorities.
- To develop the ISM model for factors important to implement GSCM.

V. SOLUTION METHODOLOGY

Identification of the various drivers involved in the implementation of green SCM under study. The various drivers important to the implementation of GSCM practices were identified based on questionnaire for Vedika Hydraulic Fitting Solution.

- i. *How many employees work within your organization? What is the annual sales revenue per year? How many supplier do you have?*
- ii. *How would you describe the general attitude of your organization towards green supply chain management practices? Are you certified by ISO 14001, EMAS, etc.?*
- iii. *Who is responsible for environmental issues within your organization? (e.g. Specific department)*
- iv. *What is your organization's overall objective in the handling of environmental issues?*
- v. *Does your organization publicize or market your environmental performances? If so how?*
- vi. *How would you describe the attitude of your organization towards environmental legislation?*
- vii. *What was your role within the green supply chain management project?*
- viii. *What were the driving forces behind the project? (e.g. legislative compliance, costs, reputation, market expectations, move towards sustainability, etc.)*
- ix. *In terms of management level (top, middle, lower, purchasing) who initiated and who supported the project?*
- x. *What was the perception of the top-management about the project?*

- xi. *What other departments (functional) areas were involved?*
- xii. *How did other departments (functional areas) help you to implement the green supply chain management practice?*

The responses from the participants are summarized in Table. In this study we asked above questions to employees and find out some drives for implementation of green supply china management. We have selected these drivers those got above 75% Yes. Further these drivers were used for this study.

<i>Drivers</i>	<i>Yes</i>	<i>No</i>
Environmental collaboration with suppliers	96.75%	3.25%
Collaboration between suppliers and designers to eliminate or reduce the environmental effects	93.75%	6.25%
Legislation and regulation of Government	95.27%	4.75%
Green design	95.27%	4.75%
Certification (ISO)	93.75%	6.25%
Motivation by organization sales network	85.25%	14.75%
Commitment of top management	85.25%	14.75%
Effective advertisement and marketing campaign towards green	93.75%	6.25%
Effective Information Technology communication	93.75%	6.25%
Environment-friendly distribution	95.27%	4.75%
Green labeling and use of green packing material	95.27%	4.75%
Recycling and reuse	93.75%	6.25%
Customer's Awareness level	85.25%	14.75%
Customer's support and encouragement	85.25%	14.75%
Effective training program schedule for customers	93.75%	6.25%
Eco Labeling of Product	43.75%	56.25%
Evaluation of Green Performance	37.50%	62.50%
Evaluation of Green Effectiveness	37.50%	62.50%
Priority of Green supply chain management In Budgeting Consideration	43.7%	56.3%

Table-1 Drivers of Green SCM.

Drivers	Source
1. Environmental collaboration with suppliers	Zhu and Sarkis, Zhu et al., Lippmann , Yuang and Kielkiewicz-Yuang, Klassen and Vachon, Lippman, Hu and Hsu, Vachon and Holt and Ghobadian
2. Collaboration between suppliers and designers to eliminate or reduce the environmental effects	Zhu and Sarkis, Zhu et al., Lippmann, Yuang and Kielkiewicz-Yuang, Klassen and Vachon, Lippman
3. Legislation and regulation of Government	Green et al., Walton et al., Beamon, Hall, Min and Galle and Walker et al.
4. Green design	Zhu et al., Hu and Hsu, Routroy and Zhu and Sarkis
5. Certification (ISO)	Zhu and Sarkis, Zhu et al., Rao and Holt, Hu and Hsu, Vachon and Holt and Ghobadian
6. Motivation by organization sales network	Ilgin and Gupta, Ravi and Shankar, Sarkis et. al., Singh and Kant, Yu, 2007; Yu and Hui,
7. Commitment of top management	Digalwar and Metri, Hamel and Prahalad, Mudgal et. al., Mudgal et. al., Ravi and Shankar
8. Effective advertisement and marketing campaign towards green	Luthra et al.
9. Effective Information Technology communication	Alemayehu, McLaren et. al., Ravi and Shankar, Rogers and R.S, Sarkis et. al., Yu, Yu and Hui,
10. Environment-friendly distribution	Ilgin and Gupta; Srivastva
11. Green labeling and use of green packing material	Sarkis; Min and Galle.
12. Recycling and reuse	Rao and Holt, Holt and Ghobadian, Paulraj, and Vachon
13. Customer's Awareness level	Green et al., Alhola, Zhu et al.
14. Customer's support and encouragement	Reijonen, Lamming and Hamapson; Chien and Shih, Rao and Holt
15. Effective training program schedule for customers	Ravi and Shankar; Sarkis et al. ; Wu et al.

Table 2 Structural self-interaction matrix for the drivers

Drivers	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
1. Environmental collaboration with suppliers	O	O	O	V	A	V	O	X	O	A	V	V	A	X	-
2. Collaboration between suppliers and designers to eliminate or reduce the environmental effects	O	O	A	V	V	V	O	A	O	X	A	V	A	-	
3. Legislation and regulation of Government	V	V	V	V	V	V	V	V	V	V	V	V	-		
4. Green design	O	A	A	X	X	X	O	A	A	A	X	-			
5. Certification (ISO)	O	A	O	A	A	X	A	A	V	X	-				
6. Motivation by organization sales network	V	X	V	A	A	V	X	A	V	-					
7. Commitment of top management	O	A	O	V	V	V	V	V	-						
8. Effective advertisement and marketing campaign towards green	V	X	V	A	X	X	A	-							
9. Effective Information Technology communication	O	V	V	O	O	V	-								
10. Environment-friendly distribution	A	A	A	A	A	-									
11. Green labeling and use of green packing material	O	A	O	V	-										
12. Recycling and reuse	A	A	A	-											
13. Customer's Awareness level	A	A	-												
14. Customer's support and encouragement	A	-													
15. Effective training program schedule for customers	-														

Step 1: The drivers affecting the implementation of green SCM for the firm under study are listed.

Step 2: For each pair of drivers identified in Step 1, a contextual relationship is established.

Step 3: A Structural Self-Interaction Matrix (SSIM) is developed, which indicates pairwise relationships among drivers of the system under consideration.

Step 4: A reachability matrix is developed from the SSIM and the matrix is checked for transitivity. The transitivity rule states that if a variable 'A' is related to 'B' and 'B' is related to 'C', then 'A' is necessarily related to 'C'.

Step 5: The reachability matrix obtained in Step 4 is partitioned into different levels.

Step 6: Based on the relationships given above in the reachability matrix, a directed graph is drawn and the transitive links are removed.

Step 7: The resulting digraph is converted into an ISM by replacing the variable nodes with statements.

Step 8: The ISM model developed in Step 7 is reviewed to check for conceptual inconsistencies, and necessary modifications are made.

Development of Structural Self-Interaction Matrix (SSIM)

Based on contextual relationship among identified drivers, a Structural Self-Interaction Matrix (SSIM) was developed (Table 1). This matrix indicates the pairwise relationships among the drivers affecting the implementation of green SCM initiatives for the firm under consideration.

The symbols used to denote the direction of the relationship between the drivers are given below.

V – Driver i will help to achieve Driver j;

A – Driver j will help to achieve Driver i;

X – Drivers i and j will help to achieve each other; and

O – Drivers i and j are unrelated.

Reachability Matrix

We derived the reachability matrix from the structural selfinteraction matrix (SSIM) developed in the previous step. The initial reachability matrix is constructed from the structural selfinteraction matrix (SSIM) using the following rules:

If the (i, j) entry in the SSIM is V, the (i, j) entry in the reachability matrix is set to 1 and the (j, i) entry is set to 0.

- If the (i, j) entry in the SSIM is A, the (i, j) entry in the reachability matrix is set to 0 and the (j, i) entry is set to 1.
- If the (i, j) entry in the SSIM is X, the (i, j) entry in the reachability matrix is set to 1 and the (j, i) entry is set to 1.
- If the (i, j) entry in the SSIM is O, the (i, j) entry in the reachability matrix is set to 0 and the (j, i) entry is set to 0.

Table 3 Reachability Matrix

Drivers	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
1. Environmental collaboration with suppliers	0	0	0	1	0	1	0	1	0	0	1	1	0	1	1
2. Collaboration between suppliers and designers to eliminate or reduce the environmental effects	0	0	0	1	1	1	0	0	0	1	0	1	0	1	1
3. Legislation and regulation of Government	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4. Green design	0	0	0	1	1	1	0	0	0	0	1	1	0	0	0
5. Certification (ISO)	0	0	0	0	0	1	0	0	1	1	1	1	0	1	0
6. Motivation by organization sales network	1	1	1	0	0	1	1	0	1	1	1	1	0	1	1
7. Commitment of top management	0	0	0	1	1	1	1	1	1	0	0	1	0	0	0
8. Effective advertisement and marketing campaign towards green	1	1	1	0	1	1	0	1	0	1	1	1	0	1	1
9. Effective Information Technology communication	0	1	1	0	0	1	1	1	0	1	1	0	0	0	0
10. Environment-friendly distribution	0	0	0	0	0	1	0	1	0	0	1	1	0	0	0
11. Green labeling and use of green packing material	0	0	0	1	1	1	0	1	0	1	1	1	0	0	1
12. Recycling and reuse	0	0	0	1	0	1	0	1	0	1	1	1	0	0	0
13. Customer's Awareness level	0	0	1	1	0	1	0	0	0	0	0	1	0	1	0
14. Customer's support and encouragement	0	1	1	1	1	1	0	1	1	1	1	1	0	0	0
15. Effective training program schedule for customers	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0

Table 4 Final reachability matrix for the drivers.

Drivers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Driver power
1	1	1	0	1	1	0	0	1	0	1	0	1	0	0	0	7
2	1	1	0	1	0	1	0	0	0	1	1	1	0	0	0	7
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
4	0	0	0	1	1	0	0	0	0	1	1	1	0	0	0	5
5	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	6
6	1	1	0	1	1	1	1	0	1	1	0	0	1	1	1	11
7	0	0	0	1	0	0	1	1	1	1	1	1	0	0	0	7
8	1	1	0	1	1	1	0	1	0	1	1	0	1	1	1	11
9	0	0	0	0	1	1	0	1	1	1	0	0	1	1	0	7
10	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0	4
11	1	0	0	1	1	1	0	1	0	1	1	1	0	0	0	8
12	0	0	0	1	1	1	0	1	0	1	0	1	0	0	0	6
13	0	1	0	1	0	0	0	0	0	1	0	1	1	0	0	5
14	0	0	0	1	1	1	1	1	0	1	1	1	1	1	0	10
15	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	5
Dependence power	6	7	1	13	11	9	5	9	4	15	7	10	7	6	4	

Level Partitions

The reachability and antecedent set for each driver were found from the final reachability matrix (Table 4). The reachability set for a individual driver consists of itself and the other drivers which it may help to achieve. The antecedent set consists of the drivers themselves and the other drivers which may help in achieving it. The intersection of both these sets was also derived for all drivers. If the reachability set and the intersection set for a given driver are the same, then that driver is considered to be in level I and is given the top position in the ISM hierarchy (Kannan and Haq, 2007). With this partition, iteration 1 is completed. After the first iteration, the drivers forming level I are discarded and with the remaining drivers, the abovementioned procedure is continued in iteration 2. These iterations are continued until the levels of each driver has been found.

Table 5 Level Partition of Drivers

Drivers	Reachability set	Antecedent set	Intersection	Level
1	1,2,4,5,8,10,12	1,2,3,6,8,11,	1,2,8	IV
2	1,2,4,6,10,11,12	1,2,3,5,6,8,13	1,2,6	IV
3	1,2,3,4,5,6,7,8,9,10,11,12.. 15	1	1	VI
4	4,5,10,11,12	1,2,3,4,5,6,7,8,10,11,12,13,14	4,5,10,11,12	I
5	2,4,5,6,7,10	1,3,5,6,8,9,10,11,12,14	5,6,10	IV
6	1,2,4,5,6,7,9,10,13,14,15	2,3,5,6,8,9,11,12,14	2,5,6,9,14	II
7	4,7,8,9,10,11,12	3,5,6,7,14	7	VI
8	1,2,4,5,6,8,10,11,13,14,15	1,3,7,8,9,10,11,12,14	1,8,10,11,14	II
9	5,6,8,9,10,13,14	3,6,7,9	6,9	V
10	4,5,8,10	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	4,5,8,10	III
11	1,4,5,6,8,10,11,12	2,3,4,7,8,11,14	4,8,11	IV
12	4,5,6,8,10,12	1,2,3,4,7,11,12,13,14,15	4,12	V
13	2,4,10,12,13	3,6,8,9,13,14,15	13	VI
14	4,5,6,7,8,10,11,12,13,14	3,6,8,9,14,15	6,8,14	IV
15	10,12,13,14,15	3,6,8,15	15	VI

V. FORMATION OF ISM MODEL

With the help of the level partition shown in Tables 5 and 6, a model of the various drivers important to implementing green SCM for the industries under this study was developed, and is shown in Fig. 2

Table 6 Level partition of drivers

Drivers	Level
1. Environmental collaboration with suppliers	IV
2. Collaboration between suppliers and designers to eliminate or reduce the environmental effects	IV
3. Legislation and regulation of Government	VI
4. Green design	I
5. Certification (ISO)	IV
6. Motivation by organization sales network	II
7. Commitment of top management	VI
8. Effective advertisement and marketing campaign towards green	II
9. Effective Information Technology communication	V
10. Environment-friendly distribution	III
11. Green labeling and use of green packing material	IV
12. Recycling and reuse	V
13. Customer's Awareness level	VI
14. Customer's support and encouragement	IV
15. Effective training program schedule for customers	VI

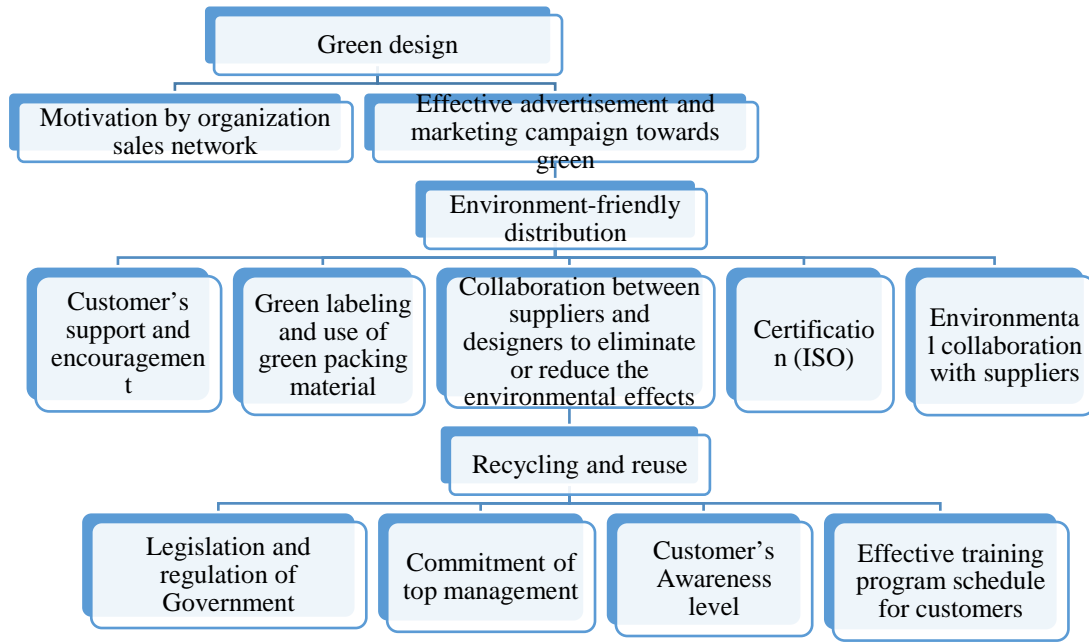


Fig. 2. ISM model for the drivers affecting the implementation of green supply chain management.

Drivers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15	3														
14															
13			Sector IV								Sector III				
12															
11									6,8						
10						14									
9															
8							11								
7				9	7	1	2			Sector II					
6		Sector I								12	5				
5				15			13						4		
4															10
3															
2															
1															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

DEPENDENCE POWER

Fig. 3. Driving Power and dependence power diagram.

VI. MICMAC ANALYSIS

In MICMAC analysis, the dependence power and driver power of the variables were analyzed. In this study, the drivers were classified into four sectors. The four sectors are autonomous, dependent, linkage, and driver/independent. In the final reachability matrix, shown in Table 4, the driving power and dependence of each of the drivers are calculated. The drivers that have weak driver power and weak dependence will fall in sector I and are called autonomous elements. Drivers that have weak driver power, but strong dependence power will fall in sector II and are called dependent elements. Drivers that have both strong driver power and dependence power will

fall in sector III and are called linkage elements. These elements are unstable due to the fact that any action on these elements will affect the others, and may also have a feedback effect on themselves. Drivers that have strong driver power but weak dependence power will fall in sector IV and are called driver/independent elements.

VII. DISCUSSION AND CONCLUSION

The drivers involved in the implementation of GSCM for the industries in this study pose considerable challenges for the management. Due to the complexity of GSCM practices, customer and cost pressures and regulation

uncertainty, implementing GSCM is considered as a thankless task that increases overall product cost (Hsu and Hu, 2008). Decision makers must be aware of the relative importance of the various drivers and the techniques for implementing them. Highlighting the 15 kinds of drivers, an ISM model was developed and the interaction between these drivers were analyzed. From Fig. 2, it is evident that legislation and regulation of Government, commitment of top management, customer's awareness level and effective training program schedule for customers are significant drivers to achieve the recycle and reuse driver, which is in turn critical to achieving the GSCM certification of suppliers' environmental management system, environmental collaboration with suppliers, ISO certification, green labeling and use of green packing material and customer's support and encouragement drivers are placed at an intermediate level of the ISM model. Motivation by organization sales network, effective advertisement and marketing campaign towards green and green design are at the top level of the ISM hierarchy. This model is based on the ISM methodology, which has its own limitations. For example the model is highly dependent on the judgements of the expert team.

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