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Sustainable Supply Chain Management in India: Industry-Specific Drivers and Practices

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A B S T R A C T

Sustainable Supply Chain Management (SSCM) is important in India for the growing awareness of environmental issues and the stringent regulations according to market-driven expectations that demand-sustainability. This paper seeks to explore such industry-specific drivers and practices of SSCM adoption across three principal sectors in India: power generation, automotive manufacturing, and electronics production. The research highlights the critical role played by various governmental regulations, such as Environment Protection Act or Extended Producer Responsibility (EPR), in pushing the company towards adopting environmental measures.

In the power sector, companies have taken measures to control emissions, including gas-flow desulfurization and the use of low-sulphur coal. As a policy, companies also recycle fly ash to be applied to construction material. Automotive manufacturing companies have gone to electric and hybrid vehicles as being propelled by strict environmental norms and overall global competition. Otherwise, the lesser-used and more expensive technologies are brought in to be put to practical applications for viable cleaner emissions. Along similar lines, substantial pressure and tension are faced by manufacturers of electronics because of international take-back obligations and current e-waste legislation at home, which require formulation of systems for recycling as well as waste management

This investigation concludes that certain factors like compliance regulations, economic incentives, and CSR play a role. All industries show that the most global of global supply chains have the most advanced sustainability practices due to export compliance rules. The research finds that the implementation of SSCM in business processes should be reinforced by government support, investment in green technologies, and active corporate management engagement. These are the measures to make industrial sustainability in India shine and improve national competitiveness in global export markets.

Keywords: *Automotive Manufacturing, Environment Protection Act, Extended Producer Responsibility (EPR), e-waste Regulations, Green.*

1. INTRODUCTION

Sustainable Supply Chain Management (SSCM) has come into vogue as a strategic response to these complexities, with organizations streamlining their operations according to environmental, social, and economic objectives. By making their supply chains more sustainable, businesses can preferably decrease their environmental impact while simultaneously improving their operational efficiency and competitive position in the global markets. SSCM encompasses beyond the mainstream practices of supply chains by necessitating the adoption of environmentally conscious, socially inclusive, and economically viable tactics across the entire supply chain life cycle. In India, a number of factors have enhanced the relevance of SSCM, namely, increasing environmental awareness, evolving vistas of regulation, and the emergence of consumers with sustainability concerns.

The findings of this project underscore the importance of a multi-stakeholder approach in advancing SSCM in India. Continued policy support, investment in green technologies, and active engagement from management are essential for embedding sustainability into business strategies. By adopting such measures, Indian industries can not only enhance their environmental and social performance but also strengthen their global competitiveness. Ultimately, this research aims to pave the way for a more sustainable industrial ecosystem in India, aligning economic growth with environmental and social well-being.

2. IMPORTANCE

- The scope of this study on Sustainable Supply Chain Management (SSCM) in India: Industry-Specific Drivers and Practices encompasses a comprehensive exploration of sustainability practices across major industrial sectors in India, focusing on the power generation, automotive,

and electronics industries. It covers various aspects of SSCM, including regulatory frameworks, technological innovations, corporate strategies, and environmental management practices.

3. OBJECTIVES

- To Identify Key Industry-Specific Drivers
- To Analyse Sector-Specific SSCM Practices
- To Assess the Role of Regulatory Frameworks
- To Recommend Policies for Managerial Strategies

4. LITERATURE REVIEW

Carter and Rogers **(2008)** - proposed a theoretical framework linking sustainability to supply chain competitiveness through environmental, social, and economic dimensions This model underscores the importance of environmental sustainability as a strategic asset.

Research highlights that government policies significantly influence SSCM adoption. Rao and Holt **(2005)** - demonstrated that regulatory pressures compel firms to implement green practices to avoid penalties and enhance market access.

In India, the Environment Protection Act and E-Waste Management Rules drive sustainability practices, particularly in the power, automotive, and electronics sectors. Studies by Srivastava **(2007)** and Zhu et al. **(2008)** explored industry-specific SSCM drivers, emphasizing sectors with high environmental impacts.

Technological innovations like blockchain, artificial intelligence, and Internet of Things (IoT) have facilitated real-time monitoring and transparency in supply chains. Dubey et al. **(2019)** found that digital technologies strengthen SSCM by enabling better decision-making and resource optimization.

5. NEED OF THE STUDY

Sustainable Supply Chain Management (SSCM) is becoming an important strategy used by industries to weigh economic development against environmental concerns. In India, the industries are facing increasing difficulties due to stringent environmental regulations, global competition, and an aware consumer base with regards to sustainability concerns. Although some developments have taken place, a large number of sectors are still in the process of adopting acceptable environmental practices due to regulations that lack coherence, technology constraints, and inadequate infrastructure.

The need for this study arises from the pressing requirement to understand how different industries in India respond to sustainability pressures. While regulatory compliance is often cited as the main driver, the integration of sustainability into business operations goes beyond meeting legal requirements. Companies must adopt proactive strategies involving emission reduction, waste recycling, and cleaner production technologies to remain competitive globally.

6. METHODOLOGY

The research regarding Sustainable Supply Chain Management in India: Industry-Specific Drivers and Practices adopts different research methodologies, that relate to qualitative and quantitative data collection and analysis. The basic aim of the methodology is to analyze sustainability drivers, regulatory impacts, industry practices, and managerial responses in the Indian context.

The survey was run in three steps:

Surveys during workshops: On 45 questionnaires sent during a workshop in October 2023 at the Indian Institute of Management, Ahmedabad, 28 usable responses were collected.

1. Interviews and field visits: To familiarize field practitioners with SSCM practices within Indian industry settings, interviews and site visits were organized in Bengaluru Industrial Zone and Chennai Manufacturing Corridor. An additional 22 responses were added, aggregating multiple responses from the same enterprise into one entry.

2. Second Workshop: In February-March 2024, a workshop was held at the National Institute of Industrial Engineering (NITIE), Mumbai. This second-round survey aimed at mid-level managers from the selected industries. From 100 distributed questionnaires, 65 usable responses were obtained, consolidating multienterprise responses.

Data Sources Company and Industry

Sustainable Supply Chain Management (SSCM) has come into vogue as a strategic response to these complexities, with organizations streamlining their operations according to environmental, social, and economic objectives. By making their supply chains more sustainable, businesses can preferably decrease their environmental impact while simultaneously improving their operational efficiency and competitive position in the global markets. SSCM

encompasses beyond the mainstream practices of supply chains by necessitating the adoption of environmentally conscious, socially inclusive, and economically viable tactics across the entire supply chain life cycle. In India, a number of factors have enhanced the relevance of SSCM, namely, increasing environmental awareness, evolving vistas of regulation, and the emergence of consumers with sustainability concerns.

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Overview of VRL Logistics:

VRL Logistics Limited is one of India's leading logistics and transportation companies, with a significant presence in the cargo and passenger transportation sectors. Founded in 1976 by Dr. Vijay Sankeshwar, the company has grown from a modest fleet of vehicles to a diversified and expansive network that serves both urban and rural areas across the country. VRL Logistics operates in various domains, including freight transportation, courier services, and bus passenger transport, making it a critical player in India's logistics and supply chain ecosystem.

The company's mission is to deliver reliable and efficient logistics solutions by leveraging state-of-the-art technology, a robust infrastructure, and a customer-centric approach. With its headquarters in Hubballi, Karnataka, VRL Logistics has established itself as a trusted partner for businesses across multiple industries, including retail, e-commerce, automotive, and pharmaceuticals. The company's commitment to operational excellence, sustainability, and innovation has enabled it to remain competitive in the dynamic logistics sector.

Impacts:

1. Internal Environmental Management
2. Green Purchasing
3. Cooperation with customers on environmental requirements
4. Investment Recovery
5. Eco-design practices

7. RESULT ANALYSIS

We contrasted the drivers/pressures and practices of SSCM in three industries in India. To check for significant differences in drivers/pressures and practices among these industries, we have run a one-way analysis of variance (ANOVA). Further, two-tailed independent-samples t-tests were performed to determine whether one industry has advanced farther than the other two in some respects. Composite factors were analyzed first for insights across the board, and the specific items within those factors were evaluated afterward.

Based on literature [27,36,41,45,47–49] and inputs from experts in environmental management with experience in the Indian manufacturing industries, the environmental drivers/pressures were classified into five groups. Table 1 gives the updated distribution of surveyed enterprises, while Table 2 elaborates on the group categories and specific elements incorporated into the questionnaire. Composite factors and items for each category, together with the means and standard deviations, are shown in Table 2. The last four columns of Tablecontain t-test and ANOVA results for the industries related to Proposition 1.

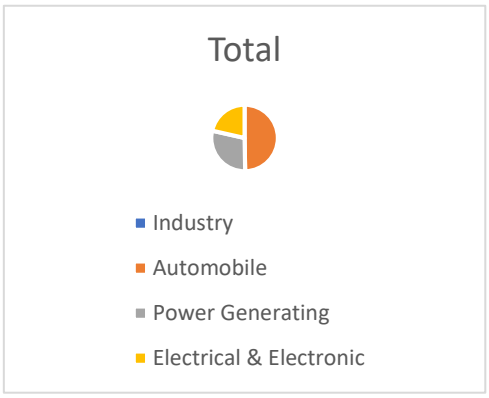
From the ANOVA results in Table 2, only one composite factor, marketing, is found to have significant differences (<0.05 level) among the three industries, while some internal factors are found to have marginal differences (<0.10 level). In general, ANOVA results of the five composite factors only partially support Proposition 1. Further, from the t-test, automobile industries were found to have the highest marketing pressures significantly against power plants, and slightly

against the electronics industry. Minor but significant differences were observed in the internal composite factor, indicating higher marketing pressures on the automobile sector, including any other factor that substantially affects driving the industries.

Updated Table 1: Distribution of Survey Respondent Enterprises

Category	**Total**	**Percentage**
Industry		
Automobile	**88**	**50**
Power Generating	**51**	**28.8**

Category	Total	Percentage
Electrical & Electronic	**38**	**21.2**
Total	**177**	**100**
Size (Employees)		
>3000	**42**	**23.7**
500–3000	**87**	**49.2**
≤500	**48**	**27.1**
≤100	**14**	**7.9**
Total	**177**	**100**
Ownership		
State-Owned	**108**	**61.0**
Foreign Direct Investment/Joint Venture	**41**	**22.9**
Private	**29**	**16.1**
Total	**177**	**100**



Paths to Regulation

In India, regulatory pressures remain the strongest drivers for SSCM adoption. As shown in Table 2, for almost all sectors, the means of four items exceed 4.00 except for import countries' environmental regulations in the power generation sector, which fits the observation that most of the generated power is consumed within India.

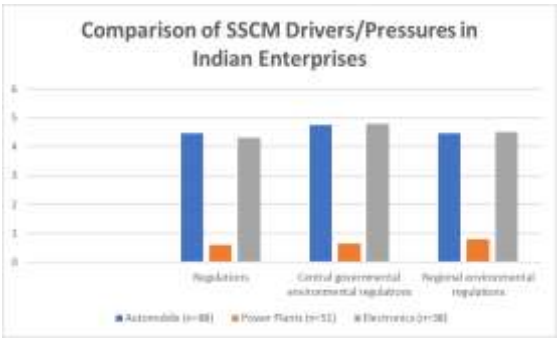
According to the ANOVA results presented in Table 2, there are significantly different pressures exerted by central governmental environmental regulations across industries. T-tests further indicate that there is no statistically significant difference between the automobile and power generation industries, but there are significant differences between the electronics sector with the other two sectors.

The automobile sector sees domestic central government environmental regulations as the most pertinent, scoring a mean of 4.75 because of stringent emission standards for vehicles. So too, thermal power plants perceive extremely high pressure due to the government's stringent regulations on sulfur dioxide emissions, with a mean score of 4.79. The electronics industry being "clean" is exerted with much less pressure in regard to central government laws.

Our survey results have also indicated that regional environmental regulations are the next major pressure, with an average mean of 4.40 for all industries. This could be due to regional governments bringing in stricter regulations in order to tackle more localized environmental problems.

Updated Table 2: Comparison of SSCM Drivers/Pressures in Indian Enterprises

Item	Automobile (n=88)	Power Plants (n=51)	Electronics (n=38)	ANOVA (F-statistic)	Industry Comparisons (t-tests)
	Mean	S.D.	Mean	S.D.	Mean
Regulations	4.46	0.596	4.31	0.507	4.27
Central governmental environmental regulations	4.75	0.632	4.79	0.415	4.24
Regional environmental regulations	4.47	0.796	4.50	0.590	4.06
Import countries' environmental regulations	4.47	0.754	3.88	1.361	4.29
Products potentially conflicting with laws	4.14	0.805	4.08	0.830	4.25



Regulations at the state level, acting as an enforcement mechanism for stricter environmental standards than those imposed by the country's central government, play an important role in driving the sustainability-focused strategies of industries. Table 2 indicates through ANOVA and t-tests that means for these three industries are not significantly different.

There is a fair consistency across industries about product awareness conflicting with the laws. The automobile industry scores 4.14, while the power plants are rated 4.08, with electronics companies scoring slightly higher at 4.25. This could indicate that the electronics industry is more aware of environmental issues due to its export activities and working with foreign clients. ANOVA and t-tests also show that there are no statistically significant differences between the industries in their mean ratings for this variable.

Discussion of Results

The Indian scenario paints a different picture altogether in terms of drivers and pressures for adopting Sustainable Supply Chain Management (SSCM) practices, with varying degrees of implementation across different industries. This preliminary work attempts to draw the line on where these differences lie and to pinpoint those industries further along in terms of the adoption of SSCM practices, chiefly those highly sensitive and impactful in the environmental arena.

Automobile Sector

The automobile sector in India is under severe pressure to move toward SSCM, especially by external factors like environmental regulations in export markets and consumer demand for greener products.

Power Generation Industry

The power plants in India have been strongly regulated to boost environmental progress. Domestic regulations of power generation and the environmental mission of corporate development

8. FINDINGS

- Regulatory Pressures as a Primary Driver
- Export Market and Foreign Regulations Impact SSCM Adoption
- Internal Environmental Management Enhances Performance
- Variation in Marketing Pressures Across Sectors
- Corporate Social Responsibility (CSR) and Reputation Management

9. RECOMMENDATIONS

- Strengthen Policy Support for Investment Recovery
- Enhance Training and Capacity-Building Programs
- Promote Certification and Compliance with International Standards
- Encourage Sector-Specific SSCM Adoption Strategies
- Incentivize Green Innovation and Technology Adoption

10. CONCLUSION

In conclusion, the Indian industries studied face a complex interplay of regulatory pressures, market demands, and environmental challenges that influence their adoption of SSCM practices. While the automobile industry is still catching up, power plants and the electronics sector have made more significant strides, driven by both domestic and international pressures. Future research should further explore the specific drivers of SSCM in these industries and assess how regulatory policies, in particular, can continue to propel the adoption of sustainable practices across Indian industries.

Lye et al. highlighted that ecological damage can be minimized if all stages of a product are designed to be environmentally sustainable [63]. In the Indian context, through cooperation with both upstream and downstream companies, Sustainable Supply Chain Management (SSCM) has the potential to improve environmental performance not just for individual companies but for the entire supply chain. O'Brien emphasized that creating a sustainable economy in developing countries like India presents a challenge: achieving economic parity with the developed world without extensive pollution of the environment [28]. At the same time, the manufacturing sector holds a particular responsibility for achieving international sustainability standards. This paper examines the drivers and practices of SSCM in three major manufacturing sectors in India.

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