Performance Measurement of Green manufacturing criteria in Indian SMEs

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Abstract

Green Manufacturing is a method for manufacturing that minimizes waste and pollution. It slows the depletion of natural resources as well as lowering the extensive amounts of trash that enter landfills. Its emphasis is on reducing parts, rationalizing materials, and reusing components, to help make products more efficient to build. The approach of the research includes a literature review, in depth interviews and questionnaire surveys. This paper discusses about the important criteria of green manufacturing practices among the Indian manufacturing Industries. This research paper discusses about the analysis of 80 SMEs from automobile, chemical, plastic industries for its publication, as well as its content. Factor analysis is done using Statistical Package for the Social Sciences (SPSS) software to help managers understand the important environmental dimensions. The data are analysed using "mean score".

Keywords- Green manufacturing, SMES, Environmental Performance Measures, Factor Analysis.

1. Introduction

Manufacturing methods that support and sustain a renewable way of producing products and/or services that do no harm to you nor the environment. Green manufacturing is defined as the design, processing and commercial use of materials processes and products, which are economical and sustainable while minimizing pollution and risk to human health and the environment. Green Manufacturing is actually more of a philosophy rather than an adopted process or standard. In Green Manufacturing, environmental impact of all stages of production is considered. The manufacturer will not use any materials which are harmful to the ecosystem in the design, life disposal stages of the product. The goal of Green Manufacturing is to support future generations by attaining sustainability by preserving natural resources. Green Manufacturing" refers to a set of multidisciplinary approaches aimed at reducing (1) Energy consumption (2)) Material usage/toxic. Green manufacturing involves transformation of industrial operation in the three ways; (1) using green energy (2) developing and selling Green products and employing Green processes in the business operation. A recent global survey by BCG reveals that as many as 92 per cent. of the companies surveyed are engaged in green initiatives. Manufacturing companies that adopt Green practices benefit not only through long-term cost savings, but equally importantly, from brand enhancement with customers, better regulatory transactions, greater ability to attract talent and higher investor interest. The impact of Green initiatives also varies by the industry sector. For example – Green initiatives in power sector have the maximum impact on reducing CO2 emissions followed by transportation and then the industrial sector. Successful implementation of green manufacturing requires going beyond small standalone initiatives and adopting an integrated three step framework, (a) planning for Green as a core part of business strategy (b) executing Green initiatives across the value chain by shifting towards Green energy, Green products , and Green processes and (c) communicating and promoting processes to their benefits to stakeholders. Successful transformation into green manufacturing will bring tremendous benefits, both tangible and intangible.

This study explains the implementation of green manufacturing factor among the various manufacturing Industries located in India. Total 8 practices namely Management Initiative, Environment Friendly procurement Application of Green Design Technology, Implementation of green Manufacturing process , Environmental Legislation ,Performance assessment of Optimized Resources, Performance assessment Of Green cost are considered with 24 sub-criteria. This study consists of 5 section. After this introduction, in Section 2, review of the relevant literature is given. It helps in establishing a link among green manufacturing chain management and environmental performance measures. Section 3 contains research methodology

Result and comparative analysis of various factor of green supply chain management by calculating mean score ‘are presented in section 4. Finally conclusion is presented in section 5.

2. Literature Survey

Jian Xu & Qingshan Zhang et al (2008) [5] suggests that green manufacturing is a key technology to enhance the eco-industry and sustainable development .The view of continuing development and green manufacturing mode has been accepted by many government and society widely and the research and the implementation appears the trend of more and more international and law, it has formed a irreversible social power which challenges to the traditional manufacturing industry, it now affects and change the trend of the market. Ahmed A. Deif (2011) [6] develops a system model for new green manufacturing paradigm. the model captures the various planning activities to migrate from a lesser green to greener and more eco-efficient manufacturing . The various planning stages are accompanied by the required planning control matrices as well as various green tools in an open mixed architecture. The proposed model is a qualitative comprehensive approach to design and or improve green manufacturing system as well as roadmap to future quantitative research to better evaluate the new paradigm. Nkechinyere Vanessa Attah (2010) [7] emphasis on the concept of environmental sustainability with a focus on global efforts to achieve this. The purpose of this to prevent the impact of environmental degradation on society by some developed and developed countries such as Switzerland, United States and China. This also strives the balance between environmental sustainability can only be achieved through the integration of policies.

E.E Smith, (2010) [8] suggests the perception of consumers regarding greening in the manufacturing industry. Two hundred self-administered questionnaires were distributed to consumers in the designated population and 120 of these questionnaires were completed. Manufacturing firms are regarded as the major contributor to environmental pollution and global warming and thus need to realise the environmental impact of their activities. Practical guidelines are provided to assist manufacturing firms to become greener. Green awareness or environmental awareness has increased significantly over the years and therefore the need for green products has also increased. Consumers are becoming increasingly aware of manufacturing businesses damaging the environment.

Mohanthy and deshmukh (1998) [9] highlighting the importance of green productivity as a competitive edge. They defined green productivity as all activities attempting to decrease waste. Naderi (1996) [10] showed that green manufacturing is highly tied to waste management through the elimination of casual factors. Jovane et al (2003) [11] presented the sustainable and green manufacturing as future paradigm with business model based on designing on environment using nano/bio/ material technologies. They highlighted that new paradigm will respond to the customer need of more eco-friendly products. Wang and Lin (2007) [12] proposed triple bottom line framework to track and categorize sustainability information at the corporate level through a sustainability index system. Burke and Goughran (2007) [13] also presented another framework for sustainability to realize green manufacturing. The framework was based on their studies of SME manufacturtereres who achieved ISO 14001 certification.

As per Devi s. kalla and Aron Brown (2012) [14] concerns about the Green manufacturing is an emerging field in recent years and is also the sustainable development model for modern manufacturing industries. Sustainable green manufacturing emerges the concept of combining technical issues of design and manufacturing, energy conservation, prevention, health and safety of communities and consumers. Many industries are directing their resources to reduce the environmental impact of their produced products and services. Engineering technology education strives to produce graduates who are ready to perform at a high level immediately after receiving their degrees and who can achieve strong professional growth throughout their careers. In this case the importance of infusing sustainability into current mechanical/manufacturing engineering technology curriculum in order to address current unsustainable practices in industry and society. As per Yixiang Xu, Milford A. Hanna and Loren Isom (2008) [15] utilization of renewable resources to replace petroleum as a primary feedstock for liquid fuels, chemicals and materials has become a topic of interest around the world. The fossil fuel crisis and environmental concerns has been courage scientist to explore new resources and pathways for chemicals production. Low cost and sustainability, together with chemical compositions similar as fossil feedstock’s, render biomass a promising raw

material for production of biochemical. Technological advancements, including bio-refineries, heterogeneous catalysts and genetic engineering, guarantee development of green chemicals from biomass.

3. Research Methodology

The quantitative approach was chosen as the research design. Hypotheses testing were used to test the relationships that exist among variables. The dependent variable or measured outcome in this research is Performance of optimized Resources, Performance Assessment of Industrial Emissions, and Performance Assessment of Green Cost whereas the independent variable Management Initiative, Environmental Friendly Procurement, Application of Green Design and technology and Implementation manufacturing Process and Environmental Legislation.

A set of questionnaires, which is adapted based on past research, was used to measure these variables. All variables were examined individually to determine whether significant relationship exist between them. The data was collected from marketing managers, operation managers and those managers who have been involved in Green manufacturing operation. The unit of analysis in this Patalganga, turbhe in Navimumbai.

Based on their feedback, with each sub-criteria falling under their respective criteria/major criteria. At the end of pre-testing stage, 24 sub-criteria under the heading of 8 major criteria were finalized. Each criterion in the questionnaire was judged on a 5 point. Likert Scale, where, 1 = very low, 2 = low, 3 = moderate, 4 = high and 5 = very high.

3.1 Data Collection Method

The primary data in this study was collected through interviews with marketing managers, operating managers, general managers, or managing directors with experiences in product development. The data collection was conducted within one-month period using personal interviews. This study mainly depended on personal interviews because it gave higher response rate compared to other methods. Telephone calls explaining the purpose of the study were made to relevant departments of each organization before any arrangements of appointment being made. About 90 sets of questionnaires were distributed to the manufacturing companies. Out of this, only 80 sets of questionnaires were collected and 80were usable for further analysis. Secondary data in the form of public records, journals, books, master's theses, and magazines that reflect the area of investigation were also being extensively collected and reviewed for this study.

3.1.1 Data Analysis

J. Pallant stated in her book that reliability can be measured in various ways. The most common method to measure reliability is by using Cronbach's alpha, which was carried out using SPSS. This statistic indicated the correlation of the items that make up the scale. The values ranged from 0 to 1, with higher values indicating greater reliability. Nunnally (1978) recommended a minimum value of 0.7. Cronbach's alpha values are dependent on the number of items on the scale. If the number of items in the scale are less than 10 (as in this study, where each criteria has 10 or less sub-criteria under it) then Cronbach's alpha values can be quite small. Here, the mean inter-item correlations were calculated. J. Pallant recommended their optimum value to be above 0.3. Item analysis was conducted for each of the 24 parameters through a mean score method. These dimensions are represented in the form of questionnaire, for measuring the different facets of green manufacturing practices implementation.

4. Factor analysis, comparative analysis of criteria, Result and Discussion

4.1 Reliability Analysis

Reliability indicates the extent to which an experiment, test or any other measuring procedure yields the same results. Reliability analysis was carried out using total 24criteria on SPSS software. The final Cronbach's values and the range of correlation coefficients proved that the scale chosen was free from random error. It also proved that the sub-criteria had been properly assigned to their respective criteria as final Cronbach's Alpha values were more than 0.7. Table 1 with reliability analysis confirms that all the 7 major criteria were suitable for applying factor analysis.

Table-1 Reliability Analysis

Factor	Cronbach's Alpha
Management Initiative(MI)	0.743
Environmental Friendly Procurement(EFP)	0.697
Application of Green Design and Technology(AGDT)	0.819
Implementation of Green Design and Technology(IGDT)	0.885
Environmental Legislation(EL)	0.757
Performance assessment of industrial emission (PAIE)	0.789
Performance assessment of Optimized Resources(PAOR)	0.751
Performance assessment of Green Cost(PAGC)	0.750

4.1.1 KMO and Bartlett's Test of Sphericity

The next appropriateness for factor analysis was determined by examining the strength of relationships among the sub-criteria. This was conducted by three measures, the coefficients in the correlation matrix, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of Sphericity. Tabachnick and Fidel recommended an inspection of correlation matrix for evidence of coefficients greater than 0.3. He stated that if only a few correlations above this level are found, then factor analysis may not be appropriate. The Bartlett's test of Sphericity should be significant ($p < 0.05$) for the factor analysis to be considered appropriate. The KMO index ranges from 0 to 1 with 0.6 recommended as the minimum value (J Pallant, 2001). Meanwhile Digalwar and Sangwan, (2007) recommended KMO value more than 0.5 as optimal. A visual inspection of the correlation matrix in Table 1 revealed that a majority of the correlations were greater than 0.3. This indicated that the sub-criteria had common factors (Digalwar and Sangwan).

Table-2 KMO and Bartlett's test of Sphericity

Criteria	KMO	Bartlett's significance value (p)
For independent variable	0.745	0.0000
For dependent variable	0.763	0.0000

Analysis of the KMO measure using SPSS in Table 2 revealed that all the measures meet the required standard. Bartlett's test indicated that all the criteria were significant i.e., $p < 0.05$.

4.1.2 Factor Analysis

Factor analysis was conducted on each criterion. The components were extracted in SPSS using principalcomponent analysis with varimax rotation. Initially, factors with Eigen value over 1 were extracted and the scree plot along with the unrotated factor solution analyzed. Those factors with significant slope above the bend in the scree plot were extracted [11]. A sample component plot for Green manuafaturting practices are shown in the Fig-1.

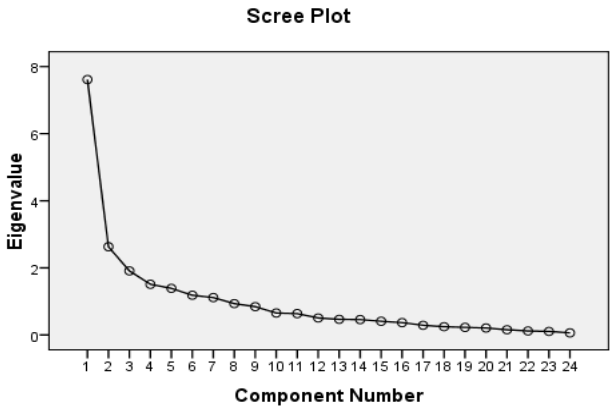

Fig-1 Sample Scree plot for all components

Table-3 Factor analysis of green manufacturing variable (independent variable)

	Component			
	1	2	3	4
M1				0.848
M2				0.783
EFP2		0.615		
EFP3		0.674		
AGDT1			0.732	
AGDT2			0.747	
AGDT3			0.809	
IGMP1	0.859			
IGMP2	0.850			
IGMP3	0.851			
EL1		0.623		
EL2		0.806		
EL3		0.638		

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

From this above rotational matrix Table 3 it has been found that all the dimensions are unit dimensionality.

Eight green manufacturing with 24 underlying dimensions considered in this study and each dimension has its own importance for effective green supply chain performance. Table 4 shows the mean values (M) and standard deviation (S.D) of the criteria and sub-criteria respectively obtained from various respondents. The tables show the important criteria in the descending order of their means. Higher mean values indicate more important criteria.

Table-4 Performance of main factors

Criteria	Mean	Standard Deviation
Performance assessment of Industrial emission (PAIE)	4.2500	0.64631
Environmental Legislation (EL)	4.0417	0.85746
Performance Assessment of optimized Resources (PAOR)	4.0042	0.74156
Implementation of Green Manufacturing Process(IGMP)	4.0042	1.09947
Management Initiative (MI)	3.7708	0.96170
Performance Assessment of Green Cost(PAGC)	3.7500	0.7767
Application of Green Design and Technology (AGDT)	3.6667	1.08952
Environmental Friendly Procurement (EFP)	3.5333	0.88367

Among all eight green manufacturing factors performance assessment of industrial Emissions was the most important criteria for the manufacturing industries. Performance assessment of Industrial Emission was followed by Environmental legislation and Performance assessment of optimised resources respectively.

Table-5 Importance of Sub-Criteria-Application of Green design and Technology

Sub-Criteria	Mean	Standard Deviation
Product design meet environmental Regulation and safety standards	3.9125	1.22436
Product design for easy dismantling and recycling of materials	3.6625	1.24213
Design of product for renewable energy sources (like CNG, LPG ,Solar etc.) or optimum consumption of materials and environmental energy	3.4250	1.792

Application of Green design and Technology which had 3 underlying was having Product design meet environmental Regulation and safety standards as the most important dimensions (3.9125) followed by Product design for easy dismantling and recycling of materials (3.6625).

Table-6 Environmental Friendly Procurement

Sub-criteria	Mean	Std. Deviation
Use of electronic processes for procurement process	3.7500	1.17463
Selecting eco-friendly product suppliers	3.6625	1.0811
Procurements mainly from ISO14000 certified suppliers	3.1875	1.15937

Environmental Friendly Procurement which had 3 underlying dimensions was having Use of electronic processes for procurement process as the most important dimensions (3.7500) followed by selecting eco-friendlyproductsuppliers (3.6625).

Table-7 Performance Assessment of Green Cost

Sub-criteria	Mean	Std. Deviation
Reduction in energy consumption cost	3.8625	0.89646
Reduction in Human Resources cost.	3.7125	0.91671
Reduction in water and air pollution treatment cost	3.6750	1.04063

Performance Assessment of Green Cost which had 3 underlying dimensions Reduction in energy consumption cost as the most important dimensions (3.8625) followed by Reduction in Human Resources cost(3.7125).

Table-8 Management Initiative

Sub-criteria	Mean	Std. Deviation
Awareness of govt. norms and regulation intended for clean environment among the employees	4.1125	0.96766
Application of environmental protection issues and norms	3.9500	1.06617
Degree of Implementation of ISO 14001 certification	3.2500	1.54674

Management Initiative which had 3 underlying dimensions, Awareness of govt. norms and regulation intended for clean environment among the employees was having as the most important dimensions(4.1125) followed by Application of environmental protection issues and norms (3.9500).

Table-9 Implementation of Green manufacturing Process

Sub-criteria	Mean	Std. Deviation
Minimizing use of toxic and hazardous material and optimizing energy consumption during manufacturing	3.97500	1.21150
Consideration of environmental issues in Selection of manufacturing processes	3.9000	1.24800
Consideration of environmental issues in production Planning and Control	3.8625	1.19856

Implementation of Green manufacturing Process which had 3 underlying dimensions, Minimizing use of toxic and hazardous material and optimizing energy consumption during manufacturing as the most important dimensions (3.97500) followed by Consideration of environmental issues in Selection of manufacturing processes (3.900).

Table-10 Performance Assessment of Optimized Resources

Sub-criteria	Mean	Std. Deviation
Optimized Man power use	4.0625	0.83201
Optimized Energy Consumption	4.0375	0.83353
Recycling Of waste wastewater	3.9125	1.06965

Performance Assessment of Optimized Resources which had 3 underlying dimensions ,was having of Optimized Man power use as the most important dimensions, (4.0625)followed by Optimized Energy Consumption (4.0375) .

Table-11 Environmental Legislation

Sub-criteria	Mean	Standard Deviation
Does it follow emission norms ?	4.3750	0.7855
Does it follow Clean Air Act?	4.1625	1.04873
Does it follow resource conservation and recovery Act?	3.5875	1.24975

Environmental Legislation which had 3 underlying dimensions, Does it follow emission norms? was having the most important dimensions (4.3750) followed by Does it follow Clean Air Act?(4.1625) .

Table-12 Performance assessment of Industrial Emissions

Sub-criteria	Mean	Standard Deviation
Reduction of waste water	4.2625	0.75881
Minimization of solid waste and other waste products	4.2500	0.75473
Minimization of air pollution	4.2375	0.79443

Performance assessment of Industrial Emissions which had 3 underlying dimensions was having the most important dimensions (4.2625)followed by Minimization of solid waste and other waste products (4.2500).

5. Conclusion

The research presents practitioners with a 1 to 5 item measurement scale for evaluating the different facets of their green manufacturing process. Green manufacturing is a relatively new green issue for the majority of Indian industries. The present empirical study investigated the Green

manufacturing process adopted by different industries in Maharashtra, India. The study investigated the important performance measures for green supplier selection by "mean method".

The study shows that among all 8 green manuafaturting Performance measures, Performance assessments of Industrial Emissions are the most important criteria for the manufacturing Industry in India. Performance assessment Industrial emissions followed by the Environmental Legislation and Performance assessment of Optimized Resources. Then finally implementation of green manufacturing process will follow the application management initiative towards and green manufacturing process , which follow up the performance value of green cost i.e. whether the industries can invest the cost in air pollution and water treatment cost and finally the product which is used for green manufacturing process was recyclable and the supplier should be from ISO14001 and supply the eco-friendly products to the industries which is weaker in these parameters.

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