

DEVELOPMENT OF FRAMEWORK FOR IMPLEMENTATION OF GREEN SUPPLY CHAIN MANAGEMENT IN STEEL INDUSTRY USING INTERPRETIVE STRUCTURAL MODELING UNDER FUZZY ENVIRONMENT

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Abstract - The steel industries use immense raw material and water and are also the leading contributor to the undesirable emissions. The presence of a large number of steel industries in Chhattisgarh makes the status of the environment critical for sustenance. An effort has been made in this research to study and find a solution for sustainability through Green Supply Chain Management. The research was carried out through the pilot study based on the questionnaire which was filled up by the personnel of the steel plant. Then more exhaustive investigation was carried out by sending the questionnaire to a large number of persons from the steel industry. The weighted average score of the data was obtained through MS Excel and the relevance of the enablers was ascertained. Then, reliability testing of the data was done through SPSS software. Interpretive Structural Modelling was done by the data obtained and Interpretive Structural Modelling (ISM) framework was suggested. Then, the study was carried on a larger population which included 251 respondents. The data obtained was again analysed on SPSS for reliability and validity. Then a framework of action to be taken was proposed to the experts. Upon analysing the data it was found that more than eighty percent of the actions suggested to be taken for the implementation of Green Supply Chain Management (GSCM) had a weighted average score more than 0.8. The GSCM framework was also checked for reliability through SPSS software. Hence, the proposed GSCM framework proposed to the steel industries in Chhattisgarh holds good.

Keywords: Green Supply Chain Management, Steel Industries, Interpretive Structural Modelling, Descriptive Analysis, SPSS, GSCM Framework.

1 INTRODUCTION

The industries are the workhorses which churn out the appetizers for the human beings which further increases its appetite. The lure of producing more at a lesser time has always captivated the human mind thus resulting in the neglect of the safety norms and the damage to the environment. The profit earned and the revenue generated has become the matter of prime concern and the planning and the execution of the industrial policies for the production units circumvents around them. The atmospheric, the surface and the underground resources provided by the nature has been assumed by the human beings to remain perpetually of a good quality and the inane production activities will not bring any harm to them but this thought has been belied by the warming of the globe, the melting of the glaciers and the rising of the sea level.

The fact remains that the production activities cannot be stopped or curtailed but sincere efforts should be made to identify the elements responsible

for the degradation of the environment and ensure the implementation and the maintenance of sustainable technologies. The state of Chhattisgarh which has been carved out of the erstwhile state of Madhya Pradesh on the 1st of November 2000 is on the path of development across all cross-sections of the activities, which also includes the industrial activities as well. The nature has bestowed Chhattisgarh with abundant natural resources in the form of coal, iron ore, limestone, dolomite, bauxite, gold, diamond etc. The abundant ability of iron ore has resulted in the functioning of more than a hundred steel manufacturing units. The presence of the steel industry is a source of revenue and job generation but they have also become the reason for the active contribution towards the degradation of the environmental condition by way of introducing substances generated out of the production activities into the air makes it

of unacceptable standard for the human beings and the animals alike.

1.1 Role of Supply Chain in Manufacturing and Service Sector

Oliver and Webber introduced the term supply chain management in the early 1980's and since then it has continued to stay. Initially, it was misunderstood to be a simple process of the chain of the transfer of the goods from one point to another till it reaches the customers or the end users. It also stressed upon the transfer of information and the revenue.

Traditionally, the only goal for the enterprise is to pursue the maximum economic benefits. In order to pursue its own interests, the enterprise will not undertake the corresponding responsibility of improving the environment.

1.2 Objectives

1. To study the theory and practice of Supply Chain Management.
2. To study the theory and practice of Green Supply Chain Management
3. To evaluate the scope for the improvement of the existing practices in the steel industry pertaining to sustainability.
4. To study the theory and practice of steel industry in Chhattisgarh using Interpretive Structural Modelling by considering the responses from various stakeholders at different levels.

2 EVOLUTION OF SUPPLY CHAIN

Oliver and Webber introduced the term "supply chain management" in 1980s. Supply Chain Management includes the planning, management and execution of the activities involved in outsourcing, procurement processing and logistics. Supply Chain Management also includes linkages and co-ordination with the business partners, suppliers, customers and regulatory agencies. Thus, it includes the gamut of activities involved for sustainable production and leads to the integration of the supply and the demand of the participating companies. Several researchers have proposed their ideas and observations regarding the supply chain management.

3 SALIENT FEATURES OF FUZZY

Fuzzy concept is a condition in which the boundaries of application can vary considerably according to context or conditions, instead of being fixed once and for all. This means the concept is vague in some way, lacking a fixed, precise meaning, without however being unclear or meaningless altogether.

3.1 Salient Features of Interpretive Structure Modelling

Interpretive Structure Modelling is an interactive computer-assisted learning process into a set of heterogeneous directly related elements structured into a comprehensive systematic model. ISM also gives the basic ideas to develop a map of the compound associations between the numerous elements concerned in multifaceted circumstances.

The most important idea of ISM is to use the practical experience of experts and their knowledge to decompose a complicated taxonomy into numerous sub-systems as well as assemble a multi-tiered structural form. Raj et al. (2008) focused on ISM approach to identify the mutual interaction of the manufacturing competitive enablers that help in the achievement in manufacturing sector. As well as it also helps to identify the driving and the dependent enablers. Raj et al. (2008) presented the following characteristics of ISM are as follows:

- (i) This methodology is interpretive as the judgment of the group decides whether and how the different elements are related.
- (ii) It is structural, too, on the basis of relationship; an overall structure is extracted from the complex set of variables.
- (iii) It is a modelling technique, as the specific relationships and overall structure are portrayed in a digraph model.
- (iv) It helps to impose order and direction on the complexity of relationships among various elements of a system.
- (v) It is primarily intended as a group learning process, but individuals can also use it.

ISM methodology has many advantages, but apart from that it has a few disadvantages or limitations. The main limitations of ISM are the relationship among the variables which

totally depends upon the users' knowledge and their experience within the industry. Therefore, prejudice of someone who is judging the variables might manipulate the final result.

4 METHODS AND MATERIALS

4.1 Introduction

Interpretive Structural Modelling (ISM) is a well-established methodology for identifying and summarizing relationships among specific variables, which define a problem. As the method is simple to use and transparent hence it will be used to analyse the data obtained through questionnaire.

4.2 Need for Research in Study Area

The presence of a large number of small, medium and large sized steel manufacturing units in the state of Chhattisgarh and their definite impact on the environment was the reason behind taking up the research topic. The aim is to study the existing level of implementation of GSCM in the industry and to propose a new framework for improved performance.

The literature review provides very little information on the implementation of GSCM in steel industry in India. Although Chhattisgarh has a large number of steel manufacturing units but there is no research paper pertaining to GSCM in it.

So, there is a gap in literature in terms of implementation of GSCM in steel industry in Chhattisgarh and the use of ISM approach in any of the industry, in spite of the method being used in different parts of the world in different types of industry.

5 RESULTS AND DISCUSSIONS

5.1 Introduction

The answer to the research pertaining to GSCM is provided through the analysis of the data obtained through questionnaire and the case study.

5.2 Policy planning

The focus of economic policy has shifted to liberalization and globalization. It has paved the way for the global players to enter into the Indian market. This has led to a massive change in the outlook of the Indian industry because now it is facing a stiff competition in terms of the availability, the quality and the pricing of

the products. The cost cutting was the first phase of the competition but it could not sustain because there was a limit to it. It led to the closure of many manufacturing units. Then, it was realized that in order to stay in the competition large scale production with added features and competitive pricing will keep them in the market. But then the greed to earn quick profit also led to the damage to the environment because of the greenhouse gasses, which had its own impact. The climate pattern started changing and the life cycle was disturbed.

The government had to interfere by making stringent regulations regarding the exhaust emissions and other environmental protection laws. So, the industry had to fall in line with it and the concept of Green Supply Chain Management came into being with a massive and long term positive impact on the profits and the conservation of environment.

5.3 Pilot Test

The following analysis has been done

1. The software packages used for data analysis are IBM SPSS Statistics V22.0 and Microsoft Excel.
2. IBM SPSS Statistics V22.0 was used for calculating the Cronbach Alpha to check the reliability of the scale and the data collected. The coefficient of alpha value for the pilot test was obtained as 0.930 thus indicating that the scale is greater than 0.7 and is internally consistent. Thus the data collected for the analysis satisfied the condition for reliability
3. Microsoft Excel was used for the evaluation of the weighted average score to check the validity of the data collected from the responses. It was assumed that all the enablers scoring a value greater than 0.6 will be considered for further analysis. As all the variables have a value greater than 0.6 hence there was no elimination of enablers.

21 responses were obtained from the 35 respondents to which the questionnaires were provided.

5.4 Case Study

The following analysis was done:

1. The software packages used for data analysis are IBM SPSS Statistics V22.0 and Microsoft Excel.
2. IBM SPSS Statistics V22.0 was used for calculating the Cronbach Alpha to check the reliability of the scale and the data collected. The co-efficient of alpha value for the pilot test was obtained as 0.804 thus indicating that the scale is greater than 0.7 and is internally consistent. Thus the data collected for the analysis satisfied the condition for reliability.
3. Microsoft Excel was used for the evaluation of the weighted average score to check the validity of the data collected from the responses. It was assumed that all the enablers scoring a value greater than 0.6 will be considered for further analysis. As all the variables have a value greater than 0.6 hence there was no elimination of enablers.
4. 251 responses were obtained from the 400 respondents to which the questionnaires were provided.

5.5 Descriptive Statistics and GSCM Pressures

Reliability Testing

Table 5.1 Reliability Statistics

Cronbach's Alpha	N of Items
0.804	20

The reliability analysis confirms the reliability of the enablers identified from E1 to E20 with the value of the co-efficient of alpha equal to 0.804. This value is above 0.70, which ensures the internal consistency of the construct and its validity which therefore leads to the validity of the questionnaire and its relevance.

- Commitment of Top Management, with the mean 4.0956, is lying within 4 and 5 (in the five-point scale of this research, 4 = Agree and 5 = Strongly Agree) and the standard deviation of 1.43625. 10 enablers have mean between 4 and 5 i.e. between Agree and Strongly Agree and the other 10 lie between 3 and 4 i.e. between Neither Agree nor Disagree and Agree which shows a good construct of the questionnaire.
- Cost, with the mean 3.5618, is within 3 to 4 (in the five-point scale of this research, 3= Neither Agree nor

- Disagree and 4 = Agree) and the standard deviation is 1.41392.
- Environmental Collaboration with the suppliers, with the mean 3.7410, is within 3 to 4 (in the five-point scale of this research, 3= Neither Agree nor Disagree and 4 = Agree) and the standard deviation is 1.53905.
- Environmental Control Norms, with the mean 4.1315 is within 4 to 5 (in the five-point scale of this research, 4 = Agree and 5 = Strongly Agree) and the standard deviation is 1.14309.
- Internal Service Quality, with the mean 3.9323 is within 3 to 4 (in the five-point scale of this research, 3= Neither Agree nor Disagree and 4 = Agree) and the standard deviation is 1.52558.
- Green Design, with the mean 3.7291 is within 3 to 4 (in the five-point scale of this research, 3= Neither Agree nor Disagree and 4 = Agree) and the standard deviation is 1.34399.
- Green Purchasing, with the mean 4.0279 is within 4 to 5 (in the five-point scale of this research, 4 = Agree and 5 = Strongly Agree) and the standard deviation is 1.21787.
- ISO, with the mean 3.9920 is within 3 to 4 (in the five-point scale of this research, 3= Neither Agree nor Disagree and 4 = Agree) and the standard deviation is 1.09176.
- Internal Green Production Plan, with the mean 4.0837 is within 4 to 5 (in the five-point scale of this research, 4 = Agree and 5 = Strongly Agree) and the standard deviation is 1.03391
- Presence of Performance Measurement Methods, with the mean 4.1474 is within 4 to 5 (in the five-point scale of this research, 4 = Agree and 5 = Strongly Agree) and the standard deviation is 0.82352
- Government policies and incentives, with the mean 4.2112 is within 4 to 5 (in the five point scale of this research, 4 = Agree and 5 = Strongly Agree) and the standard deviation is 1.08408.

5.6 GSCM Framework

The following GSCM framework was suggested to the company being studied for the case study. The framework includes:

- The ranking of the enablers according to the weighted average score and
- Action to be taken for the achievement of each of the enabler

Table 5.2 GSCM Framework

E's Code	Enabler	Weighted Average Score	Rank	Actions to be taken
E10	Presence of Performance Measurement Methods	0.854	1	Establish Stringent quality control methods
				Maintain a database of performance records
				Reward the good performers
E13	Local environment law puts pressure	0.844	2	Design the production system as per the laws
				Establish a department to co-ordinate with the local authorities
E11	Government policies and incentives	0.829	3	Availability of bank loans for technology upgradation
				Subsidies for green technology
				Tax rebates for the use of environment friendly technology
E4	Environmental Control Norms	0.826	4	Eliminate harmful emissions
				Replace the existing machineries with the eco-friendly ones
E14	Middle management supports the GSCM practices	0.826	5	Provide training to the executives
				Provide incentives for innovative ideas
E12	Organisation has a vision for GSCM	0.822	6	Arrange visits to other plants in foreign countries
				Establish a dedicated department
				Take up environment protection as CSR
E9	Internal Green Production Plan	0.821	7	Reduce power consumption in products
				Increase product life-span resulting in higher efficiency and productivity
				Improve Machine Uptime
				Promote refurbishing and recycling
E18	The organization follows methods for proper waste disposal	0.818	8	Improve Machine Performance
				Set rules for the proper disposal of the waste
				Set up a database unit to collect and record information about production
E1	Commitment of Top Management	0.816	9	Orient the policy towards green production
				Earmark budget for GSCM implementation and maintenance
E8	ISO	0.8	10	Make ISO Certification mandatory for all the departments
				Make all the employees aware of the ISO norms
E15	Organization has the budget for GSCM	0.797	11	Provide financial support to the departments
				Provide financial support for green activities in nearby area
E7	Green Purchasing	0.79	12	Purchase materials or parts only from Green Partners who satisfy green partner environmental quality standards and pass audit process in following regulations for the environment-related substances.
				Select suppliers who control hazardous substances in company's standard lists and obtain green certificate

E's Code	Enabler	Weighted Average Score	Rank	Actions to be taken
E20	Organisation wants to be a brand in GSCM	0.79	13	Mention carbon footprint on the products
				Mention water footprint on the product
E17	The organization follows methods for control of pollution	0.783	14	Conduct environment audits regularly
				Immediately replace the polluting machines
E19	Organization conducts GSCM related training and awareness programmes for the employees	0.773	15	Conduct seminars and conferences on GSCM
				Sponsor employees to academic institutes to upgrade their qualification
E5	Internal Service Quality	0.753	16	Improves communication
				Regular co-ordination meetings
E3	Environmental Collaboration with the suppliers	0.749	17	Quality control in inputs at vendor site
				Provide technological support to the suppliers
E6	Green Design	0.737	18	Downsize packaging
				Use --green/ packaging materials
				Cooperate with vendor to standardize packaging
				Promote Eco design
E20	Cost	0.716	19	Designed for recycling
				Finance is always available
				The cost of GSCM technology is affordable
E16	Organization has specialized human resource for GSCM	0.705	20	Train all the employees
				Sponsor the employees for specialized training/education
				Trained Professionals can be hired

If GSCM is implemented effectively then it can bring a major improvement in the environment thus leading to a better economic and environmentally secure practice.

5.7 Observations

- The steel manufacturing units use waste or residues as resources. The aim of this research is to find ways to improve the environmental, the operational and the economic performance.
- The presence of stringent emission norms from the industry and the compulsory installation and the use of electrostatic static precipitator has resulted in the abatement of the damage to the environment.
- The effluent disposal norms need to be strengthened and before its release a government authority should mandate the fitness to release it in the moving water.

5.8 Conclusion of Findings

This chapter presents the results and the key findings from both the questionnaire survey and the case study. The enablers were assigned codes and the respondents assigned 1 to 5 points to each of the enabler on the Likert Five Point Scale for the questionnaire of the case study and 1 to 10 for the questionnaire on the actions to be taken for the implementation of the GSCM framework development. The data was analysed on SPSS 22.0. The Cronbach alpha co-efficient values for the enablers were more than 0.7, which indicated a high reliability of the questionnaire for the pilot test and the case study. The high value of Cronbach alpha coefficient indicated a high degree of reliability of the survey questionnaire and also for the questionnaire of the actions to be taken for the implementation of the GSCM framework development.

6 CONCLUSION OF RESEARCH

The sample size can be increased in comparison to the large number of steel manufacturing units in Chhattisgarh. Due to the constraints related to data collection only 251 valid responses were obtained for this study. The sample size may be increased. The questions may be extended to other practices adopted in the industry on a micro level.

The case study method provided a detailed insight into the functioning of the steel industry in terms of GSCM

practices. The status of the industry in terms of non-compliance with the sustainable practices provided a valid reason to go ahead with the research.

6.1 Future Scope

- In view of the difficulties in the collection of data, a much bigger sample can be attempted which will provide a still better result and a comparative analysis can be made with the data of the steel industry in other countries.
- The GSCM framework developed may be applied across the geographical limits of the state and be implemented in other states also.
- The data collected for this research will pave the way for analysing it from different viewpoints and coming to a conclusion on different terms.
- The research can be expanded to micro level of the industrial processes.
- The findings of this research may be compared with the findings in the other industry.
- Interpretive Structural Modelling can be integrated with other methods to look for still better results.
- The implementation of GSCM in other industry can also be studied on the same pattern.

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