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Green Supply Chain Practices Implementation in Indian Automobile Industry

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Abstract: *Environmental issues have drawn an attention of researchers and supply chain practitioners to manage supply chain. Eleven green supply chain practices have been identified from literature review. Questionnaire based survey has been used to indicate the significance of these practices. Interpretive Structural Modeling (ISM) methodology has been utilized for hierarchy structure of these practices. Classification of these practices depending upon their driving and dependence power has also been carried out by using MICMAC analysis. "Proper Workplace Management" has been found dependent top level practice and "Environmental Management System Implementation" has been found independent bottom level practice to implement GSCM in Indian automobile industry. This paper will help to understand contextual relationships among these practices to implement GSCM in Indian automobile industry.*

NOMENCLATURE

Green Supply Chain Management (GSCM), Green Supply Chain Practices, Indian Automobile Industry, Interpretive Structural Modeling (ISM), MICMAC Analysis

1. INTRODUCTION

In recent years the topic of Green Supply Chain Management (GSCM) has received growing attention in industry, government, peoples as well as researchers. GSCM may be defined as:

GSCM is integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing process, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life [1].

GSCM is new issue for majority of Indian companies. A growing need has been reported for integrating environmentally sound choices into supply chain management [1]. The Indian automobile industry holds a promising and challenging tenth position in the entire world with being "Number Two" in two wheelers and "Number Four" in commercial vehicles [2].

Environmental or legislative reasons have increased the requirement of GSCM in Indian Automobile industry [3]. Therefore, it has been observed important to identify various green practices to implement GSCM in Indian automobile industry. ISM has been identified as an appropriate tool to indentify the contextual relationships among these identified green practices, classify these practices depending upon their driving and dependence power and finally to develop structured model of these practices.

Organization of the paper

Green practices to implement GSCM in Indian automobile industry have been identified and described in the next section. Afterwards, methods used in the research have been explained. Thereafter, the results and discussions of this research are presented, followed by limitations and scope for future research and conclusions.

2. IDENTIFICATION OF GREEN PRACTICES TO IMPLEMENT GSCM IN INDIAN AUTOMOBILE INDUSTRY

Eleven green practices have been identified thorough extensive literature review. They are explained as follows:

Environment Management System Implementation

Environmental management system (EMS) generally consists of internal policies, assessments, plans, and implementation actions [4]. Environmental management system (EMS) ISO: 14000 Series, is a set of International standards for improving and harmonizing environmental management [5].

Innovative Green Product Development

Green products are the products that generally put less strain on the environment than conventionally manufactured goods of similar type. Green product

development addresses environmental issues through product design [5, 6]. Green Product development should focus on entire production processes not only the product. All the market externalities of product must be considered [1, 5, 7- 8].

Design for Environment (DFE)

Design for Environment (DFE) focuses on production processes that adopt environmentally friendly Specifications [9]. Green product design is a broad concept that attempts to reduce the impact of a product on the environment in a systematic and structured way. Eco-design is a systematic way to include environmental life cycle considerations in the product design. Eco-design aims at avoiding or minimizing environmental impacts of a product throughout its life cycle [10] and covers the whole product chain from materials extraction, through production processes, packaging, transport and product use phase to the end-of-life treatment [11].

End of Life Product Management

End of life product management is safe disposal of products after successful end of the life. In today's scenario, product end life management has been a major issue towards greening the supply chain [3]. Life-cycle analysis was introduced to measure environmental and resource related products to the production process [1].

Use of New Products and Process Optimization

Optimization of processes reduces air emission and noise and use cleaner technology processes making savings in term of energy and water [2]. Use and development of new environment-friendly products and processes will help in improving environmental performance [3].

Total Quality Environment Management (TQEM) Practices Implementation

TQEM is defined as application of quality management principles to those aspects of manufacturing practices and processes that affect the quality of environment. Studies suggested that the implementation of TQEM as an effective method to improve business sustainability [12-14]. GSCM and TQEM initiatives must be integrated to more effectively achieve waste and hazardous materials minimization and enhance green performance [14].

Green Procurement Strategies

Green purchasing is adding environmental aspects of price and performance criteria when making purchasing decisions. This practice involves the selection of supply chain partners (raw material, components and subassemblies suppliers) based on environmental standards and eco labels [9]. Effective and standardized purchasing management can have a significantly positive effect on business performance [15-17]. A procurement manager who wants to purchase "green" products must be able to define the Products standards for "green" products like products made with recycled content, products that are more species-friendly, products that are more energy-saving, involve less harmful effluents in the production process, or other intrinsic or extrinsic factors [18-20].

Use of Environment Friendly Packing and Labeling of Products

Environmental friendly packing refers to use of recyclable or dissolvable materials for packing. Environment friendly packing and labeling of products has a clear objective of encouraging business to market greener products [21]. Eco-labeling is a voluntary scheme designed to encourage businesses to market environmental friendly products and services [5].

Waste Management and Use of Recyclability Evaluation Methods

Waste management and Recyclability Evaluation Methods (REMs) will help in managing and minimizing waste. Various recyclability methods will help in reduction of waste and improving the environment [1, 7, 22].

Use of Lean / Flexible Manufacturing

Lean manufacturing is described as an integrated approach to the management of a manufacturing organization that encompasses a wide variety of practices, including just-in-time, quality systems, work teams, cellular manufacturing and supplier management [23]. Lean production is used for elimination of waste in each area of production [24]. Use of lean or flexible manufacturing will help in continuous improvement and elimination of waste in all forms.

Proper Workplace Management

Proper workplace management may help in managing resources in efficient and effective way. Proper workplace management is a basic measure of improving environmental performance in any organization. Usage of resources like water, air and energy can be significantly reduced through minimizing leaks and spills [5].

3. METHODS

Questionnaire based survey; ISM approach and MICMAC analysis have been utilized to achieve the objectives of this research work.

Questionnaire Based Study

Questionnaire based survey has been used to indicate the significance and ranking of these practices. In the present survey, the respondents were asked to indicate the

significance of 11 green practices on a five-point Likert scale. The questionnaire was mailed to concerned persons of Indian automobile industry. 289 questionnaires were sent. After several reminder emails in addition to some telephonic calls, 87 questionnaires were received. Ten questionnaires were incomplete and were discarded. So, only 77 questionnaires were analyzed. This gives an overall response rate of 26.64%. A study was done on green supply chain initiatives in Southern Asia and reported a response rate of 10% [25].

Interpretive Structural Modeling

Interpretive Structural Modeling was first proposed by J. Warfield [26] in 1974 to analyze the complex socioeconomic systems. Interpretive Structural Modeling (ISM) is a methodology used for indentifying contextual relationships among specific items, which define a problem or issue and first developed in the 1970's [26]. ISM generally has the following steps [26-29]:

1. Variable affecting the system is listed: In our research work, green practices to implement GSCM in Indian automobile industry have been identified as variables.
2. From the variables identified in step 1, contextual relationships among the variables are found.
3. A Structural Self-Interaction Matrix (SSIM) is developed for variables, which indicated pair wise relationships among variables of the system.
4. A reachability matrix is developed from the SSIM and the matrix is checked for transitivity. The transitivity of the contextual relation is a basic assumption made in ISM. It states that if a variable A is related to variable B and variable B is related to variable C, then variable A is necessarily related to variable C.
5. The reachability matrix obtained in Step 4 is partitioned into different levels.
6. Based on the contextual relationships given above in the reachability matrix, a directed graph is drawn and the transitive links are removed.
7. The resultant diagraph is converted into an ISM, by replacing variable nodes with statements.
8. The ISM model developed in step 7 is reviewed to check for conceptual inconsistency and necessary modifications are made.

MICMAC Analysis

Matrice d'Impacts croises-multipication applique´ an classment (cross-impact matrix multiplication applied to classification) is abbreviated as MICMAC. In the MICMAC analysis, the dependence power and driver power of the green practices are analyzed. The driving power and dependence of each of the green practice are plotted.

4. RESULTS AND DISCUSSIONS

The results and discussions of this research are presented in this section as follows:

Questionnaire Based Study

On the basis of responses green practices to implement GSCM in Indian automobile industry have been presented in the decreasing order of their significance in Table 1.

Table 1: Survey Results of Green Practices to implement GSCM in Indian Automobile Industry

S. N.	Practices To Implement GSCM	Mean	Std. Deviation	Rank
1	Environment Management Systems Implementation	4.54	0.550	1st
2	TQEM Practices Implementation	4.48	0.596	2nd
3	Green Procurement Strategies	4.44	0.614	3rd
4	Innovative Green Product Development Practices Adoption	4.41	0.631	4th
5	Design for Environment	4.34	0.658	5th
6	Use of New Products and Process Optimization	4.21	0.692	6th
7	End of Life Product Management	4.11	0.716	7th
8	Waste Management and Use of Recyclability Evaluation Methods (REMs)	3.99	0.725	8th
9	Use of Lean/Flexible Manufacturing	3.91	0.788	9th
10	Use of Environmental Friendly Packing and Labeling of the Products	3.82	0.797	10th
11	Proper Workplace Management	3.73	0.812	11th

"Environment Management Systems Implementation" has been observed highest mean, lowest standard deviation and "Proper Workplace Management" highest standard deviation and lowest mean has been observed in Table 1.

Interpretive Structural Modeling (ISM)

ISM methodology as explained in the previous section, the results are as follow:

Structural Self-Interaction Matrix (SSIM) Formation: We conducted a workshop, in which different experts (Three were from industry and four were from academia) were invited. Experts were consulted during the workshop conducted to identify the nature of contextual relationships among practices to implement GSCM in Indian automobile industry for analyzing in developing SSIM. Following four symbols have been used to denote the direction of relationship between two practices (i and j).

V- Practice i will help to achieve practice j;
A- Practice j will help to achieve practice i;
X- Practices i and j will help achieve each other;
O- Practices i and j are unrelated.
Based on the contextual relationships the SSIM has been developed (Table 2).

[Table 2 about here]

Reachability Matrix Formation: The SSIM has been converted in to a binary matrix, named as Initial Reachability Matrix, by substituting V, A, X, O by 1 or 0 as per following rules:

If (i, j) value in the SSIM is V, (i, j) value in the reachability matrix will be 1 and (j, i) value will be 0;

If (i, j) value in the SSIM is A, (i, j) value in the reachability matrix will be 0 and (j, i) value will be 1;

If (i, j) value in the SSIM is X, (i, j) value in the reachability matrix will be 1 and (j, i) value will be 1 and If (i, j) value in the SSIM is O, (i, j) value in the reachability matrix will be 0 and (j, i) value will be 0. By applying these rules, initial reachability matrices have been obtained for green practices. The final reachabilty matrix may be obtained by adding transitivity as explained in Step 4. The final reachability matrix for green practices has been shown in Table 3.

[Table 3 about here]

Table 2: Structured Self Intersection Matrix (SSIM) for Green Practices to implement GSCM in Indian Automobile industry

S. N.	Green Practices To Implement GSCM	Green Practices Number →									
		11	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
1	Environment Management Systems Implementation	O	V	V	V	V	V	V	V	V	V
2	Innovative Green Product Development Practices Adoption	O	V	V	O	V	O	A	V	V	
3	Design for Environment	O	V	V	V	V	A	V	V		
4	End of Life Product Management	O	V	V	A	A	O	A			
5	Use of New Products and Process Optimization	O	O	V	O	A	O				
6	TQEM Practices Implementation	V	V	V	O	O					
7	Green Procurement Strategies	O	O	V	V						
8	Use of Environmental Friendly Packing and Labeling of the Products	O	O	O							
9	Waste Management and Use of Recyclability Evaluation Methods (REMs)	V	V								
10	Use of Lean/Flexible Manufacturing	V									
11	Proper Workplace Management										

Table 3: Final Reachablility Matrix for Green Practices to implement GSCM in Indian Automobile industry

S. N.	Green Practices To Implement GSCM	Green Practices Number ⟶											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Driving Power ▼**
1	Environment Management Systems Implementation	1	1	1	1	1	1	1	1	1	1	1*	**11**
2	Innovative Green Product Development Practices Adoption	0	1	1	1	1*	0	1	1*	1	1	1*	**09**
3	Design for Environment	0	1*	1	1	1	0	1	1	1	1	1*	**09**
4	End of Life Product Management	0	0	0	1	0	0	0	0	1	1	1*	**04**
5	Use of New Products and Process Optimization	0	1	1*	1	1	0	1*	1*	1	1*	1*	**09**
6	TQEM Practices Implementation	0	1*	1	1*	1*	1	1*	1*	1	1	1	**10**
7	Green Procurement Strategies	0	1*	1*	1	1	0	1	1	1	1*	1*	**09**
8	Use of Environmental Friendly Packing and Labeling of the Products	0	0	0	1	0	0	0	1	1*	1*	1*	**05**
9	Waste Management and Use of REMs	0	0	0	0	0	0	0	0	1	1	1	**03**
10	Use of Lean/Flexible Manufacturing	0	0	0	0	0	0	0	0	0	1	1	**02**
11	Proper Workplace Management	0	0	0	0	0	0	0	0	0	0	1	**01**
Dependence Power ⟶		**01**	**06**	**06**	**08**	**06**	**02**	**06**	**07**	**09**	**10**	**11**	**72/72**

means value after applying transitivity

Level Partitioning: The reachability set for an individual practice consists of the practices and the other practices which it may help achieve. The antecedent set consists of the practices themselves and the other practices which may help in achieving it. The intersection of both these sets was also derived for all practices. If the reachability set and the intersection set for a given practice are the same, then that practice is considered to be in level 1st and is given the top position in the ISM hierarchy [30]. With this partition, iteration 1 is completed. 1st Level partitioning of level of practices to implement GSCM in Indian automobile industry has been shown in Table 4.

Table 4: 1st Level partitioning for Green Practices to implement GSCM in Indian Automobile industry

Practice S. N.	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,2,3,4,5,6,7,8,9,10,11	1	1	
2	2,3,4,5,7,8,9,10,11	1,2,3,5,6,7	2,3,5,6	
3	2,3,4,5,7,8,9,10,11	1,2,3,5,6,7	2,3,5,6	
4	4,9,10,11	1,2,3,4,5,6,7,8	4	
5	2,3,4,5,7,8,9,10,11	1,2,3,5,6,7	2,3,5,6	
6	2,3,4,5,6,7,8,9,10,11	1,6	6	
7	2,3,4,5,7,8,9,10,11	1,2,3,5,6,7	2,3,5,6	
8	4,8,9,10,11	1,2,3,5,6,7,8	8	
9	9,10,11	1,2,3,4,5,6,7,8,9		
10	10,11	1,2,3,4,5,6,7,8,9,10		
11	11	1,2,3,4,5,6,7,8,9,10,11	11	Ist

After the first iteration, the practice forming level 1st is discarded and with the remaining practices, the above mentioned procedure is continued in iteration 2. These iterations are continued until the levels of each practice have been found. The final level of each practice is given in Tables 5.

Table 5: Final Level of Green Practices to implement GSCM in Indian automobile industry

Level No.	Importance of Practices to implement GSCM in Indian automobile industry
1st	Proper Workplace Management (11)
2nd	Use of Lean/Flexible Manufacturing (10)
3rd	Waste Management and REMs (9)
4th	End of Life Management (4)
5th	Use of Environment Friendly Packing and Labeling (8)
	Awareness Level of Customers (12) Information Quality & Sharing (16)
6th	Green Procurement Strategies (7) New Materials & Process Optimization (5) Design for Environment (3) Innovative Green Product Development (2)
7th	Total Quality Environment Management(6)
8th	Environment Management System Implementation (1)

"Proper Workplace Management" practice has been found top (1st) level and it will come top of the ISM hierarchy. "Environment Management System Implementation" has been found last (8th) level and will come bottom of the ISM hierarchy.

ISM Based Model Formation: From the final reachability matrices (Table 3), the structural model has been generated after removing the transitivity's links. This ISM model for green practices to implement GSCM has been shown in Figure 1

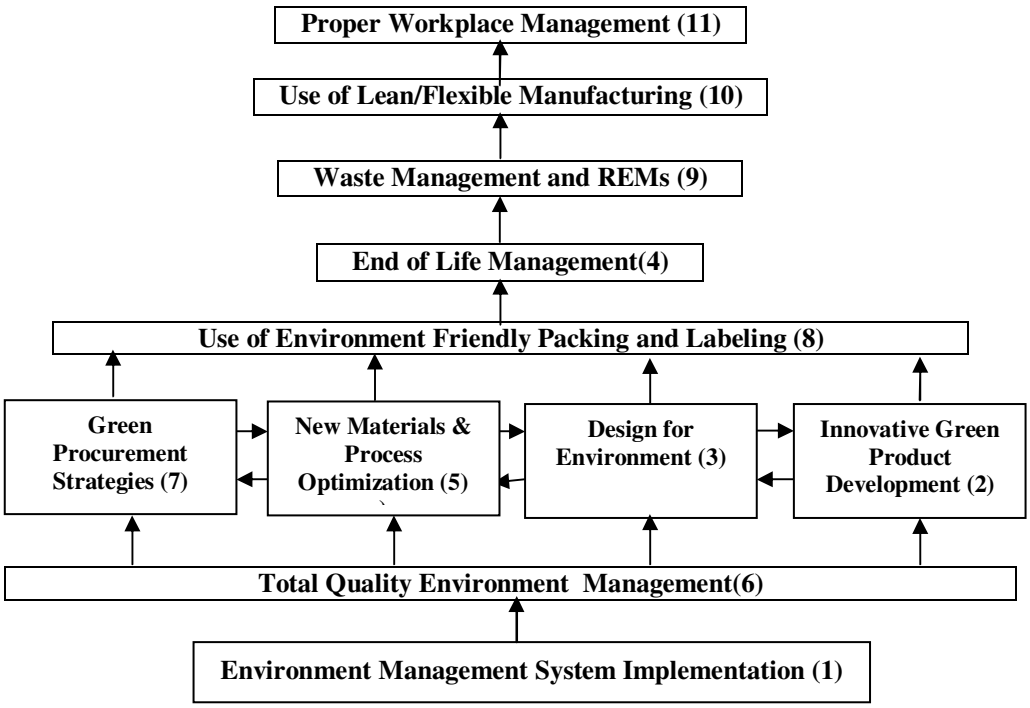

Figure 1: ISM Model for Green Practices to implement GSCM in Indian automobile industry

MICMAC Analysis

These practices are classified in to four clusters named autonomous practices dependent practices, linkage practices and independent practices [3, 5, 30]. Autonomous practices have weak driving power and weak dependence power. These practices can be disconnected from the system. In our study, no practice is lying in this range. The second clusters named dependent practices have weak driving power and strong dependence power. Proper workplace management, Use of lean/flexible manufacturing, Waste management and Use of recyclability evaluation methods, End of life product management and Use of environmental friendly packing and Labeling of the products have been identified as dependent green practices to implement GSCM in Indian automobile industry. The third cluster named linkage practices having strong driving power and strong dependence power. In our study, Innovative green product development practices adoption, Design for environment, Use of new products and process optimization and Green procurement strategies have been identified as linkage variables and comes at the middle level in the ISM hierarchy. The fourth cluster named independent practices has strong driving power and weak dependence power. In our study, Environment management system implementation and TQEM practices implementation have been identified as independent variables. Environment management system implementation has the highest driving power and the least dependence power. It will come at the bottom most level in the ISM hierarchy. The graph between dependence power and driving power for green practices to implement GSCM in automobile industry is shown in Figure 2.

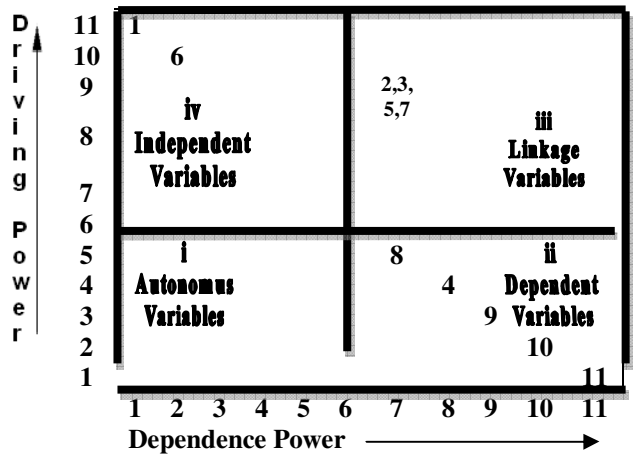

Figure 2: MICMAC Analysis of Green Practices to implement GSCM in Indian automobile industry

5. CONCLUSIONS

Eleven practices have been identified from the literature review, the experts' opinion (Academia and Industry) and validated from questionnaire based survey. The objective of the research is to understand contextual relationships between various green practices and develop a hierarchy of green practices to implement GSCM in Indian automobile industry. "Proper workplace management" has been found dependent top level green practice and "Environmental management system Implementation" has been found independent bottom level green practice to implement GSCM in Indian automobile industry MICMAC Analysis has also been carried out. "Proper workplace management", "Use of lean/flexible manufacturing", "Waste management and Use of recyclability evaluation methods", "End of life product management" and "Use of environmental friendly packing and labeling of the products" are dependent green practices to implement GSCM in Indian automobile industry. Dependent practices are weak drivers but strongly dependent on other practices. These practices represent desired objectives for the implementation of GSCM in Indian automobile industry. "Environment management systems implementation" and "TQEM practices implementation" have been identified as driver green practices to implement GSCM in Indian automobile industry. Driver practices have high driving power and low dependence power. They will play an important role to implement GSCM in Indian automobile industry. Management needs to address these practices more carefully. "Innovative green product development practices adoption", "Design for environment", "Use of new products and process optimization" and "Green procurement strategies" have been identified as green practices to implement GSCM in Indian automobile industry. Linkage practices have high driving power and high dependence power. These practices are unstable that any action on these practices will have an effect on others and also a feedback on themselves. No practice has been identified as autonomous, which indicates no practice may be considered as disconnected from the system. This model suggests how these green practices to implement GSCM in Indian automobile industry are interrelated. An organization may be benefited in analyzing which practice they have to improve upon to implement GSCM in Indian automobile industry.

6. LIMITATIONS AND SCOPE OF FUTURE WORK

Though the model is developed on basis of opinion of experts from selected automobile companies, as it is natural, opinions of experts may be different. Green practices identified are quite similar and may be applied to other industry like electronics and electrical industry with

marginal modifications. Interpretive Ranking Process (IRP) may be used to rank practices to implement GSCM in Indian automobile industry. Structural equation modeling (SEM) may be used to test the validity of the suggested model.

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