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Driving Profit through Sustainability: The Role of Green Supply Chain Practices in Enhancing Resilience

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Abstract: ***This paper analyzes the impact of Green Supply Chain Management (GSCM) on operational resilience and profitability for Indian Electric Vehicle (EVS) manufacturers. A total of 200 managers, engineers, and others associated with the supply chain responded to a structured questionnaire containing items measuring GSCM practices, operational resilience, and profitability based upon a five-point Likert scale. Descriptive Research Design methodology was employed. Data collected through the survey were subjected to statistical analysis using SPSS-25, including reliability analysis, descriptive statistics, correlations, and regression analysis. Results indicate that all of the constructs demonstrate adequate levels of reliability as reflected by their corresponding Cronbach Alpha values exceeding .80; thus, demonstrating adequate levels of reliability in the measures. Additionally, results of the descriptive analyses indicated moderate to high levels of GSCM practice usage among the EV firms. Moreover, results of the descriptive analyses demonstrated a strong perceived level of operational resilience and profitability. Results of the correlation analysis demonstrated a highly statistically significant positive association between GSCM practices and both operational resilience (r = .712), and profitability (r = .645). These findings suggest that the implementation of GSCM contributes to greater operational stability resulting in increased financial performance. Furthermore, results of the correlation analysis demonstrated a positive association between operational resilience and profitability (r = .689). Finally, results of the multiple regression analysis demonstrated that GSCM practices (Beta = .521) and operational resilience (Beta = .384) each positively influence profitability while collectively explaining 53.6% of the variance in the model. Overall, these findings suggest that although "green" practices may necessitate certain initial investment costs, long term benefits such as improved efficiency, reduced risks and ultimately enhanced competitiveness will provide cost savings. As such, overall, this study demonstrates that GSCM is a critical strategic tool for enhancing sustainability efforts while improving firm resilience and profitability in today's rapidly evolving EV environment.***

Keyword: Green Supply Chain Management, Operational Resilience, Profitability in Electric Vehicle Industry.

I. INTRODUCTION

The growing global need for environmentally friendly products, low-carbon footprints, and conservation of natural resources have significantly impacted every part of business. Green Supply Chain Management (GSCM) was therefore created as a new paradigm for Supply Chain Management (SCM), incorporating "green" factors into each area of the Supply Chain (procurement, production, distribution, reverse logistics). The aim of GSCM is to minimize ecological damage, increase productivity and enhance long-term company performance (Sarkis, 2019). For developing nations like India with the duality of economic development and environmental destruction, there is an increasing need for adoption of green practices. The auto-industry specifically the electric vehicles (EV) manufacturing section in India is a perfect example to implement GSCM. The EV manufacturing sector is experiencing rapid growth due to rising gas prices, environmental awareness and government incentives such as the Faster Adoption and Manufacture of Hybrid and Electric Vehicles Scheme (FAME) in India. However, many different types of supply chain challenges still exist in the EV manufacturing sector. These are based upon EV manufacturing's dependence on imported raw materials such as lithium and cobalt; lack of supporting infrastructure; and vulnerability to external events. The aforementioned challenges highlight the need for additional strong, sustainable supply chains (Ahi et al., 2013).

Supply Chain Resilience refers to a supply chain's ability to prepare for disruptions, respond to disruptions, and recover from disruptions. Since previous examples indicated how important resiliency is for complex, interdependent industries such as EV manufacturing, it also provides an opportunity to maintain supply chain continuity and competitiveness (World Economic Forum, 2021).

Practices of GSCM, such as local procurement, improved energy efficiency through reduction of consumption and waste generation, and implementation of circular economy-based strategies to support a sustainable supply chain can promote resilience in a supply chain by providing fewer dependencies on limited supplies and enhancing flexibility. Additionally, these practices allow organizations to achieve environmental sustainability by minimizing emissions and conserving natural resources (Carter & Rogers, 2008).

Another aspect of GSCM is its influence on profit margins. While some researchers have argued that green practices require high up-front investments, others have suggested that green practices can generate long-term cost savings and higher profits for firms through enhanced operational efficiencies and stronger brand identities (Chopra & Meindl, 2019). Given the rapidly changing nature of the technology-driven EV marketplace, understanding relationships among GSCM, resilience, and profitability will become increasingly important for firms competing in this space.

While considerable literature documents GSCM practices and environmental performance, little prior research has evaluated simultaneous links between GSCM and both resilience and profitability. In addition, very few studies document GSCM-related research in developing countries.

Therefore, the overall goal of this dissertation is to investigate whether or not GSCM positively affects both resilience and profitability in the Indian automobile EV manufacturing industry. Through analysis of the extent to which green practices are adopted in the EV manufacturing industry in India, along with an evaluation of those practices' positive impacts on resilience and profitability; this research will provide useful information to manufacturers and policymakers involved in the automotive EV industry.

Additionally, this research will aid in establishing more resilient and efficient supply chain networks in the rapidly evolving Indian automobile EV ecosystem (Christopher, 2016).

II. RESEARCH METHODS

This investigation employs a structured systematic research method to assess the impact of Green Supply Chain Management (GSCM) on operational resilience and profitability in the Indian automobile electric vehicle (EV) manufacturing environment. Both descriptive and analytical designs are utilized to present a clear understanding of the current state of affairs in relation to current GSCM practices and an assessment of the connections among key variables (Govindan et al., 2014).

This study is cross sectional in nature; therefore, data was collected at one moment in time in order to represent the current situation of the automotive EV manufacturing industry. Primary data collection was achieved through surveys administered through both written questionnaires and interviews with personnel involved in EV manufacturing operations and those responsible for managing supply chains. The use of primary data ensures that a realistic view of industry-wide GSCM practices will be available (Mentzer et al., 2001).

Secondary data was obtained from articles published in academic journals, industry reports and government documents in order to assist in validating the theoretical framework used to guide the research.

The number of respondents included in the survey totaled approximately 200. Respondents included individuals working in EV manufacturing companies as well as personnel responsible for managing supply chains for these companies. Nonprobability sampling methods were utilized to identify suitable respondents. Convenience sampling and purposive sampling were two nonprobability sampling methods that were used. The advantages of utilizing both types of nonprobability samples ensure that only qualified and knowledgeable individuals working within the EV manufacturing domain participated in the research project (Statista, 2024).

Statistical Package for the Social Sciences (SPSS) was the statistical package selected for analyzing collected data. Multiple statistical procedures were employed in analyzing data collected throughout this study. Mean and standard deviation measures of central tendency were calculated to describe respondent demographics along with frequency levels for adopted GSCM practices. Correlation coefficients were computed to assess the directionality as well as intensity of relationships between GSCM practices, resilience to disruptions, and financial profitability. Linear regression analyses were also performed to determine if any statistically significant relationships existed between GSCM Practices (Independent Variables) and dependent variables (Resilience to disruptions, financial profitability). Hypothesis testing was performed to verify the existence of hypothesized relationships among variables assessed during this research study (Chopra & Meindl, 2019).

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III. RESULTS AND DATA ANALYSIS (SPSS OUTPUT FORMAT)

A. Sample Profile

The demographics of all respondents provide insight to the nature of the sample. In terms of gender representation, 66% of respondent were men; 34% of respondents were women. Thus, this sample was predominantly composed of males. This could be reflective of the typical gender breakdown found in technical/managerial professions.

When examining the level of work experience, the largest group of respondents had an amount of work experience between 5-10 years (41%), thus indicating that most respondents were middle-management employees with significant exposure to their industry. There were 32% of respondents who reported having over 10 years of work experience. Therefore, there was a large number of senior employees included as part of this study. Finally, 27% of respondents indicated they had less than five years of work experience; these respondents would represent those at the beginning of their careers. As such, the distribution among these categories enhanced the overall quality and dependability of findings across various levels of employee experience (Dubey et al., 2019). Respondents' jobs consisted primarily of managers (44%), followed closely by engineers (36%) and then "other" types of jobs (20%). The high percentage of managers in the sample suggests that there is a good cross-section of decision-makers' viewpoints represented in this study. The inclusion of engineers in the sample suggests that there will be technical perspectives represented in the data. The inclusion of the “other” category provides a measure of diversity to the data set collected from this sample (Sarkis, 2019). This sample provided a diverse range of employees based on both role and experience. However, it is slightly male-dominant and has more managerial-type employees. These characteristics should be taken into consideration when reviewing the research findings.

Table 1: Demographic profile of the respondent

Variable	Category	Frequency	Percentage (%)
Gender	Male	132	66.0%
	Female	68	34.0%
Experience	< 5 Years	54	27.0%
	5–10 Years	82	41.0%
	> 10 Years	64	32.0%
Job Role	Managers	88	44.0%
	Engineers	72	36.0%
	Others	40	20.0%

B. Reliability Analysis (Cronbach’s Alpha)

The Cronbach's Alpha reliability test was conducted to determine if the scales measuring each of the constructs were internally consistent. The results indicate a very high degree of internal consistency among all of the constructs studied. For example, the Cronbach's Alpha for green supply Chain practices has a value of .872, which represents excellent reliability. This result suggests that there is a very high correlation (or relationship) between the five items on the survey designed to measure this construct. Therefore, it can be inferred that the items used to assess Green Supply Chain Practices are consistent measures of this variable (Ellen, 2015). In addition, operational Resilience had a Cronbach's Alpha of .854, which is indicative of a strong reliability coefficient. Since the alpha value is so close to one (.95), the four items measured as part of this construct effectively represent the variable and do not include any measurement errors. Furthermore, profitability had a Cronbach's Alpha of .836, which is within an acceptable range of reliability coefficients. Therefore, the data collected by means of the profitability scale can be considered reliable and consistent. All three variables have Cronbach's Alpha reliabilities exceeding .70, (Table 2) which is the most widely referenced threshold for determining the reliability of scales. These results indicate that the questionnaires were properly developed to yield statistically reliable data. The high reliability coefficients associated with each of the constructs strengthen the credibility of the study and support the validity and dependability of the study's findings (Ahi & Searcy, 2013) .

Table 2: Reliability analysis

Construct	No. of Items	Cronbach’s Alpha
Green Supply Chain Practices	5	0.872
Operational Resilience	4	0.854
Profitability	4	0.836

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C. Descriptive Statistics

The overall trend of the results was generally positive across each variable. In terms of operational resilience, the average response (mean) for this variable was 4.12 indicating an extremely high level of perceived ability of organizations to be adaptable and recover. The mean for GSCM Practices was 3.98 with respect to the amount of green supply chain management being practiced by companies, which is indicative of widespread implementation of environmentally responsible practices. While the mean for profitability was 3.85 it appears that respondents are satisfied with the financial success of their company. Additionally, the SD values were very similar (0.64-0.71), as well as small in magnitude, indicating that respondents' answers were highly consistent and there was little variation among participants. These findings (Table 3) illustrate a consistent and optimistic view regarding sustainability, organizational resiliency, and profitability. The mean values indicate a moderate to high adoption of green practices and a strong perception of resilience and profitability benefits (Zhu et al., 2012).

Table 3: Descriptive statistics

Variable	Mean	Std. Deviation
GSCM Practices	3.98	0.68
Operational Resilience	4.12	0.64
Profitability	3.85	0.71

D. Correlation Analysis

The findings of this study show a very large and positive association among the three variables Green Supply Chain Management (GSCM) Practices; Operational Resilience; and Profitability. There is a very large positive relationship between GSCM Practices and Operational Resilience ($r = .712$, $p < .01$). This indicates that companies employing green supply chain management practices have higher levels of operational resilience than other companies when it comes to dealing with disruption. In addition, there is a very large positive relationship between GSCM Practices and Profitability ($r = .645$, $p < .01$). Therefore, while environmental responsibility can lead to improved financial outcomes, GSCM practices can also provide an additional source of profit (Ponomarov & Holcomb, 2009).

There was found a very large positive relationship between Operational Resilience and Profitability ($r = .689$, $p < .01$). Therefore, operational resiliency is important for companies to achieve their desired financial goals during times of uncertainty. In addition, as all of the associations were statistically significant at the 1 percent level, they demonstrate the strength of those associations. Overall, these results demonstrate that sustainability and resiliency are interdependent, and therefore both are essential to achieving organizational success (Carter & Rogers, 2008). In addition, it also noticed that strong correlation between GSCM and Resilience (r=0.712).

Table 4: Correlation analysis

Variables	GSCM	Resilience	Profitability
GSCM Practices	1	0.712**	0.645**
Operational Resilience	0.712**	1	0.689**
Profitability	0.645**	0.689**	1

E. Regression Analysis

1) Model Summary: There was a positive and strong relationship between the independent and dependent variables as indicated by the regression output. The correlation value of R= .732 indicates a very high degree of association between the predictor(s) and the outcome variable. With an $R^2 = .536$, it follows that about 53.6% of the variability in the dependent variable has been accounted for by the model. After adjusting for the number of predictors (using Adjusted $R^2 = .529$) there is little difference from the original R^2, indicating that the model is reliable and not overfitting. Overall, the model's ability to explain the data appears to be excellent, so it may be used for statistical significance for analysis and interpretation (Seuring & Muller, 2008).

Table 5: Model summary

Model	R	R^2	Adjusted R^2
1	0.732	0.536	0.529

2) ANOVA: The results from the ANOVA show that the regression model has statistical significance. It shows how well the model fits to the data as compared to a model with no predictors by its F-Value (113.45). A Sig. Value of 0.000, which is below .05, confirms the overall regression is significantly large and therefore indicates that there is a collective effect of each of the independent variables in relation to the dependent variable. The fact that the Regression Sum of Squares (82.54) is larger than Residual Sum of Squares (71.78) also demonstrates good explanatory ability. Therefore, it can be concluded that the model will be reliable and useful for further analysis of hypotheses.

Table 6: ANOVA Results

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	82.54	2	41.27	113.45	.000
Residual	71.78	197	0.36		
Total	154.32	199			

3) Coefficients: The results of the regression analysis show that both GSCM Practices and Operational Resilience have a positive and statistically significant relationship to the dependent variable. Therefore, there was no difference found in terms of their contribution to the variance in the dependent variable; however, the t-values were much higher for GSCM practices (8.94) than for operational resilience (6.72). Additionally, the Sig. value for GSCM Practices (.000) was also lower than that of operational resiliency (.000), which indicates that the t-value is larger and the probability of observing this result by chance is less when comparing these two independent variables as predictors (Srivastava, 2007).

Table 7: Regression analysis

Variable	Beta (β)	t-value	Sig.
GSCM Practices	0.521	8.94	.000
Operational Resilience	0.384	6.72	.000

F. Hypothesis Testing Summary

Hypothesis	Statement	Result
H1	GSCM → Operational Resilience	Supported
H2	GSCM → Profitability	Supported
H3	Operational Resilience → Profitability	Supported

IV. DISCUSSION

This study's results provided empirical proof to support that Green Supply Chain Management (GSCM) Practices are positively associated with both Organizational Profitability and Operational Resilience. The same practices that help protect our planet by being environmentally conscious also help create more resilient and adaptable supply chain operations. Therefore, in addition to helping to preserve our environment, sustainability is becoming a key element in helping companies remain stable in today's ever-changing global marketplace. Therefore, this study clearly shows the positive association between GSCM practices and operational resilience and, therefore, companies engaged in different forms of "green" practices (for instance, decreasing waste, obtaining supplies from suppliers who use eco-friendly products, etc.), have created systems that are more adaptive and responsive. With such systems in place, companies will be able to respond to any unexpected disruptions or shortages in their supply chains (Tang, 2006). These disruptions could potentially consist of shortfalls of raw materials, changing government regulations, or fluctuations in the marketplace. Thus, this study supports existing supply chain management theory that advocates for developing flexible and sustainable systems to improve overall resilience. Furthermore, the significant impact of GSCM practices on Organizational Profitability demonstrate that companies who implement "green" practices will experience financial benefits from those actions. Companies will receive cost savings through increased efficiency in resource utilization and reduced waste. Additionally, companies will generate financial income through establishing and maintaining a good reputation and attracting loyal customers (Zhu & Sarkis, 2004).

Prior to this study, it was often assumed that environmental programs would increase costs to the organization. Contrary to this assumption, this study's results indicate that companies can derive financial benefits while protecting the environment via green strategies. To summarize, the results of this study validated the theoretical model proposed and indicated that integrating sustainability into supply chain processes produces two benefits: improved operational resilience and increased profitability. Therefore, sustainability should be one of the primary strategies used by organizations if they wish to remain competitive in the long run.

This study contributes valuable knowledge regarding the effects of green supply chain management (GSCM), it is possible for future researchers to build upon the current study's focus by conducting similar studies with larger and more diverse samples of organizations across multiple industries and geographical areas. Additional constructs (such as technological innovation, regulatory pressures and organizational culture) can also be included in these studies (Porter. Longitudinal studies can then be conducted by researchers to examine the long-term consequences of adopting GSCM on both environmental and business performance improve et al., 1995) ments. In addition,

Limitations to this First, the limited sample size and cross-sectional nature of the data collected limits the generalizability of this study's results to other firms. Second, because this study based its conclusions on respondent opinions only, respondents may have introduced a certain degree of response bias into the results. Finally, because only selected variables were examined in this study, there exists a possibility that additional variables exist that relate to either resiliency or profitability that were excluded from consideration.

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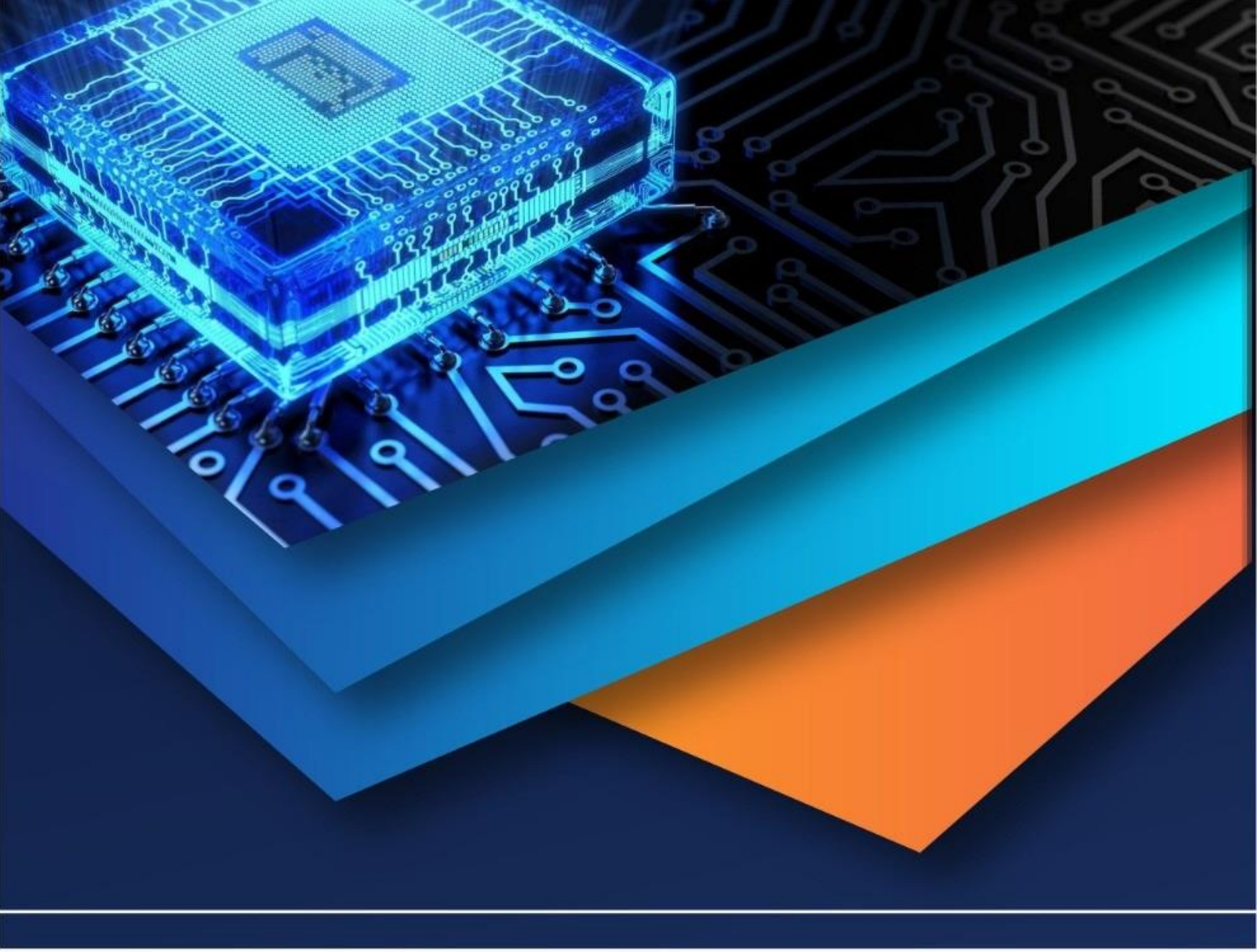

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