ISSN: 0974-5823 Vol. 7 No. 1 January, 2022

*International Journal of Mechanical Engineering*

# Relationship Between Sustainable Logistics Practices and the Organization's Performance in Automobile Industry-An Empirical Study with Logistic Regression Machine Learning

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*Abstract* - The present study attempts to understand sustainable logistics practices in automobile and logistics sectors in India and examines the relationship between these practices and organization's performance (environment, economic and operation) using binary logistic regression machine learning model. Rapid growth in industrial activities has led to increase of GHG levels in the atmosphere which is continuously causing heating of the earth and creating global warming and climate change. The automobile sector is the second-largest contributor to the $CO_2$ emission from fossil fuel after the power sector in India. There is an urgent need to integrate sustainability with organizations' operations in order to deal with climate change. Structured questionnaire was used to conduct empirical survey and responses were collected from various companies operating in passenger vehicle and its component manufacturing companies. The study found that most of sustainable logistics practices increased the chance in improving performance of organizations, however, sustainable warehousing and sustainable packaging played the most significant role.

*Index Terms* - Sustainable Logistics, Sustainable Transportation, Sustainable Warehousing, Sustainable Packaging, Reverse Logistics. Green Supply Chain Management

## INTRODUCTION

The climate change, due to increasing level of greenhouse gas emissions (GHG), is a problem that the global community of nations have been facing with enormous variation in in terms of per capita or cumulative. [1] defines sustainability, which is defined as, "as ... development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The sustainability has drawn a major attention among various stake holders to address the concern of climate change. At the same, sustainable development is being considered as desired alternatives to address the scarce natural resources and also preserving the environment for future generations. [2] observed that the major global environmental impacts were not just due to use of automobiles in terms of fuel consumption, pollution, etc. but also because of manufacturing of vehicles and its final disposal. [3] analyzed the environmental sustainability in logistics and examined the impact of logistics on the environment in terms of natural resources, water, energy, gas emission, and waste generation. According to the Emissions Database for Global Atmospheric Research [4], the transport (automobile) sector contributed the growth more than 21% over year 2005 to year 2017 in $CO_2$ emission i.e. the 2$^{nd}$ largest after power sector. Over the last decade, automobile companies have been experiencing challenges towards adoption of green practices. However, the nature and characteristics of these companies vary significantly. Further, the automobile industry can be categorized based on engine, transmission, electrical parts, equipment, and other parts. The automobile industry can be divided into four different segments i.e. two-wheelers, passenger vehicles, commercial vehicles, and three-wheelers. The two-wheeler segment dominates the market in terms of volume because of the rising middle class and a young population. India is also one of the leading exporters of automobiles and experts imagine it will be in the future as well.

## REVIEW OF LITERATURE

Logistics management is defined as the aspect of supply chain management that schedule, executes, and manages the effective, efficient forward flow and reverses the transfer and storage between the point of origin and the point of consumption of goods, services, and related information in order to meet the requirements of customers [5]. The major functions encompassed by logistics are transportation, packaging, warehousing, and reverse-logistics [3,6] and each element are important for logistics & environmental performance. [7] defined the sustainability as the ability to conduct business with a strategic goal of maintaining the equilibrium between economy, environment, and society. Major practices of logistics have been identified as- transportation, warehousing, and packaging and reverse logistics. Among sustainable logistics practices, sustainable packaging could minimize the carbon footprint of the entire supply chain and could lead to a reduction in overall costs by use of green or reusable packaging [3,8,9,10]. Reverse logistics, another key component of sustainable logistics practices, is the process of planning, implementing and controlling, unprocessed material, the available inventory, finished goods, and related information from the point of

consumption to recover its value of proper disposal through an economical and efficient method [11,12,13]. [14] conducted a case study to identify green logistics preferences among automobile industry. [15] developed supply chain performance framework and emphasised on measure supply wide performance to help companies gain significantly in customer services and financial performance. [16] found that the environmental management collaboration of manufacturers had a significant effect on environmentally friendly product design and logistics, was positively related to the company's profitability and economic performance. [17] suggested that the sustainable practices have created new business opportunities and can provide a long-term competitive advantage for the organizations. [18] observed that adoption of sustainable supply chain management (SSCM) practices would improve operational performance. [19] developed a model which explained the strong linkage between adoption of green practices in supply chain and the company's performance.

## STATEMENT OF THE PROBLEM

There is increasing level in greenhouse gas emissions due to rise in market demand for logistic and passenger vehicles as a result of increase in output volume by the respective companies. Studies have indicated that environmental degradation is major cause of concern and should be on high priority for companies operating in supply chains due to external and internal factors. Indian automobile sector has witnessed a significant growth in the last two decades which is also one of the biggest emitters of CO2.

## NEED OF THE STUDY

Various literatures identified green and sustainable practices by organization in general and very limited research works in the context of automobile sector, especially in India, have been observed. Most of the papers have covered green supply chain management in broader context ranging from sourcing to distribution of products or services, but every key element of logistics like transportation, packaging, warehousing and reverse logistics, etc. together specific to automobile companies, have not observed in the literatures. Empirical study examining the relationship specific to sustainable logistics practices with indicators of firm's performance separately is not available. Therefore, it is very imperative to explore the current logistics practices among automobile companies in India, and. also examine that whether logistics practices (especially sustainable practices) by these firms relate with the key metrics of company's performances or not.

## OBJECTIVES OF THE STUDY

There are following objectives for the current research work

i. To study the sustainable logistics practices in Indian passenger vehicle manufacturing (automobile) organizations and logistics service providers.
ii. To study the relationship between sustainable logistics practices and organization's performance.

## RESEARCH HYPOTHESIS.

**$H_{01}$**: There is no relationship between sustainable logistics practices and organization's environmental performance
**$H_{02}$**: There is no relationship between sustainable logistics practices and organization's economic performance
**$H_{03}$**: There is no relationship between sustainable logistics practices and organization's operational performance

## RESEARCH METHODOLOGY

**Sample Selection:** For present study, the target samples were the passenger vehicle manufacturing companies and their associate companies i.e. key tier-1 supply chain partners & logistics partners operating pan India. There were 30 samples for pilot study and 244 samples for final study.

**Sources of Data**: The present study was carried using primary and secondary data. Various scholarly published literatures from related journals, books, and official reports, etc. were used as secondary sources. Structured questionnaire was used as research instrument to collect the responses through email from the senior management in respective organizations.

**Period of Study:** The study was conducted between the year 2017 till October 2021.

**Tools used in the Study:** A five-point rating scale was used design the questionnaire. Cronbach's alpha was used to test the reliability and expert's inputs to validate the research instrument. Collected data were tested for its normality with the help of Kolmogorov-Smirnov and Shapiro-Wilk through SPSS 23.0 software. For examining the relationship of sustainable logistics practices with the firm's performance, binary logistic regression analysis was carried out using R-software. Questionnaire was divided into two sections-(i) sustainable logistics practices by automobile companies, and (ii) impact of organization performance. Constructs for independent variables were sustainable transportation (STP), sustainable warehousing (SWH), sustainable packaging (SWH) and reverse logistics (RVL) and for dependent variables -environment (IENV), economic (IECOP) and

operational performance (IOPN). Each of these performances was referred as dimension of organization's performance. Responses for all variables were converted into binary scale as. Responses for organization's performance were classified into categories (Impact on performance =1 and No impact on performance=0)

Further, a binary logistic regression machine learning model was fitted for each response variable and examined the trained model's generalization strength on test data set.

## DATA ANALYSIS

After model development, the model summary table was used to interpret the model coefficients. The model summary provided model coefficients and their significance with 95% confidence interval values, it also provided model fit statistics -Null Deviance i.e. intercept model and Residual Deviance i.e. fitted model. Output of model development and model evaluation for each outcome or response variable are described in the subsequent subsections.

**Sustainable logistics practices and organization's environmental performance:** Binary logistics regression model outputs are shown in the Table 1.1, Table 1.2 and Table 1.3. Coefficient values for sustainable packaging and sustainable warehousing are significant i.e., sustainable packaging and sustainable warehousing are positively (significant) related with organization's environmental performance. Residual deviance value (126.76) indicated that the response variable was predicted better with inclusion of independent variables. McFadden R-squared value and Nagelkerke R-squared value are 0.22 and 0.27 which indicates that the model fit is good. Log-Likelihood difference between null model and residual model fitted with all independent variables is 17.97, indicating improved model fit which was significant. The trained model classified test data with accuracy of 91.2 percent.

Result: The null hypothesis is rejected i.e. there exists a significant relationship between sustainable logistics practices and organization's environmental performance.

**TABLE -1.1: LOGISTIC REGRESSION MODEL COEFFICIENTS**

| | **B (Estimates)** | **Standard Error** | **Z -value** | ***p*-value** |
|---|---|---|---|---|
| **(Intercept)** | -1.7650 | 0.8760 | -2.015 | 0.043914 |
| **STP** | 0.2097 | 0.7530 | 0.278 | 0.780656 |
| **STPKG** | 2.0416 | 0.5339 | 3.824 | 0.000131 |
| **SWH** | 2.1107 | 0.9089 | 2.322 | 0.020217 |
| **RWL** | 0.6348 | 0.6274 | 1.012 | 0.311572 |
| **Null deviance** | 162.72 on 273 degrees of freedom | | | |
| **Residual deviance** | 126.76 on 269 degrees of freedom | | | |

**Source:** Developed by the author from the primary data using R

**TABLE -1.2: OVERALL MODEL FIT AND GOODNESS-OF-FIT STATISTICS**

| **Test** | **Pseudo R-Squared value** |
|---|---|
| McFadden | 0.220953 |
| Cox and Snell (ML) | 0.122970 |
| Nagelkerke (Cragg and Uhler) | 0.274606 |
| Likelihood Ratio | -17.976 (p-value significant) |

**Source:** Developed by the author from the primary data using R

| | | **Predicted Value** | |
|---|---|---|---|
| | | **0** | **1** |
| **Actual Value** | **0** | 2 | 22 |
| | **1** | 2 | 248 |
| Classification Accuracy | | | **91.2 percent** |

**TABLE-1.3: MODEL EVALUATION OF TEST DATA (CLASSIFICATION ACCURACY)**

**Source:** Developed by the author from the primary data using R

**Sustainable logistics practices and organization's economic performance:** Binary logistics regression model outputs are shown in the Table 2.1, Table 2.2 and Table 2.3. Coefficient value for sustainable warehousing was found to be significant. Residual deviance value (274.27) indicated that the response variable was predicted better with inclusion of independent variables. the McFadden R-squared value and Nagelkerke R-squared values indicate that the model fit is weak. Log-Likelihood difference between null model and model fitted with all independent variables is 8.14, indicating improved model fit. Fit improvement was also significant. The trained model classified test data with accuracy of 79.6 percent. The precision of prediction was also observed to be 77.8.

Result: The null hypothesis is accepted i.e., there no significant relationship between sustainable logistics practices and organization's economic performance.

**TABLE -2.1: LOGISTIC REGRESSION MODEL COEFFICIENTS**

| | **B (Estimates)** | **Standard Error** | **Z -value** | ***p*-value** |
|---|---|---|---|---|
| **(Intercept)** | -1.5225 | 0.8982 | -1.695 | 0.0501 |
| **STP** | 0.7400 | 0.7156 | 1.034 | 0.3011 |
| **STPKG** | -0.5416 | 0.5257 | -1.030 | 0.3028 |
| **SWH** | 2.2104 | 0.8743 | 2.528 | 0.0115 |
| **RVL** | 0.5107 | 0.5027 | 1.016 | 0.3097 |
| **Null deviance** | 290.56 on 273 degrees of freedom | | | |
| **Residual deviance** | 274.27 on 269 degrees of freedom | | | |

**Source:** Developed by the author from the primary data using R

**TABLE -2.2: OVERALL MODEL FIT AND GOODNESS-OF-FIT STATISTICS**

| **Test** | **Pseudo R-Squared value** |
|---|---|
| McFadden | 0.0560517 |
| Cox and Snell (ML) | 0.0577068 |
| Nagelkerke (Cragg and Uhler) | 0.0882782 |
| Likelihood Ratio | -8.1431 (p-value significant) |

**Source:** Developed by the author from the primary data using R

**TABLE-2.3: MODEL EVALUATION OF TEST DATA (CLASSIFICATION ACCURACY)**

| | | **Predicted Value** | |
|---|---|---|---|
| | | **0** | **1** |
| **Actual Value** | **0** | 7 | 54 |
| | **1** | 2 | 211 |
| Classification Accuracy | | | **77.8 percent** |

**Source:** Developed by the author from the primary data using R

**Sustainable logistics practices and organization's economic performance:** Binary logistics regression model outputs are shown in the Table 3.1, Table 3.2 and Table 3.3. Coefficient value for only sustainable warehousing was found to be significant i.e. sustainable warehousing is positively (significant) related with organization's operational performance. Residual deviance value (73.87) indicated that the response variable was predicted better with inclusion of independent variables. McFadden R-squared value and Nagelkerke R-squared value indicate a good model fit. Log-Likelihood difference between null model and model fitted with all independent variables is 12.33, indicating improved model fit and was also significant. The trained model classified test data with accuracy of 97.1 percent. The precision of prediction was also observed to be 83.3 percent. Further, trained model has a classification strength of 55.6 percent.

Result: The null hypothesis is accepted i.e., there does not exist significant relationship between sustainable logistics practices and organization's operational performance.

**TABLE -3.1: LOGISTIC REGRESSION MODEL COEFFICIENTS**

| | B (Estimates) | Standard Error | Z -value | *p*-value |
|---|---|---|---|---|
| **(Intercept)** | -4.1182 | 0.94735 | -0.435 | 0.663776 |
| **STP** | 0.78202 | 1.17685 | -0.665 | 0.506368 |
| **STPKG** | 0.04407 | 0.92125 | 0.048 | 0.961842 |
| **SWH** | 3.51506 | 0.99967 | 3.516 | 0.000438 |
| **RVL** | 1.48527 | 0.87178 | 1.704 | 0.88434 |
| **Null deviance** | 98.544 on 273 degrees of freedom | | | |
| **Residual deviance** | 73.873 on 269 degrees of freedom | | | |

**Source:** Developed by the author from the primary data using R

**TABLE -3.2: OVERALL MODEL FIT AND GOODNESS-OF-FIT STATISTICS**

| Test | Pseudo R-Squared value |
|---|---|
| McFadden | 0.2503580 |
| Cox and Snell (ML) | 0.0861064 |
| Nagelkerke (Cragg and Uhler) | 0.2850460 |
| Likelihood Ratio | -12.336(p-value significant) |

**Source:** Developed by the author from the primary data using R

**TABLE-3.3: MODEL EVALUATION OF TEST DATA (CLASSIFICATION ACCURACY)**

| | | Predicted Value | |
|---|---|---|---|
| | | **0** | **1** |
| **Actual Value** | **0** | 5 | 7 |
| | **1** | 1 | 261 |
| Classification Accuracy | | | **55.6 percent** |

**Source:** Developed by the author from the primary data using R

## FINDINGS OF THE STUDY

The present study applied binary logistic regression as machine learning tool for analysis of examining the relationship. On environmental indicator of organization performance, all independent variables were observed to be positively related environmental performance, however, relationship with only sustainable warehousing and sustainable packaging was significant. It means that presence of all these practices will significantly increase the chance of positive impact on environmental performance. On economic indicator of the organization performance, all independent variables, except sustainable packaging, were observed to be positively related economic performance, however, relationship with only sustainable warehousing was found to be significant. It means that presence of these practices, except sustainable packaging will increase the chance of positive impact on economic performance. On operations indicator of the organization performance, all independent variables, except sustainable transportation, were observed to be positively related operational performance, however, relationship with only sustainable warehousing was found to be significant. It means that presence of these practices, except sustainable transportation, will increase the chance of positive impact on economic performance.

## SUGGESTIONS

The study suggests that sustainable warehousing and sustainable packaging have more and significant positive impact on environmental performance as compared to sustainable transportation and reverse logistics. While examining the economic performance, the study suggests that sustainable transportation, sustainable warehousing and reverse logistics have more impact in economic indicator of performance as compared to sustainable packaging. Further, the operations performance in the organization is positively (and significantly) impacted by sustainable warehousing as compared to sustainable packaging and reverse logistics practices. Based on the findings, it can be inferred that investment in sustainable transportation, sustainable warehousing, sustainable packaging and reverse logistics practices is justified in order to improve the organizational performance and help in achieving sustainable goal.

## CONCLUSION

The present study made an attempt to identify various sustainable logistics practices and its relationship with the three key metrics of organizational performance-environmental, economic and operational. Binary logistic regression analysis was carried out for model development and its evaluation. The study found that sustainable logistics practices can help in improving organizational performance. The study also indicated that sustainable warehousing plays a significant role in improving organization's performance on all three metrics of organization's performance, whereas sustainable packaging helped significantly on environmental as well as operational performances

## LIMITATION OF THE STUDY

The study was limited to the passenger vehicles segment in the automobile sector, which includes two-wheelers & four-wheelers but excluding three-wheelers segment. Convenience sampling method used for present research was another major limitation. The sample used for the study didn't cover the automobile companies from the eastern part of India.

## SCOPE FOR FURTHER RESEARCH

Similar study can be conducted for tier-2 and tier-3 suppliers in the automobile sector. As energy-intensive industries like power, steel, cement, textile, etc also contribute significant to the GHGs emission, so similar research can be extended to these industries. The current research can help industry practitioners to explore and evaluate various practices within the organization that may help not only in improving the performance of the organizations but also stepping towards achieving sustainability goals.

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