Study of Environmental Sustainability and Green Manufacturing Practices in the IndianAutomobile Industry

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Abstract: Automobile manufacturing firms across the world are making use of optimised, sustainable and environmentally friendly processes and technologies to manufacture vehicles and reduce impact on Humans and the Environment. The focus of this paper is to study the sustainability trends in Indian automobile manufacturing industry and to study the importance given to various green practices such as recycling, green marketing, green logistics etc. in Indian automobile industry.

To gain insights into the industry perspective, a questionnaire was designed and floated through an online survey to various executives of the automobile industry in India.The survey is designed for both original equipment Manufacturers [OEM's] and two and three tier automobile component manufacturers and vendors/suppliers in India. The questionnaire focused on the following factors in the automobile industry: Green Product Design, Green Technology Implementation, Green Procurement, Green Logistics, Lean Management, Waste Management, Eco-labelling and Green Marketing etc. The second part of the questionnaire looked at the importance given to adverse safety and environmental impacts. The third part looked at the importance given to various competitive environmental policies by the companies. 41 executives from the automobile industry participated in the survey. They were requested to rank the competitive environmental policies of their organization on various factors like Cost, Flexibility, Quality and Reliability, Innovation, Delivery, Morale, Customer Relations and Productivity. After getting the responses, Analytical Hierarchy Process (AHP) was used to rank the priorities.

The results of the study show that the automobile industry of India considers Green Logistics and green power as the highest prioritized criteria and Green Procurement has been given the least importance. Considering the impacts of the existing processes, adverse safety impacts are given a higher importance than adverse environmental impacts. In the parameters for competitive environmental policies, Innovation has been ranked the highest by the participants followed by morale, flexibility and productivity. The results show that automobile companies focus on innovation for competitiveness. The challenges faced by companies in switching to greener technologies and greener manufacturing processes, were the high cost compared to conventional methods and the low returns and less dedication from the top management of the companies. The other main challenge faced by companies in moving to greener production is the energy production. It is very difficult to generate the required amount of energy by greener or renewable means. The findings of this study will be helpful for firms across the Globe working or aspiring to work on sustainability and green manufacturing in the automobile industry.

Keywords: Automobile Industry; Green Manufacturing; Green SupplyChain,Sustainability; Environmental Management

Introduction

Green manufacturing is defined as "manufacturing practices that do not harm the environment during any of its journey phases". It involves green design of products, use of environment friendly raw materials, eco-friendly packing, distribution, and reuse after end of life of product. It slows the depletion of natural resources and lowers the trash(Paul,2014). It emphasizes on reducing parts, rationalizing materials and reusing components. Green manufacturing includes optimizing material usage along with reducing amount of material used and reusing components. It also focuses on 6R's i.e. reduce, reuse, recycle, redesign and remanufacture. Along with 6R's it also focuses on waste management, environmental protection, pollution control and other allied requirements (Rehman,2016).

Automobile companies are facing pressures from customers and the governments due to sustainability issues, health issues near manufacturing locations and global climate change (Kushwaha, 2016). Due to the increasing pressure, companies are taking action to improve their processes, technologies and operations so as to cause minimum damage to the environment.
To understand and identify the issues, challenges and the extent to which Indian automobile manufacturing firms have adopted green manufacturing, it is important to analyse the aspects with which this sector works.
In the global economy, the automobile industry is transforming rapidly. The evaluation and measurement of its performance is essential when environmental issues have been addressed all over the world. (Lin, 2011; Zhu, 2007). Setting up environmentally friendly goals, practices and relationships within the supply requirements bears a potential for all automobile manufacturers and suppliers, to impart new knowledge to the under-resourced stakeholders. It acts as a motivator for organizations to extend their goals of corporate social responsibility and to lead the industry (Simpsonet.al 2007)

The auto supply chain continues to strengthen with the evolution of the Indian automotive industry (Zhang, 2013). Logistics cost in India is around 13% of GDP. For developed countries, it is up to 8%-9%. Higher logistics costs are led by the predominant use of road transport. These impact the competitiveness of the auto supply chain.

Objectives of the study

- To review the various green manufacturing practices such as recycling, green marketing in Indian automobile industry
- To identify the priorities for implementing green technologies such as eco-design, clean production, green purchasing/distribution, etc. in Indian automobile sector

Scope of the study

The project aims to rank the green practices,initiatives, technologies in Indian automobile industry. The study is focused and restricted to automobile industry in India and is based on a survey based on a questionnaire related to green manufacturing and sustainable initiatives, motivators and limitations faced by companies in going green. The survey is designed for both original equipment Manufacturers [OEM's] and two and three tier automobile component manufacturers and vendors/suppliers in India.

Literature review

The study by Jie et.al., (2011) shows that companies are selective about those GSCM activities requiring cooperation with external actors on the supply chain. About 70% of the respondents are asking their upstream suppliers to provide cleaner materials or products to avoid possible environmental risks. Green procurement is thus an important factor. Similarly, the results of the study by Nunes &Bennett (2010) show that the world's three major car manufacturers are pursuing various environmental initiatives involving the following green operations practices: green buildings, eco-design, green supply chains, green manufacturing, reverse logistics etc., thus these points were taken into consideration while designing the questionnaire. The study by Lin et.al.,(2011) shows that the increase of cost for purchasing environmentally friendly material is the most influential and significant criterion, while the pollution control initiatives is the most effective criterion. These criteria is with reference to GSCM performance in automobile manufacturing

The study by Mitra& Datta(2014)shows that supplier collaboration for environmental sustainability had a positive impact on environmentally sustainable product design and logistics, this was also positively related to competitiveness and economic performance of the firm. The study by O'Brien (1999) discusses and finds out the various challenges faced by the companies in achieving sustainable operations management. The various

characteristics of sustainable production system and issues faced in policies have come out in focus through this paper. In the study by Dornfeld (2014) the requirements of green technology are discussed along with methods and tools to insure they are effectively applied and their impacts measured.

Methodology

Analytical hierarchy process (AHP)

In this paper, with the help of survey, factors affecting implementation of green manufacturing techniques, limitations and priorities given by companies to various competitive environmental policies are identified. Also, various environmental aspects on basis of the organization's present status are identified through the Analytical Hierarchical Process (AHP) (Alonso, 2006)

Analytical Hierarchy Process (AHP) is one of the Multiple Correspondence Analysis approaches.The advantage of AHP over other processes is that it can directly assign weights (Konstantinos, 2018). It offers a logical and representative way of structuring the decision problem and deriving priorities. It was formulated by Saaty in 1980 and is commonly used in sustainability assessment research. It ranks tangible and intangible factors against each other for resolving conflict or setting priorities. Also, it compares decision factors by pairs and assigns weights to reflect their relative importance. The advantage of AHP is that it does not require very strong assumption that the stakeholders make absolutely no errors in providing preference information. Hence, it offers a logical and representative way of structuring the decision problem and deriving priorities. It is used as a framework for presenting and discussing various dimensions and criteria to review the Indian automobile industry. An earlier study by Shao, Taisch& Mier (2016) used AHP as a method for comparisons. The decision-maker judges the importance of each criterion in pair-wise comparisons. This study focuses on formulating an AHP-based model to evaluate the sustainability performance of the product. Other tools like the modified two stage DEA [Data envelope analysis] model to simultaneously characterize a sustainable manufacturing process and measure the overall efficiency and its sub-stage efficiencies has been used by Wu *et al*.,(2017) but AHP is more popular.

Questionnaire Design

A survey questionnaire was designed and administered to obtain insights into the environmental sustainability and green manufacturing practices in the automobile industry. The questionnaire was designed by taking valuable inputs from the existing literature. A study by Olugu in 2011 found that Customer perspective had the highest score. This was followed by quality, supplier commitment, management commitment, and cost. The reverse chain measures were topped by management commitment in terms of importance.The study byZhu et.al.,(2010) focused on the Japanese manufacturers implementing four GSCM practices. These are green purchasing, customer cooperation with environmental considerations, eco-design and investment recovery – at similar levels when compared to Chinese manufacturers. The inputs from this study and other similar studies has been used while designing the questionnaire.

Table 1: Literature review table on green practices

AUTHORS	METHODOLOGY	FINDINGS	CONCLUSION/LIMITATIONS
Ki-Hoon Lee (2011)	Qualitative interview and case study	Case study of Hyundai Motor Company revealed steps taken by them to reduce carbon footprint. Identification of supplier's carbon footprint. Development of a carbon process map	Firms can track their carbon footprint by analysing their supply chain for carbon footprint. Firms should manage their carbon footprint of the product to reduce carbon emission.

Cathy Rusinko (2007)	Exploratory study: survey	Pollution Prevention practices ranged from a low of 84.6 to a high of 100. Among those who use pollution prevention practices, the predominant competitive manufacturing outcome reported was decreased manufacturing cost.	Study is focused on the competitive manufacturing outcomes of cost and product quality. Few product stewardship practices have a substantial effect on quality.
Paul Nieuwenhuis, Eleni Katsifou (2015)	Case study	Moving the de-coupling point can build a more sustainable car manufacturing model	Thescope for creating a more economically viable automotive industry that is potentially more sustainable with more positive social and environmental impacts
Qinghua Zhu, Joseph Sarkis, Kee-hung Lai (2007)	Survey	The results state that different manufacturing industry types display different levels of GSCM implementation and outcomes. Specifically, the electrical/electronic industry has relatively higher levels of GSCM implementation and achieves better performance outcomes than the other three manufacturer types.	The implementation levels of GSCM in four environmentally sensitive manufacturing industrial sectors in China differ based on the five generic categories of GSCM practices and specifically in externalGSCM practices. As the electronic/electrical industry possesses more experience of international business and the power generating industry faces higher regulatory pressure, these two industrial sectors adopt GSCM at higher levels than the automobile industry.
Dayna Simpson, Damien Power and Daniel Samson (2007)	Survey	Suppliers were found to be more responsive to their customers' environmental performance requirements where increasing levels of relationship-specific investment occurred. As the level of investment in the customer supplier relationship increased, suppliers become less likely to believe that they would be penalized for non-compliance with the customer's environmental performance requirements.	Survey data were collected in 2004 and are limited to the Australian automotive industry. The sample size available for the regression analysis also precluded the use of more comprehensive analytic techniques. The research offers new insight into the issue of how firms might improve the environmental performance of suppliers and the sustainability of their supply chain.

Qinghua Zhu, Joseph Sarkis, Kee-hung Lai (2007)	Survey	This paper explores the GSCM pressures/drivers (motivators), initiatives and performance of the automotive supply chain using an empirical analysis of 89 automotive enterprises within China.	The results show that the Chinese automobile supply chain enterprises have experienced high and increasing regulatory and market pressures and at the same time have strong internal drivers for GSCM practice adoption. However, their GSCM implementation, especially with consideration of external relationships, is poor. Therefore, GSCM implementation has only slightly improved environmental and operational performance, and has not resulted in significant economic performance improvement.
Ali Diabat, Kannan Govindan (2011)	Literature review and expert opinion	The various drivers important to the implementation of green supply chain management practices were identified based on literature review and a decision-making team which included experts from the industry. Based on contextual relationship among identified drivers, a Structural Self-Interaction Matrix (SSIM) was developed.	Government regulation and legislation and reverse logistics are significant drivers to achieve the collaboration between product designers and suppliers to reduce and eliminate product environmental impact driver, which is in tern critical to achieving the GSCM certification of suppliers' environmental management system driver. Limitation: The model is highly dependent on the judgements of the expert team.

Table 2: Details of the designed Survey questionnaire

Sr. No	Questions
1	Please rate the following environmental aspects based on your organization's present status • Green Product Design • Green Technology Implementation • Green Procurement • Green Logistics • Green Supply Chain Management • Green Energy/Power • Lean Management • Waste Management • Green Labelling/Eco-labelling • Green Marketing • Green Advertising • Green Buildings
2	Please rate the following table for Evaluation of Impacts of EXISTING manufacturing • Adverse Environmental Impacts • Adverse Safety Impacts
3	Please indicate the rank for the competitive environmental policies of your organization • Cost • Flexibility • Quality and Reliability • Innovation • Delivery • Morale • Customer Relations • Productivity • Sustainability
4	What are the main challenges in implementing Green technologies in the organization?
5	Your recommendations on Green Manufacturing, if any?

The questionnaire was designed using the above aspects and respondents were asked to rate the responses on a 7-point Likert scale where 1 indicated least priority and 7 indicated highest priority.
The questionnaire was administered online through LinkedIn and email to personnel working in the Indian automobile industry such as Bajaj Auto, Hero Motocorp, TVS, Royal Enfield, Maruti Suzuki, Volkswagen Ashok Leyland and John Deere.

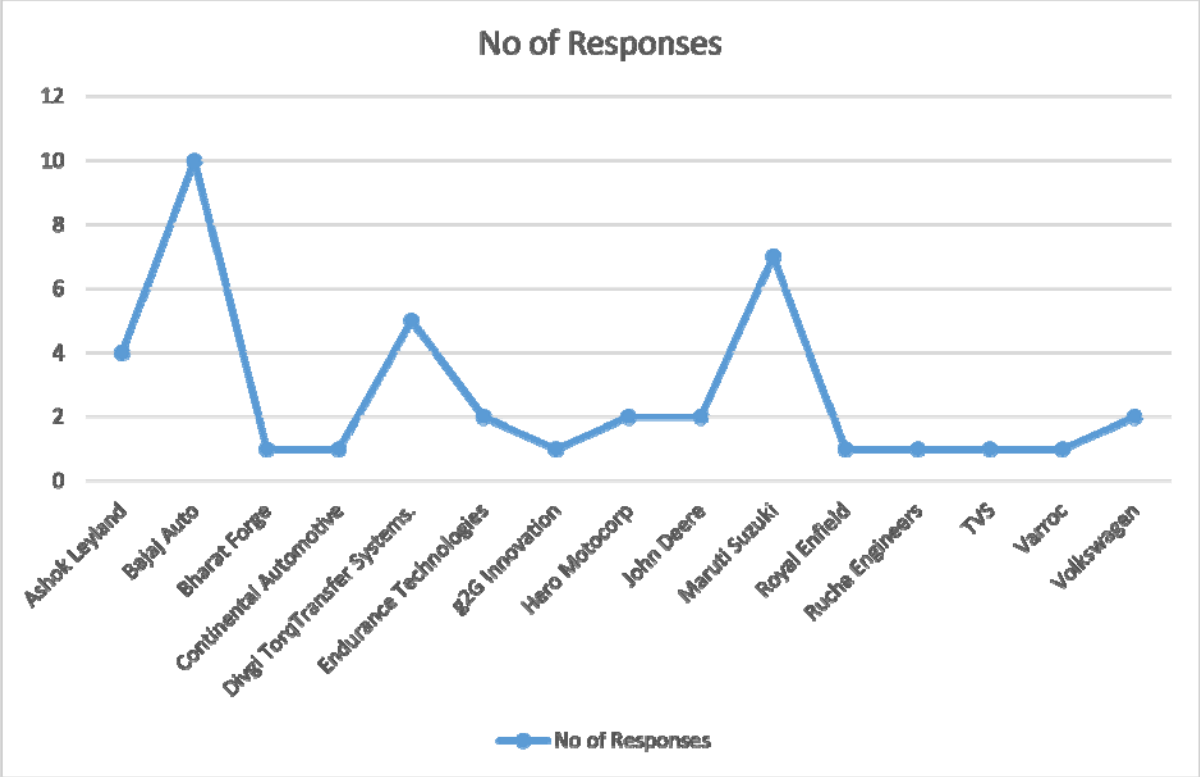

Figure 1: Number of responses from companies

A total of 43 responses were obtained. Two of the questionnaires were incomplete; hence the final number of questionnaires considered for the study was 41. Analytical Hierarchy Process (AHP) with an application for component classification is used in this paper to analyse the responses received and rank the priorities of companies for green manufacturing. Since there are three main questions asked in the survey, three different AHP matrices are created and evaluated (Lee, 2009)

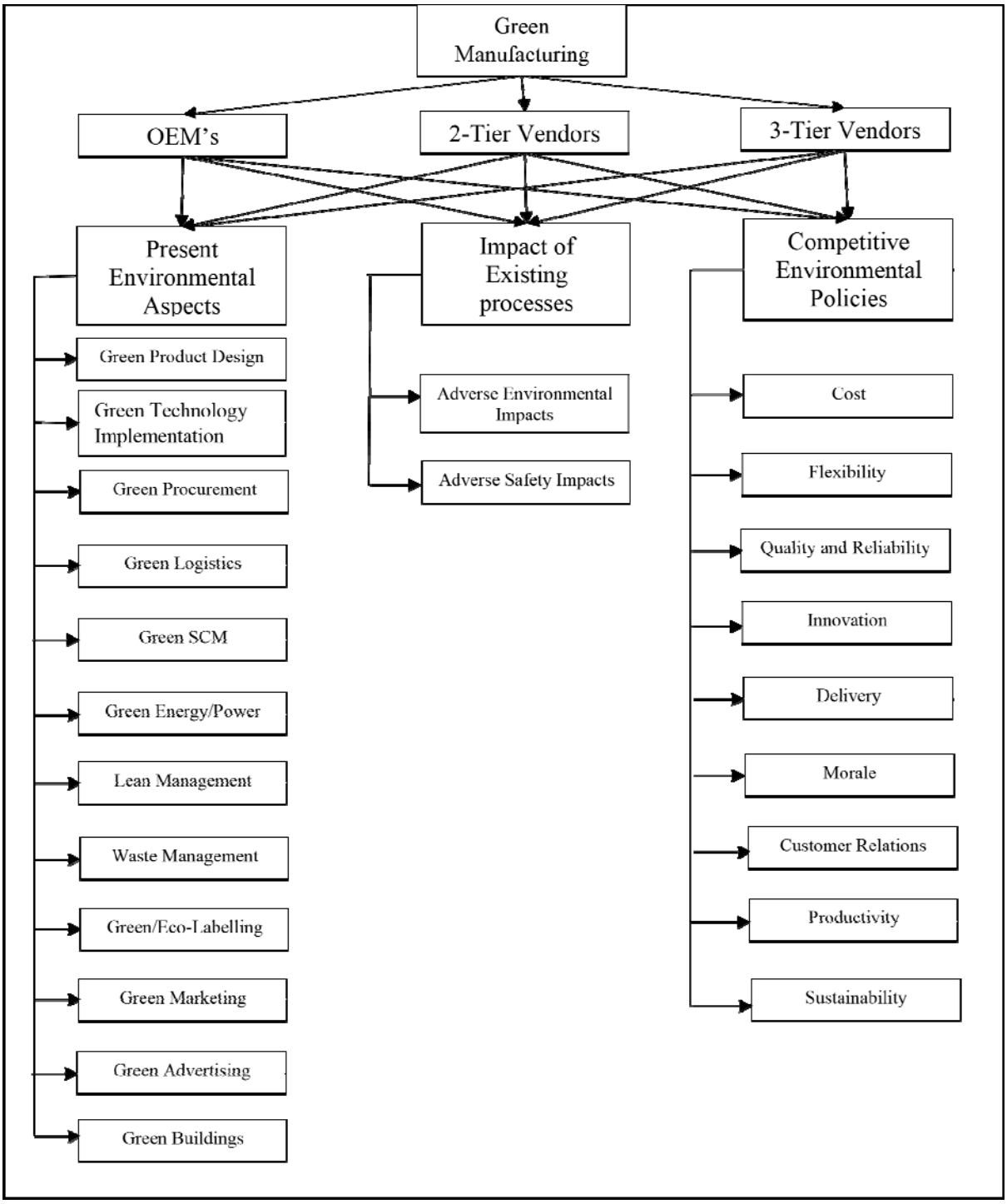

Figure 2: Hierarchy of AHP

- Level 1: Green Manufacturing (Goal)
- Level 2: Type of Automobile Manufacturing Companies
- Level 3: Parameters for Review

Further, each parameter has separate sub-levels. Local weights of each aspect of sub-level are identified.
The following steps were followed to get the results, first the Pair-wise comparison matrix of all parameters was carried out. Then the Geometric Mean and Relative Importance of each parameter was calculated

Table3: GM and RI of each parameter

Present Environmental Aspects	Geometric Mean	Relative Importance
Green product design	0.623	0.034
Green technology implementation	3.046	0.164
Green Procurement	0.266	0.014
Green logistics	4.330	0.233
Green supply chain management	0.289	0.016
Green energy/power	3.684	0.198
Lean management	0.781	0.042
Waste management	1.433	0.077
Green labelling/eco-labelling	0.392	0.021
Green marketing	2.484	0.134
Green advertising	0.683	0.037
Green buildings	0.577	0.31

Results and Discussion
Ranking of the parameters

After ranking the parameters by descending order of the overall ratings, we obtained the following results.

Table 4: Ranking of parameters for present environmental aspects

Present Environmental Aspects		
	Score	Rank
Green product design	0.034	8
Green technology implementation	0.161	3
Green Procurement	0.015	12
Green logistics	0.231	1
Green supply chain management	0.016	11
Green energy/power	0.195	2
Lean management	0.043	6
Waste management	0.078	5
Green labelling/eco-labelling	0.024	10
Green marketing	0.133	4
Green advertising	0.037	7
Green buildings	0.033	9

The most important and preferred parameter for green manufacturing in Indian automobile industry is Green Logistics, whereas Green procurement stands at the end. The study by Diabat, et.al.,(2013) supports these findings, The Green Supply Chain Management ranking results of this study show that design for environment, cooperation with customers, and reverse logistics are the top three GSCM practices which should be implemented to improve the GSCM performances. The results of the study by Zhu andSarkis (2006) show that the automobile industry has the highest marketing pressures, significantly stronger than power plants and significantly stronger than the electronic industry, this can be compared to the high rating of 4 given to green marketing in our study.

Lean management is ranked 6th by the participants of the survey. The focus on lean management can be compared to the study in Wang, et.al in 2015. The results of this study show that Lean practices such as 'multifunctional employees', TPM, and 'continuous improvement' practices contribute significantly in improving social and environmental sustainability.

Similar calculations are done for the other two aspects, i.e., Impact of Existing Processes and Competitive Environmental Policies. The rankings obtained are as follows:

Table 5: Ranking of parameters for impact of existing processes on environment

Impact of Existing processes		
	Score	Rank
Adverse environmental impacts	0.167	2
Adverse safety impacts	0.833	1

Table 6: Ranking of parameters for competitive environmental policies of the companies

Competitive Environmental Policies		
	Score	Rank
Cost	0.046	6
Flexibility	0.209	3
Quality and Reliability	0.020	9
Innovation	0.287	1
Delivery	0.023	8
Morale	0.226	2
Customer Relations	0.052	5
Productivity	0.101	4
Sustainability	0.036	7

Adverse safety impacts are on top affected parameters by existing manufacturing processes. In the parameters for competitive environmental policies Innovation has been ranked the highest by the participants followed by morale, flexibility and productivity. Innovation is the sector where Indian automobile sector is looking at for future developments. An earlier study by Sezen, et.al., (2013) shows that Eco process innovation has a significant positive impact on corporate sustainability. The results of this study show that though eco-product innovation is not as effective as Eco process innovation and that eco-process innovation had positive effects on corporate sustainability performance.

Major Findings

The major finding of this research was the trend and the preference of Indian automobile industry towards sustainable ways of production, for a greener tomorrow. After receiving the responses, it was found that the industry has a lot of potential to improvise and contribute to green manufacturing. The research was made particularly in three verticals. One, to know the present environmental aspects in various companies. Two, to know the impact of the present manufacturing processes on the environment. And three, to know the focus of the companies for competitive environmental policies, making them stay in the competition.

For automobile industry in India, logistics is the main aspect and has been ranked on the top. Followed by green logistics, the second most important factor is green energy or power. However, green procurement and green supply chain, green labelling remains at the bottom, which implies that these are the factors where the automobile industry can work upon to turn them into environmentally friendly processes.
When the impact of the existing manufacturing processes was analysed, it was found that more impact on safety happens as compared to environmental impacts. The processes may harm the health and safety of human beings near the manufacturing plant.
Innovation and moral stands at the top when the companies are asked about their competitive environmental policies.

Quality, delivery, and sustainability being the must haves in any product or service, companies might not be considering them a factor of differentiation for remaining competitive in the market and because of which they have ranked these aspects at the last. When asked about the challenges faced by companies in switching to greener technologies and greener manufacturing processes, the main reasons which came forward were the high cost compared to conventional methods and the low returns, less dedication from the top management of the companies. Also, the challenge faced by companies in starting greener production is the energy production. It is very difficult to generate the required amount of energy by greener means because of low outputs. The processes which are green or eco-friendly do not produce products with required quality standards because of which they cannot be used in the factories.

Product design and manufacturing is the key to reducing resource consumption, because of which innovation is the top priority in the Indian automobile manufacturing industry.

Conclusions

The automobile industry of India considers green logistics and green power as the highest prioritized criteria and green procurement has the least priority given. Considering the impacts of the existing processes, adverse safety impacts are given a higher rank than adverse environmental impacts by the executives of the participating companies. As far as competitiveness is concerned Innovation is the parameter where the companies are focusing the most.

For doing this research, the automobile manufacturers of India are considered. Whereas, green manufacturing or sustainable production are global issues, and need worldwide attention. Because of which, a further research can be done by taking global manufacturers of automobiles into account. (ÕBrien, 1999)
This study was carried out with the help of a survey. A future research on a larger scale can be carried out by conducting interviews with personnel from the industry along with a survey.
The companies looking forward to switch to greener technologies in future must take the trend in the industry into consideration and start the transformation process. Also, along with this change in the operations, companies should also maintain their core competitiveness.

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