Analysis of Factors Affecting Green Supply Chain Management by Interpretive Structural Modelling(ISM) Technique

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Abstract— Industrialization plays a major role in economic development, infrastructure, growth and prosperity of any country. But these industries affect our environment so badly which causes global warming, greenhouse effect, ozone layer depletion, acid rain, pollution etc. Due to these threats green supply chain management comes into picture and many researchers are working on this. It will help in sustainable development of the society. With the help of many researches, literature we are able to know about drivers and barriers of Green Supply Chain Management. There are many methodologies like Interpretive Structural Modelling (ISM Technique), Regression Analysis, Questionnaire Process available which can analysed effect and response of Green Supply Chain Management. This paper has analysed some researches and shows the response of the industries which had surveyed; drivers and factors of Green Supply Chain; Requirements for effective Green Supply Chain Management. In the way of implementation of GSCM, there are some factors in the way of GSCM which we have analysed in this paper with the help of ISM technique. With the ISM technique we will obtain the ranking or hierarchy of some factors of GSCM which will help in the industries to focus on those problems and we can know that which factor is most dominating and which is least dominating.

Keywords: ISM Technique, GSCM, MICMAC

I. INTRODUCTION

Green Supply Chain Management (GSCM) is tied in with conveying items and administrations from providers, producers to end clients through material stream, data stream and trade stream out the setting of condition. Conventional Supply Chain Management centers around Total Quality, ideal Cost and best administration which somehow added to condition [16]. The present Green Supply bind administration commands to consolidate the ecological thought in every last phase of the item and administration in a Supply Chain. Thus Supply chain directors have an awesome part in creating imaginative natural advancements to handle the issues looked by the economy on ecological issues and convey this to each partner in the chain. Lean Manufacturing is dispensing with squander in each phase of SC. It centers around delivering financially and earth cordial quality items which meets the client desire. It is the best practice to be taken after since it diminishes stock, spares space and vitality. Henceforth Lean assembling adds to the Green condition. EPI is to quantify the viability of ecological exhibitions of a nation [17]. This measure gives the points of interest on how shut the nations can build up ecological agreeable arrangements and methodology. The idea of GSC was first emerged by the Michigan State University in 1996 amid an "ecologically dependable assembling" look into. It was turned out to be a powerful method for administration by the researchers in Michigan State University. Later they found the foundation of green production network administration in these ventures, for example, IBM adequately settled the contention between monetary interests of ecological security, so individuals respect it. GSC birthplaces from SCM and manageable advancement hypopaper. It is another subject, individuals have not examined it sufficiently profound. As of recently, there is still no bound together, clear, legitimate definition. The GSCM is a framework, it incorporates the procedure of material obtaining, handling, bundling, warehousing, transportation, deal and use to the finish of life treatment, reusing [16]. The procedure is guided by the standard of enhancement designation of assets, upgrading benefits, accomplishing the objective of the similarity with the earth. As a rule, it is a green framework consolidates by the providers, producers, merchants, retailers, purchasers.

II. METHOD OF THE PAPER

The method which is used to obtain main objective of the paper is Interpretive Structure Modelling (ISM) technique. This technique is so helpful to find out the factors of GSCM and then set it into a hierarchy and find out which factor is most dominating and which is least dominating.

First by literature survey and some analysis list of factors have been found. Secondly by applying ISM technique levels of factors have been obtained and then draw a diagram which shows which factor is dependent on which factor and which factor drive other factor. At last by using MICMAC Analysis driving power and dependence power have been shown in a graph.

Result and discussion

- Step 1 – With the help of literature and industrial survey (Saif Food Private Ltd. and Global Heavy Engineering Industry), I have listed out the factors which will be set into a hierarchy and by ISM technique, ranks will be provided; so that we can easily find the most and least dominating factor.
- Step 2 – Establish contextual relationship among those variables which are examined.
- Step 3 - Construct Structural Self-Interaction Matrix (SSIM) is developed for variables which indicates pair-wise dependency between variables.
- Step 4 – In this step initial Reachability Matrix has been developed
- Step 5 – In this step transitivity have been added which means it is an assumption of ISM technique is that if factor A is related with factor B and factor B is related with factor C, then factor A will be related with factor C.
- Step 6 – Level Partition

In this step the reachability set and antecedent set are determined by final reachability matrix. Reachability set are those set which influence the factor and antecedent set are those set which may influence the factor. Intersection set are the intersection of reachability set and antecedent set. Level

partition of factors has been done according to reachability set and intersection set.

The list of factors which I have taken for the analysis are following:-

S.No.	Name of factors	References
B1	Supplier management	[25]
B2	Green procurement	[13]
B3	Life cycle management	[19]
B4	Green logistic	[07]
B5	Non availability of bank loans to encourage green Product	Self-Contributed factor
B6	Economical performance	Self-Contributed factor
B7	Green design	[04]
B8	Green manufacturing	Self-Contributed factor
B9	Customer support	[15]
B10	Lack of sustainability certification (ISO 14001)	[18]
B11	High initial cost	Self-Contributed factor
B12	factor accounting	Self-Contributed factor

III. SSIM MATRIX

factors	12	11	10	9	8	7	6	5	4	3	2	1
1	V	O	V	V	O	V	V	O	A	V	V	X
2	A	A	O	A	V	A	V	A	V	A	X	
3	V	O	O	V	V	X	V	O	O	X		
4	O	O	V	O	V	V	V	V	X			
5	O	A	V	A	O	V	O	X				
6	A	O	V	A	V	A	X					
7	X	V	V	O	V	X						
8	A	O	V	O	X							
9	O	O	O	X								
10	O	O	X									
11	A	X										
12	X											

If there is a factor i and factor j then above symbols V, A, X, O denotes-

Vij = factor i will lead to factor j
Aij = factor j will lead to factor i
Xij = factor i and j will lead to each other
Oij = factor i and j are unrelated

e.g. In factor 1 and factor 3, factor 1 leads to factor 3 so B (1, 3) is denoted by V; so that B (3,1) automatically represents by A. In factor 2 and factor 3, factor 3 leads to factor 1 so B (2,3) is denoted by A; so that B (3, 2) automatically represents by V. In a factor 7 and factor 12, factor 7 and factor 12 leads to each other so B (7, 12) and B (12, 7) represents by X. In factor 1 and factor 8 are unrelated so B (1, 8) and B (8, 1) represents by O.

4.1 If (i, j) value is given as V, then in reachability matrix (i, j) value will be 1 and (j, i) value will be 0.
4.2 If (i, j) value is given as A, then in reachability matrix (i, j) value will be 0 and (j, i) value will be 1.
4.3 If (i, j) value is given as X, then in reachability matrix (i, j) value will be 1 and (j, i) value will also be 1.
4.4 If (i, j) value is given as O, then in reachability matrix (i, j) value will be 0 and (j, i) value will also be 0.

A. Initial Reachability Matrix

factors	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	0	0	1	1	0	1	1	1	1
2	0	1	0	1	0	1	0	1	0	0	0	0
3	0	1	1	0	0	1	1	1	1	0	0	1
4	1	0	0	1	1	1	1	1	0	1	0	0
5	0	1	0	0	1	0	1	0	0	1	0	0
6	0	0	0	0	0	1	0	1	0	1	0	0
7	0	1	1	0	0	1	1	1	0	1	1	1
8	0	0	0	0	0	0	0	1	1	0	0	0
9	0	1	0	0	1	1	0	0	1	0	0	0
10	0	0	0	0	0	0	0	0	0	1	0	0
11	0	1	0	0	1	0	0	0	0	0	1	0
12	1	1	0	0	0	1	1	1	0	0	1	1

In initial reachability matrix, at a time dependency or relation is analyzed only between those particular two variables. So the relation with other variables is not being examined. So this matrix is not perfect matrix. So for removing that error, transitivity has been added by the assumption of ISM technique so that we can obtained final reachability matrix which has been shown below-

B. Final Reachability matrix with driving and dependence power-

factors	1	2	3		4	5	6	7	8	9	10	11	12	Driving Power
1	1	1	1		1*	1*	1	1	1*	1	1	1	1	12
2	1*	1	0		1	1*	1	1*	1	1*	1*	0	0	9
3	1*	1	1		1*	1*	1	1	1	1	1*	1*	1	12
4	1	1*	1*		1	1	1	1	1	1*	1	1*	1*	12
5	1*	1	1*		1*	1	0	1	1*	0	1*	1*	1*	10
6	0	0	0		0	1*	1	0	1	1*	1	0	0	5
7	1*	1	1		1*	1*	1	1	1	1*	1	1	1	12
8	0	1*	0		0	1*	1*	0	1	1	0	0	0	5
9	0	1	0		1*	1	1	1*	0	1	1*	0	0	7
10	0	1*	0		0	1	0	1*	0	0	1	0	0	4
11	0	1	0		1*	1	1*	1*	1*	0	1*	1	0	8
12	1	1	1*		1*	1*	1	1	1	1*	1*	1	1	12

Dependence Power	7	11	6		9	12	10	10	10	9	11	7	6	10 8/108

1* denotes added transitivity which value was 0 before adding transitivity. But by adding transitivity all the variables are inter-related so that errors of initial reachability matrix are being removed.

– Step 6 – Level Partition

In this step the reachability set and antecedent set are determined by final reachability matrix. Reachability set are those set which influence the factor and antecedent set are those set which may influence the factor. Intersection set are the intersection of reachability set and antecedent set. Level partition of factors has been done according to reachability set and intersection set.

In which factor, reachability set and intersection set are common, those factors allocated the level of factor in different iteration. In next iteration allocated factor has been removed and the common members of allocated factors has also been removed. Iteration has been repeated until all the factor have been allocated their level.

– Step 6.1 First Iteration to find Levels

Barriers	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,2,3,4,5,6,7,8,9,10,11, 12	1,2,3,4,5,7,12	1,2,3,4,5,7,12	
2	1,2,4,5,6,7,8,9,10	1,2,3,4,5,7,8,9,10,11,12	1,2,4,5,7,8,9,10	
3	1,2,3,4,5,6,7,8,9,10,11, 12	1,3,4,5,7,12	1,3,4,5,7,12	
4	1,2,3,4,5,6,7,8,9,10,11, 12	1,2,3,4,5,7,9,11,12	1,2,3,4,5,7,9,11,12	
5	1,2,3,4,5,7,8,10,11,12	1,2,3,4,5,6,7,8,9,10,11,12	1,2,3,4,5,7,8,10,11, 12	I
6	5,6,8,9,10,	1,2,3,4,6,7,8,9,11,12	6,8,9	
7	1,2,3,4,5,6,7,8,9,10,11, 12	1,2,3,4,5,7,9,10,11,12	1,2,3,4,5,7,9,10,11, 12	
8	2,5,6,8,9	1,2,3,4,5,6,7,8,11,12	2,5,6,8	
9	2,4,5,6,7,9,10	1,2,3,4,6,7,8,9,12	2,4,6,7,9	
10	2,5,7,10	1,2,3,4,5,6,7,9,10,11,12	2,5,7,10	I
11	2,4,5,6,7,8,10,11	1,3,4,5,7,11,12	4,5,7,11	
12	1,2,3,4,5,6,7,8,9,10,11, 12	1,3,4,5,7,12	1,3,4,5,7,12	

In the above table, we can see that in the factor 5 and factor 10, all the members of reachability set and intersection set are common. So they are allocated as Level I.

– Step 6.2 Second Iteration to find Levels-

In the second iteration, factor 5 and factor 10 have been removed and the common intersection set members of factor 5 and factor 10 i.e. 2, 5, 7, 10 have been removed from all set.

Barriers	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,3,4,6,8,9,11,12	1,3,4,12	1,3,4,12	
2	1,4,6,8,9,	1,3,4,8,9,11, 12	1,4,8,9,	
3	1,3,4,6,8,9,11,12	1,3,4,12	1,3,4,12	
4	1,3,4,6,8,9,11,12	1,3,4,9,11,12	1,3,4,9,11,12	
6	6,8,9,	1,3,4,6,8,9,11,12	6,8,9	II
7	1,3,4,6,8,9,11,12	1,3,4,9,11,12	1,3,4,9,11,12	
8	6,8,9	1,3,4,6,8,11, 12	6,8	
9	4,6,9,	1,3,4,6,8,9,12	4,6,9	II
11	4,6,8,11	1,3,4,11,12	4,11	
12	1,3,4,6,8,9,11,12	1,3,4,12	1,3,4,12	

In the above table, we can see that in the factor 6 and factor 9, all the members of reachability set and intersection set are common. So they are allocated as Level II.

– Step 6.3 Third Iteration to find Levels-

In the third iteration, factor 6 and factor 9 have been removed and the common intersection set members of factor 6 and factor 9 i.e. 6, 9 have been removed from all sets.

– Step 6.3 Third Iteration to find Levels-

In the third iteration, factor 6 and factor 9 have been removed and the common intersection set members of factor 6 and factor 9 i.e. 6, 9 have been removed from all sets.

Barriers	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,3,4,8,11,12	1,3,4,12	1,3,4,12	
2	1,4,8,	1,3,4,8,11,12	1,4,8,	III
3	1,3,4,8,11,12	1,3,4,12	1,3,4,12	
4	1,3,4,8,11,12	1,3,4,11,12	1,3,4,11,12	
7	1,3,4,8,11,12	1,3,4,11,12	1,3,4,11,12	
8	8,	1,3,4,8,11,12	8	III
11	4,8,11	1,3,4,11,12	4,11	
12	1,3,4,8,11,12	1,3,4,12	1,3,4,12	

In the above table, we can see that in the factor 2 and factor 8, all the members of reachability set and intersection set are common. So they are allocated as Level III.

– Step 6.4 Fourth Iteration to find Levels-

In the fourth iteration, factor 2 and factor 8 have been removed and the common intersection set members of factor 2 and factor 8 i.e. 8 have been removed from all sets.

Barriers	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,3,4,11,12	1,3,4,12	1,3,4,12	

3	1,3,4,11,12	1,3,4,12	1,3,4,12	
4	1,3,4,11,12	1,3,4,11,12	1,3,4,11,12	IV
7	1,3,4,11,12	1,3,4,11,12	1,3,4,11,12	IV
11	4,11	1,3,4,11,12	4,11	IV
12	1,3,4,11,12	1,3,4,12	1,3,4,12	

In the above table, we can see that in the factor 4, factor 7 and factor 11, all the members of reachability set and intersection set are common. So they are allocated as Level IV.

– Step 6.5 Fifth Iteration to find Levels-

In the fifth iteration, factor 4, factor 7 and factor 8 have been removed and the common intersection set members of factor 4, factor 7 and factor 8 i.e. 4, 11 have been removed from all sets.

Barriers	Reachability Set	Anteceden t Set	Intersection Set	Level
1	1,3,12	1,3,12	1,3,12	V
3	1,3,12	1,3,12	1,3,12	V
12	1,3,12	1,3,12	1,3,12	V

In the above table, we can see that in the factor 1, factor 3 and factor 12, all the members of reachability set and intersection set are common. So they are allocated as Level V.

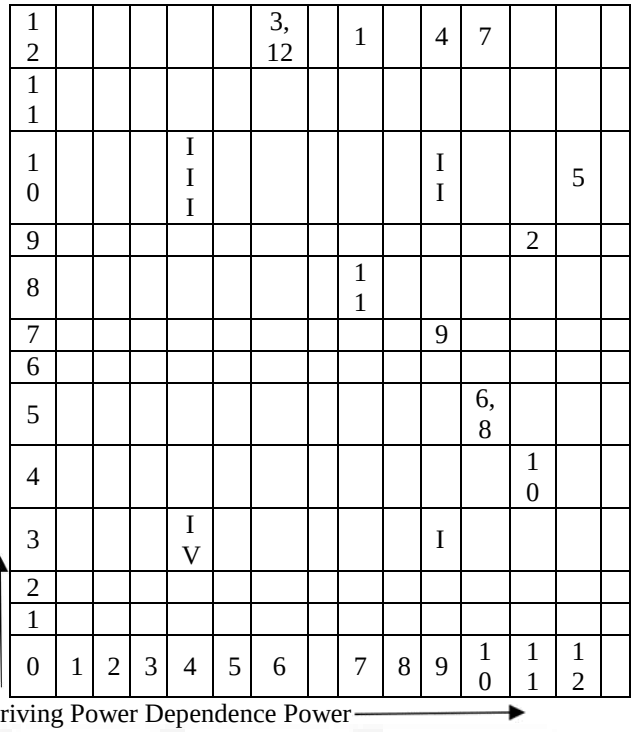
Now each factors are allocated their levels or rank which shows that which are dominating barriers and on which barrier more work and research is required.

S.No.	Levels of factors	factors of GSCM
1.	Level I	– Non availability of bank loans to encourage green product – Lack of sustainability certification (ISO 14001)
2.	Level II	– Economical performance – Lack of Customer Awareness
3.	Level III	– Green procurement – Green manufacturing
4.	Level IV	– Green design – Green logistic – High initial cost
5.	Level V	– Supplier management – Life cycle management – Environmental accounting

IV. MICMAC ANALYSIS

All the factors of GSCM are classified in four clusters which is named as Autonomous Factors, Linkage Factors, Dependent Factors, Independent Factors [58].

Autonomous Factors are those factors which have weak driving power and weak dependence power. It lies in IV cluster. No Barrier lies in this area. Dependent Factors are those factor which have weak driving power and strong dependence power. It lies in I cluster. factor 6, factor 8 and factor 10 lies in this area. Linkage Factor are those factors which have strong driving power and strong dependence power. It lies in II cluster. factor 1, factor 2, factor 4, factor 5, factor 7, factor 9 and factor 11 lies in this area. Independent Factor are those factors which have strong driving power and weak dependence power. It lies in cluster III. factor 3 and factor 12 lies in this area.



V. LIMITATION OF THIS STUDY

The factors which are listed for the GSCM those are collected by literature survey or it can collect by expert opinion of the management. But it can be biased about any particular factors. The results can change according to the place or country. This result is a model; it can change in real conditions.

VI. FUTURE SCOPE

As we know that, carbon emission rate are increasing day by day; ozone layer depletion, increase rate of greenhouse gases are increasing and industries play main role in these causes. So with the help of ISM technique, GSCM factors can be analyzed. After the implementation of GSCM these problems can be controlled at certain level. More factors can be analyzed with this technique if other factors need to be added in the future. No one knows exactly what requirements will be in the future but ISM technique will help on those factors also. It will analyze those factors and will help to implement those factors.

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