Implementation and value creation of Green Productivity by Green Supply Chain Management

[Debashree De, Sadhan K.Ghosh]

Abstract— Steel industry is the energy intensive sector directly affecting the growth of the nation. The effect of the restriction put by the government in terms of environmental emissions as well as the costs incurred due to change in environmental practices on the productivity is to be measured. The Green Productivity Index (GPI) is a cumulative index for measurement of the environmental effect and the economic performance. A system model is presented in this paper for analyzing strategy decision making by AHP analysis. A suggestion has been made for implementing the Green Supply chain process for deciding the priority in sequence of Green Manufacturing, Reverse Logistics, Green Marketing, Investment Recovery and Green Purchasing. An attempt has been made to analyze the amount of steel production, energy consumption and emissions in an integrated environmental sustainable framework from primary research data. To benchmark the productivity of a company considering the environmental effect, Green Productivity Index(GPI) is being calculated for three companies, namely Company A-Steel Giant, Company B-Customer of A, steel Processor and Company C -medium scale Steel industry. The analysis shows there has been a significant increase in the GPI after implementation of Green Supply Chain process in all the three companies. The trend of variation of GPI suggests that the Steel giant has improved better than the medium scale steel industry and hence it is able to adopt the Green Supply chain process better than mid scale industry. The steel processing industry B has an enhanced GPI due to the green supply chain management and the influence of greenness relationship between the supplier and customer.

Keywords— Green Productivity Index (GPI), Green Supply Chain Management (GSCM), Environmental Impact (EI)

I.   Introduction

Steel Industry is the energy intensive industry. It directly affects the GDP of a nation. Many researchers have analyzed energy consumption, CO_2 emission and energy efficient technologies in iron and steel industries [1]. Developing countries, like India do highlight economic development as a priority but now a requirement on priority for reduced environmental effect has come up. So, now the corporate companies focus on the integration of the Green Supply Chain Management(GSCM).

Debashree De
Post Graduate Student, Department of Mechanical Engineering, Jadavpur University India

Sadhan K.Ghosh
Professor, Department of Mechanical Engineering, Jadavpur University, India

Considering the environmental burden of the steel industry, the Pollution Control Board (CPCB), India restricts the limit of emission and the stack diameter of chimney. The short-term profitability motivates the companies to look the environmental protection as an obstacle to profit making [2].
Under the backdrop of the above scenario it becomes imperative to study the economic and environmental relationships of organization on adopting GSCM practices. The findings of the study are expected to be useful for justifying the overall environmental practices as economically positive.

The study of the effect of the Green Supply Chain on the Company's performance is done to relate supplier and customer's performance in the supply chain. From the economic perspective the environment is adversely affected by the processes of extraction, production and consumption of natural resources and generation of wastes. The excessive economic growth creates not only resource scarcity but also pollutants that might exceed the assimilative capacity of natural environments, thereby degrading essential life-supporting systems [3] and also affecting the bio diversity and destroying the flora and fauna of the area. Green Productivity Index (GPI) can be used as an index to benchmark the performance of the company considering the environmental aspect as well as economic aspect. Environmental performance evaluation is a quantitative approach to environmental decision making. It is defined as the ratio of productivity of the system to its environmental impact.

The process of adaptation of Green Supply Chain (GSCM) is an indicator for the increasing performance of the company. The idea is to develop a model for implementing the Green Supply Chain Management and answering the following research questions:

- What are the factors relevant to the Steel Industry for implementation of the Green Supply Chain Management?
- What should be the priority of implementing the strategies for the Green Supply Chain Management?
- What should be the measure of performance of a Company with regard to productivity and environmental effect?
- How do the company-Steel giant, mid scale steel industry and customer industry of the steel processing unit behave on implementation of the Green Supply Chain Management Practices?

II.   Literature Survey

Green Supply Chain Management (GSCM) is integrating environmental thinking covering all phases of product's life cycle from design, production and distribution phases to the use of products by the end users and its disposal at the end of product's life cycle[4,5].

From the study of literature, factors affecting Green Supply Chain have been identified which help to achieve the environmental sustainability in an organization. Factors have been divided into criteria [namely, Green Purchasing, Green marketing, Green Manufacturing, Reverse Logistics and Investment recovery] and sub - criteria in hierarchical order. From the literature each factor-criteria constraints associated with it have also been identified

2.1 Green Purchasing: Green Purchasing is process of selection and acquisition of product and services which minimizes negative impact over the life cycle of manufacturing, transportation, use and recycling and involves an organization assessing the environmental performance of their suppliers, which requires the suppliers to undertake measures that ensure environmental quality in their operation systems [6,7]. It is addition of the environmental aspects of price and performance criteria when making purchase decisions. It involves selection of supply chain partners (raw materials, components and sub assemblies suppliers) based on environmental standards and eco labels[8].It sets up a product standard which is with recycled content, products that are more species-friendly, products that are more energy saving, products that involves less harmful effects or less toxic chemicals in the production process or other intrinsic or extrinsic factors [9,10].Green Purchasing may help organizations achieve long term savings from protecting them from any potential damage to their brand value[11].

2.2 Green Marketing: Green marketing involves selling and promotion of products and services and highlights reduced environmental destruction [12].Advertising and marketing campaign may complement and help each other towards green efforts of organization; and further, may help in motivating customers by sales personnel and having positive perception about top management efforts towards greening[13].Green Packaging plays the most important role in the cooperation with customers [14].Environmental friendly packing refers to use of recyclable or dissolvable materials for packing. Environmentally packing and leveling of products has a clear objective of encouraging business to market greener products[15].

2.3 Green Manufacturing: Green Manufacturing aims at decreasing environmental impacts of manufacturing by reducing emissions, effluents and accidents[16]. Adopting green Manufacturing gives better working conditions: lower long-term and intangible liabilities, efficient and enhanced internal processes, lower regulatory costs, improved market opportunities and pre-empting regulation and reduced supply chain risk.

2.4 Reverse Logistics: It is the movement of goods in the reverse order, from destination(manufacturing plant for raw materials, warehouse for inventory and the consumers, retailers or distributors of the finished goods) to enable reprocessing, remanufacturing, repairing, reusing, recycling, disassembling or disposing. The measure of the reverse logistics efficiency can be done by the factors, Use of recycled products as raw materials, Waste management practices and Waste to energy conversion[17].

2.5 Investment recovery: It is considered green as it reduces wastes that could have been else discarded. It is a accessed by the factors, Investment recovery of excess inventories, Sales of scrap and used materials and Sales of excess capital equipment.[17]

III.   Methodology:

In this section there is a description of the suitable analysis for deciding importance of the factors and sub factors which affect the decision making and determining the priority of each factor. The calculation of Green Productivity is then carried out. With the study of trend variation by mean calculation and correlation techniques results have been drawn. **Hypothesis (HO$_1$):** Enterprises having higher level of implementation of Green Supply Chain practices have better environmental improvements, positive economic performance and less negative economic performance. **Hypothesis (HO$_2$):** There is no positive effect between the supplier performance improvement on the customer's performance improvement.

3.1   Identification of factors affecting the GSCM implementation: The identification of factors affecting implementation was done by literature review. The factors have been identified and hence divided into hierarchical order. Further discussion is done in section 3.4.2.

3.2 Survey questionnaire development and data collection: The survey questionnaire was developed to collect data from the experts, engineers working in the each company A,B and C by at least 35 employees. Further to understand the issues and working functionality face to face interview with experts were done.

Company A, B and C have been purposively selected due to the proximity of the researcher and Industrial Steel belt near Kolkata, India. Data were collected for the period 2007-2014.

3.3Analytic hierarchy process (AHP):
The strategy implementation has various criteria and sub criteria. The priority of strategy to implement the green supply chain process in the three different organization is to be studied. The goal, global objective determined is to implement green supply chain process. The criteria taken into account are Green Purchasing, Green Marketing, Green manufacturing, Investment recovery and Reverse logistics.

b. Hierarchical structure: Objective: Priority Strategic implementation of green supply chain process. Alternatives: Company A: Steel Giant; Company B: Processor and manufacturer of Steel Parts, A customer of Company A; and Company C:A mid-scale Steel Company but also a customer of Steel giant Company A. The Criteria and respective Sub-

Criteria are depicted in the table 1.

| Criteria		Sub-Criteria
Green Purchasing	C1	Providing design specification to suppliers with environmental requirements
	C2	Cooperation with suppliers for environmental objectives
	C3	Environmental audit for suppliers' internal management
	C4	Suppliers' ISO 14000 certification
	C5	Second tier supplier environmental friendly practice evaluation
Green Marketing	C6	Cooperation with customers for eco-design
	C7	Cooperation with customers for cleaner production
	C8	Cooperation with customers for green packaging
	C9	Cooperation with customers for least energy consumption in manufacturing
Green manufacturing	C10	Inventory management
	C11	Energy consumption
	C12	Lean approach
Investment recovery	C13	Investment recovery of excess inventories
	C14	Sales of scrap and used materials
	C15	Sales of excess capital equipment
Reverse logistics	C16	Use of recycled products as raw materials
	C17	Waste management practices
	C18	Waste to energy conversion

TABLE 1 GREEN SUPPLY CHAIN PROCESS
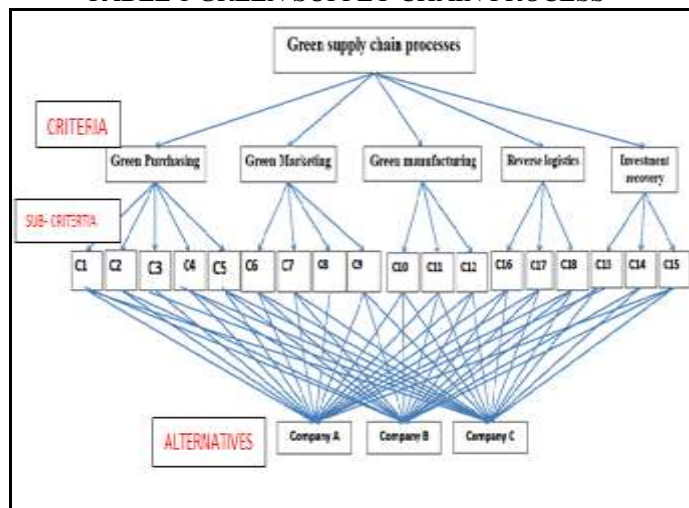
Figure 1. Green Supply Chain Framework

3.4 Green Productivity Index (GPI)

Productivity is the ratio of selling price to production cost.

$$GPI = \frac{SP/PC}{EI}$$

Where, SP=Selling price of a product, PC=product cost of a product and EI=environmental impact during manufacturing a product

EI=w_1SWG + w_2GWG +wC

Where, SWG=Solid wastes generation, GWG=Gaseous wastes generation and C=Water consumption and w_1, w_2, w are corresponding weights. GPI is a measure of environmental impact and also the production enhancement.
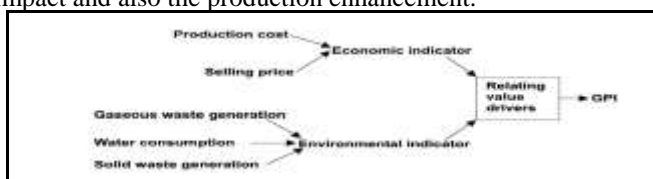

Figure 2.GPI development methodology

In composite indices, the specification of the weights for variables is an integral part of index development and the choice of weights reflect the importance given to the variables comprising the index. The weights for three environmental variables are derived from 2005 Environmental Sustainability Index (ESI) weights. The equal weighted sums aggregation method was used to derive ESI. Weights of six importance indicators of ESI are listed in the Table 2. The deriving of weights for three environmental variables of GPI from ESI weights is shown in the Table 3.

From Table II, weights for SWG, GWG and WC are found as, $w_1 = 0.17, w_2 = 0.5$ and $w_3 = 0.33$ respectively. Environmental impact during production of a product:

$$EI = 0.17SWG + 0.5GWG + 0.33WC$$

TABLE 2 GPI INDICATORS EQUIVALENT ESI INDICATORS

Name of the indicator	Weights in the ESI
Air quality	0.05
Water quality	0.05
Water quantity	0.05
Reducing air pollution	0.05
Reducing waste and consumption	0.05
Greenhouse gas emissions	0.05

TABLE 3 DERIVING OF ENVIRONMENTAL WEIGHTS

GPI indicators	Equivalent ESI indicators	Weight in ESI	Combined weights (x)	Weight (x/0.3) in the GPI
Gaseous wastes generation	Air quality	0.05	0.15	0.5
	Greenhouse gas emissions	0.05		
	Reducing air pollution	0.05		
Solid wastes generation	Reducing solid waste and consumption	0.05	0.05	0.17
Water consumption	Water quantity	0.05	0.10	0.33
	Water quality	0.05		
Total			0.3	1.0

To measure GPI the emphasis is on the development of economic and environmental indicators.

Environmental indicators

Processes have some impact on the environment but the impacts of steel industries are most vital as they have furnace, boilers etc highlighting it in the highly polluting industries and kept in a red category norm by the Indian Government.

In the selected company C, in a particular year 2010-2011, water consumption for a year was 830375 MT. Total liquid metal produced during the year was 310802MT. Environmental impacts for the production of 1 ton of hot liquid metal are:

- Water consumption is 2.6717MT.
- Solid wastes generation is 0.5492MT.
- Gaseous wastes generation is 0.8218MT.

$$EI = 0.17SWG + 0.5GWG + 0.33WC$$

EI=0.17*0.5492+0.5*0.8218+0.33*2.6717=1.3859   MT

Environmental impact during production of 1 MT of hot liquid metal is 1.3859MT.

Economic indicators

The processing cost is a performance measure of a production activity and it also considers hence the amount of raw materials that have been input to the system.

$$GPI = \frac{SP/PC}{EJ}$$

For the year 2010-2011 the SP/PC=1.1 evaluated from the data provided by the company B.

Hence, GPI=1.1/1.385925=0.7683

Similarly the data have been calculated for the three Companies A, B and C from year 2007 to 2014.The implementation of Green Supply Chain initiatives was started in the year 2010-2011 in all the three companies.

IV.   Findings and Discussion:

4.1 To identify the factors that affects the GSCM implementation in an organization. The identification was done by reading literatures based on GSCM, Suppliers assessment and SCM. The factors have been identified and hence divided into hierarchical order. Further discussion is done in section 3.4.2.

4.2 From the AHP analysis

Table 3 AHP ANALYSIS

	Green manufacturing	Green Marketing	Green Purchasing	Investment recovery	Reverse logistics	Normalized	CR
Green manufacturing	1	9	8	5	3	0.5506276	0.07727
Green Marketing	0.111111111	1	2	2	0.333333333	0.0940078	
Green Purchasing	0.125	0.5	1	2	0.2	0.0684729	
Investment recovery	0.2	0.5	0.5	1	0.5	0.0690879	
Reverse logistics	0.333333333	3	5	2	1	0.2177347	

Table 2:Pair-wise comparison of the criteria

Table 4 GPI VALUES

GPI	COMPANY A	COMPANY B	COMPANY C
2007-08	0.754	0.146	0.6707
2008-09	0.755	0.149	0.6714
2009-10	0.762	0.15	0.7413
2010-11	0.8	0.154	0.7683
2011-12	0.841	0.221	0.777
2012-13	0.892	0.25	0.7819
2013-14	0.89	0.265	0.794

4.5 To study the variation of the performance on implementation of the Green Supply Chain Process.

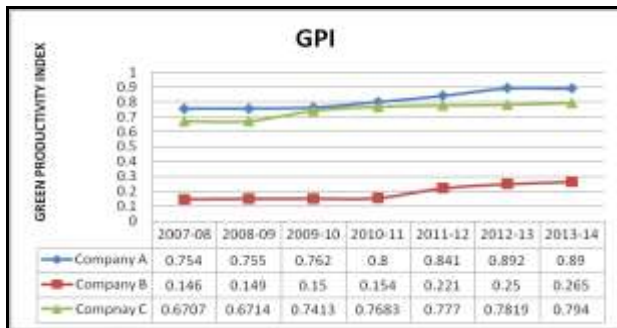| GPI	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Company A	0.754	0.755	0.762	0.8	0.841	0.892	0.89
Company B	0.146	0.149	0.15	0.154	0.221	0.25	0.265
Compnay C	0.6707	0.6714	0.7413	0.7683	0.777	0.7819	0.794

Figure 3. The trend of GPI

The graphs in Figure 3 shows an increasing trend of the GPI over the years after implementation of the Green Supply Chain process in the three companies A,B and C.

4.6 To study the behaviour of companies affected by the Green Supply Chain implementation.

The percentage change in the GPI is maximum in the Company B followed by Company A and Company C indicating that the mid-scale-customer is profited most by the Green Supply Chain process. Also the literature supports that the reason for the change in the Customer Company B is also due to the increase in the GPI of the Supplier Company A. In the steel industry the increase in the trend shows that the Steel giant is more capable of implementing and getting benefited from the green supply chain process than mid scale steel industry Company C.

Hence the Hypothesis HO_1 is accepted that is "Enterprises having higher level of implementation of Green Supply Chain practices have better environmental improvements, positive economic performance and less negative economic performance."

Figure 4. Change in the GPI of industries before and after green supply chain process implementation

TABLE 5 PERCENTAGE CHANGE IN THE GPI VALUE

	% GPI change after GSCM
COMPANY A	13
COMPANY B	50
COMPANY C	12

4.7 To study the relationship between the customers GPI-company B and supplier's GPI-Company A. TABLE 6 CORRELATION BETWEEN SUPPLIER A AND CUSTOMER B

		CompanyA	CompanyB	CompanyC
CompanyA	Pearson Correlation	1	.969'	.879
	Sig. (2-tailed)		.031	.121
	N	4	4	4
CompanyB	Pearson Correlation	.969'	1	.918
	Sig. (2-tailed)	.031		.082
	N	4	4	4
CompanyC	Pearson Correlation	.879	.918	1
	Sig. (2-tailed)	.121	.082	
	N	4	4	4

*. Correlation is significant at the 0.05 level (2-tailed).

Perusal of Table 7 revealed the co-relation co-efficient value of Company A with the Company B was found 0.969.It is significant at 5 percent level of probability. It means that the

company A exerted a significant effect on company B. This rejects the hypothesis HO_2 stated in null form that "there is no positive effect between the supplier performance improvement on the customer's performance improvement". Hence the alternate hypothesis is accepted that is "there is a positive effect between the supplier performance improvements on the customer's performance improvement".

It means that the performance improvement of the supplier affects positively the customer's performance.

v.   Conclusion:

The Green Productivity Index (GPI) of an organization is a performance measuring index of the environmental effect and the economic performance. The model presents an analysis of strategy decision making by AHP analysis. Analysis suggests, for implementing the Green Supply chain process the priority is in sequence of Green Manufacturing, Reverse Logistics, Green Marketing, Investment Recovery and Green Purchasing. The analysis integrates the amount of steel production, energy consumption and emissions to an environmental sustainable framework. To benchmark the productivity of a company with accordance to the environmental effect, Green Productivity Index(GPI) is being calculated for three companies, namely Company A-Steel Giant, Company B-Customer of A ,steel Processor and Company C -medium scale Steel industry. The analysis shows there has been a significant increase in the GPI after implementation of Green Supply Chain process in all the three companies. The trend of variation of GPI suggests that the Steel giant has improved 13 % which is better than the medium scale steel industry GPI change Percentage of 12% and hence it is able to adopt the Green Supply chain process better than mid scale industry.The steel processor industry B has an enhanced GPI change of 50% which is cumulative due to the green supply chain management and the influence of greenness relationship between the supplier and customer. A further scope of work is considering the amount of non-renewable energy source input to be integrated into the Green Productivity Index(GPI) so that performance can be studied with more generalized sense.

Acknowledgment

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About Author (s):

[For implementing the Green Supply Chain Management in Indian Steel industry, the priority advisable is in the sequence of Green Manufacturing, Reverse Logistics, Green Marketing, Investment Recovery and Green Purchasing.]