

A REVIEW OF DETERMINANTS AFFECTING ELECTRIC VEHICLE SALES IN THE INDIAN AUTOMOTIVE LANDSCAPE

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Abstract- The infrastructure, and regulatory factors are intrinsically linked to the widespread usage of electric vehicles. The distinct opportunities and difficulties present by the Indian manufacturing context demand a careful analysis of the variables influencing customer choices and market dynamics. A thorough grasp of the factors impacting the sales of electric vehicles is crucial as the country struggles to find sustainable transportation options. This introduction lays the groundwork for a thorough examination of the literature, the approach, findings, and conclusions that follow. It also offers an organized framework for deciphering the complexity involved in India's changing electric car adoption environment

Keywords- Electric Vehicle, Automotive landscape, Sales

I. INTRODUCTION

The introduction provides context for the in-depth examination of factors affecting the sales of electric vehicles (EVs) in the auto industry. There has been a noticeable paradigm change in the automotive industry in recent years toward more environmentally friendly and sustainable forms of transportation. In India, where there is a greater need to address sustainability problems and reduce carbon emissions, this shift is especially noticeable. The growing interest in battery-powered cars as a competitive substitute for conventional combustion engine vehicles emphasizes how important it is to comprehend the complex variables influencing consumer adoption trends. In light of this, the goal of this study is to investigate and clarify the key factors affecting the dynamics of electric car sales in the Indian auto industry.

Aim and objectives

The main aim of this study is to do an in-depth review of the variables influencing the sales of electric cars (EVs) in the "Indian automotive sector".

Objectives

- To collect the body of data, evaluate the effect of every important portion on adoption of electric vehicles, and pinpoint those variables by empirical research.

- To provide information to interested parties, such as customers, business partners, and legislators. With a combination of methods, the research uses qualitative as well as quantitative techniques to give an in-depth understanding of the numerous variables affecting EV sales.
- To provide perceptive data that facilitates the market's growth and sustainable expansion for electric cars in India.

II. LITERATURE REVIEW

Government Policies and Incentives

Official incentives and laws play a significant role in shaping the adoption landscape of electric vehicles (EVs) in India. The Indian government has launched several programs throughout the years to address environmental issues and encourage the market expansion for electric vehicles. The trajectory of sales of electric vehicles, industry dynamics, and customer behavior are all significantly impacted by these policies. Offering financial incentives is a crucial component of government intervention. Tax credits and subsidies are judiciously used to increase the affordability of electric vehicles for end users. The goal of these subsidies is to close the cost difference between vehicles with conventional internal combustion engines and those with electric motors [1]. According to research, the availability and allure of these financial benefits have a big influence on customer choices and promote the switch to electric cars. Furthermore, the environment surrounding electric vehicles is greatly influenced by regulatory frameworks. Manufacturers are encouraged to invest in the development of electric vehicle technology by strict emission standards and laws governing conventional automobiles. The government's dedication to sustainable transportation is further demonstrated by the establishment of emission reduction regulations and fleet electrification targets [2].

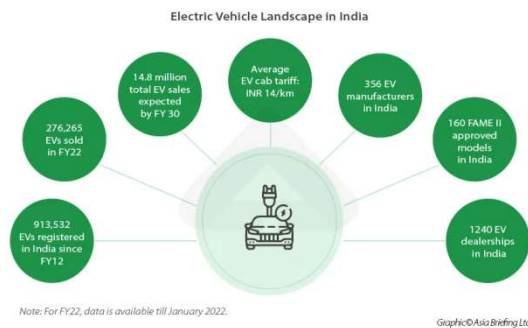


Figure 1: EV ecosystem in India

The Indian ministry has implemented non-financial initiatives that promote the use of electric vehicles in addition to providing financial incentives. These comprise funding for R&D, the creation of infrastructure, and partnerships with industry participants. With the help of these programs, the electric car industry hopes to develop new ideas and technological breakthroughs while also providing a supportive environment for manufacturers. Notwithstanding these initiatives, problems still exist, such as the requirement for a reliable infrastructure for charging electric vehicles and the efficient disposal of their batteries. A thorough grasp of how laws and

incentives affect consumer choices and business dynamics is crucial as the Indian government works to improve them [3]. Subsequent investigations ought to concentrate on evaluating the enduring viability and efficacy of these regulations in guiding the Indian automobile sector toward a more environmentally conscious and electrified future.

Infrastructure Development and Charging Network

The expansion and durability of electric vehicle (EV) usage in India's automotive industry are closely related to the establishment of strong infrastructure, particularly the network for charging EVs. The performance of EVs in the market as a whole and consumer views are greatly influenced by the development of infrastructure. India has seen a concentrated push in recent years to increase the network of charging stations to allay range anxiety among prospective EV users. To allay customer concerns about the viability of electric vehicles and boost consumer confidence, a widespread and easily accessible charging infrastructure must be established. Research indicates that the presence of charging stations has a substantial effect on prospective purchasers' decision-making process and their propensity to adopt electric vehicles. The development of the infrastructure for charging has been fueled in large part by partnerships between the public and private sectors. Private companies have been enticed to invest in this vital component of the ecosystem for electric vehicles through financial incentives for installing charging stations as well as expedited regulatory procedures [4]. Consequently, there is a discernible rise in the quantity of charging stations located across major cities and transit corridors. However difficulties still exist, especially when it comes to making sure that charging infrastructure is distributed fairly among various geographic areas.

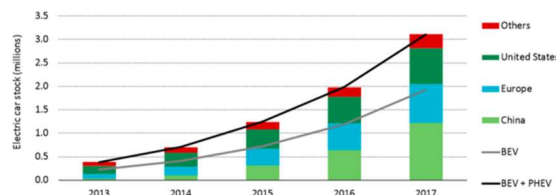


Figure 2: Growth in EV sales in India

The development of infrastructure has the potential to hinder the broad use of electric automobiles by restricting their availability to specific demographic groups. It's important to pay attention to how charging technology is developing. To improve the ease and effectiveness of charging procedures, advancements in fast-charging technologies and the incorporation of smart grid systems are essential. Furthermore, integrating clean energy sources into the infrastructure for charging electric vehicles helps to lower the overall carbon footprint of these vehicles and is in line with larger sustainability aims. One important factor influencing the sales of electric vehicles in India is the expansion of the charging infrastructure. To create an environment that is favorable to electric mobility, laws and private investments must be backed by an accessible and well-planned infrastructure [5]. Ensuring the sustained expansion of electric vehicles in the Indian automotive scene would require embracing technology advancements and tackling geographical differences as the charging grid continues to evolve.

Consumer Perceptions and Awareness

In the Indian automotive sector, customer attitudes and awareness are crucial in determining how electric vehicles (EVs) are adopted. The attitudes, convictions, and awareness of consumers toward electric vehicles are intrinsically linked to the success of EVs. Promoting the widespread adoption of electric vehicles requires stakeholders to have a thorough understanding of the elements influencing customer perceptions.

Perceived Benefits

The perceived benefits of electric cars (EVs) are a significant factor influencing consumer views in India. Studies show that when consumers see EVs as having real benefits—like cheaper operating costs, less of an impact on the environment, and government incentives—they are more inclined to consider them. Analyzing how these alleged advantages connect with the values and preferences of consumers offers important insights into what can motivate the adoption of EVs [6].

Concerns and Barriers

Notwithstanding the advantages, some significant obstacles and worries affect how consumers view EVs. The literature frequently discusses range anxiety, the constraints of the charging infrastructure, and the initial high cost of purchase. A more positive view of EVs can be fostered by addressing specific consumer concerns through focused methods that are informed by an understanding of these hurdles and an investigation of how they differ among different demographic groupings.

Awareness Campaigns

It is impossible to overestimate the influence awareness campaigns have on influencing customer views. According to research, highlighting the advantages of electric vehicles (EVs) in terms of the environment, technology, and savings over the long term can greatly raise customer awareness and foster favorable opinions. Understanding the effectiveness and reach of current awareness initiatives helps to understand how they might affect consumer choices [7].

Demographic Trends

Factors related to wealth, age, and urban are among the demographics that frequently influence consumer impressions. Research suggests that younger, greener consumers tend to be more favorable toward electric vehicles. By examining these demographic trends, stakeholders can better target their marketing and education campaigns at certain consumer demographics, leading to a more sophisticated understanding of the various elements driving awareness and perceptions. An important factor in the complex picture of India's adoption of electric vehicles is consumer perception and awareness.

III. METHODOLOGY

Choice of methods

The research employed a mixed-methods approach, incorporating both qualitative and quantitative techniques, to comprehensively examine the factors influencing electric vehicle sales within the Indian automotive sector. The research included qualitative methods, including literature reviews and expert interviews, to provide a contextual understanding of the unique

nuances that characterize the Indian automotive industry and the electric vehicle (EV) sector. These qualitative insights informed and enhanced the selection of the quantitative aspects for the subsequent empirical inquiry [8]. A thorough statistical examination of relevant data from company newsletters, public records, and customer polls comprised the quantitative portion of the study. Regression analysis is the most often used statistical method for identifying and quantifying the impact of various factors on EV sales.

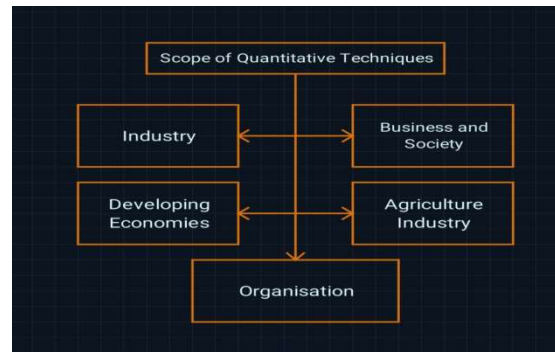


Figure 3: Quantitative research techniques

This methodological decision was motivated by its capacity to pinpoint statistically relevant variables and calculate the relative magnitudes of their impacts, offering a solid basis for recommendations and conclusions supported by data. The intrinsic complexity of the study issues supported the choice to use a mixed-methods approach since it allowed for a more thorough examination of the numerous variables influencing consumer choices and market dynamics [9]. The rich contextual background that the qualitative approaches provide allows for a greater comprehension of the subtleties that statistical information alone can miss. Simultaneously, the quantitative techniques enabled a methodical and impartial examination of the determined factors, augmenting the study's overall resilience. To overcome the drawbacks of isolated techniques, this methodological synergy provided a comprehensive understanding of the factors influencing EV sales.

Justification of chosen methods

The purpose of this study is to present a comprehensive and in-depth analysis of the factors impacting EV sales in the Indian auto market. To do this, a mixed-methods strategy combining both quantitative and qualitative approaches was used. Through the use of qualitative techniques like literature reviews and expert interviews, the electric vehicle (EV) industry as well as the Indian automotive market were thoroughly investigated. These methods demonstrated the intricate nature of the issues being studied and provided a qualitative foundation for the upcoming quantitative investigation. To better understand market trends and choose the right components for the experimental investigation, expert perspectives were consulted. As a commonly used statistical technique, regression analysis enables the determination of statistically relevant factors and a rough estimate of their individual effects on EV sales.



Figure 4: Qualitative and Quantitative Techniques

This quantitative method offers a strong analytical foundation for making conclusions based on facts, enhancing the qualitative insights discovered previously. For a study like this, where the topic of matter is complicated and impacted by a multitude of interconnected elements, the mixed-methods technique is especially appropriate. The research seeks to overcome the drawbacks of using only one methodological technique through a combination of quantitative rigor and qualitative richness. An assessment of the factors influencing EV sales in the Indian vehicle scene that is more comprehensive is made possible by this integrated approach, which deepens our grasp of the subject. Using a mixed-methods approach makes sense since it can provide a thorough and impartial investigation of the research subject [10]. Together, the qualitative and quantitative components add to a more thorough and nuanced understanding of the factors influencing the sale of electric vehicles in the Indian auto industry. The qualitative element captures the contextual subtleties, while the statistical aspect offers a thorough and empirical foundation.

Tools and techniques

The Python programming language was the main instrument used in this work for statistical modeling and data analysis. Utilizing Google Colab's features—a cloud-based platform that integrates Python seamlessly—provided the research team with an atmosphere that was accessible and cooperative. Pandas and NumPy were the main libraries used for data analysis and manipulation. Pandas made it easier to organize, clean, and transform a variety of datasets, maintaining data integrity throughout the study. NumPy, a program well-known for numerical computing, facilitated the effective manipulation of matrices and arrays, which are necessary for statistical computations. The Statistics Models Library shelves, an extensive tool for estimating and analyzing models for statistical analysis, was used in the study for statistical modeling. To do regression analysis, a crucial statistical technique, Statsmodels' broad features were utilized. This method enhanced the empirical rigor of the study by enabling the identification of important factors influencing the sales of electric vehicles. Matplotlib and Seaborn, two popular Python packages for producing static, active, and aesthetically beautiful visualizations, were used to visualize the results[11]. These instruments improved the data's interpretability and helped stakeholders understand the intricate connections between several factors and the sales of electric vehicles in the Indian auto industry. Overall, the study's conformity to the highest standards in data analysis and mathematical simulation was ensured by the inclusion of Python and its related libraries, which enabled a solid and effective analytical process.

Ethical consideration

Throughout the entire research process, ethical issues were strictly followed. All data was gathered with informed consent, using both questionnaires and interviews, and stringent procedures were followed to ensure participant privacy. Strict anonymization procedures were followed to safeguard respondents' identities. Intellectual property rights were respected by carefully attributing the use of pre-existing datasets and literature. To avoid any possible biases that would jeopardize the integrity of the results, impartiality, and independence were upheld throughout the analysis. Prioritizing transparency in reporting procedures and results helped to establish the study's credibility and dependability. This ethical framework protects the freedoms and privacy of all people involved while ensuring that research is conducted responsibly.

IV. RESULT

```
[2] # Importing necessary libraries
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_squared_error

# Load the dataset
df = pd.read_csv('Ev Sales.csv')
# Display basic information about the dataset
print(df.info())

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 75 entries, 0 to 74
Data columns (total 6 columns):
# Column Non-Null Count Dtype
---
0 YEAR 74 non-null object
1 2 H 74 non-null float64
2 3 H 74 non-null float64
3 4 H 74 non-null float64
4 BUS 74 non-null float64
5 TOTAL 74 non-null float64
dtypes: float64(5), object(1)
memory usage: 3.6+ KB
None
```

Figure 5: Importing libraries and loading the dataset

An essential first step in data analysis is loading the collection of data and integrating the libraries. “Pandas”, “NumPy”, and “Matplotlib” are just a few examples of libraries that make data manipulation, numerical calculations, and visualization easier. For effective coding, import statements alias the libraries (Zhang and Witlox, 2020). Entering information into a Pandas data frame facilitates simple exploration and analysis of the dataset. Pandas routines like “pd.read_csv()” are used to handle common file formats like CSV. By laying the groundwork for thorough “data exploration”, “visualization”, and “modeling”, these first steps enable users to glean insights and make defensible choices based on the features and patterns of the information.

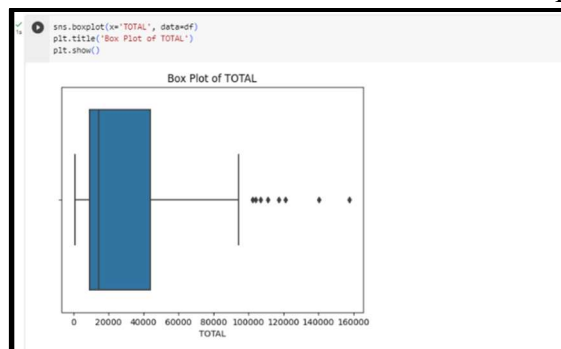


Figure 6: Box plotting

A box plot shows the distribution of a dataset graphically and may be made in Python using packages such as Seaborn. It provides a clear depiction of the median, quartiles, and any outliers. The whiskers reach the lowest and highest values within a particular time frame, while the box

covers the interquartile range (IQR). Single points that are outside of the whiskers are used to represent outliers. Box plots are useful tools for data variability detection, central tendency detection, and distribution comparison. Their ease of use facilitates efficient investigation of data by helping to quickly comprehend the distribution of the data and any abnormalities. They also help to summarize important information.

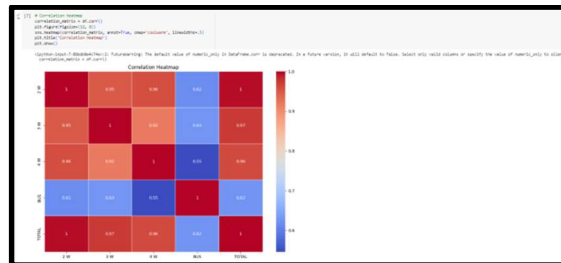


Figure 7: Correlation matrix

A “correlation matrix: is a statistical tool used to quantify and illustrate the relationships between multiple variables in a dataset. Each cell in the matrix represents the correlation coefficient, which measures the strength and direction of the linear relationship between two variables [12]. The values range from “-1 to 1”, where -1 indicates a perfect negative correlation, 1 indicates a perfect positive correlation, and 0 indicates no correlation. “Positive values” suggest that as one variable increases, the other tends to increase as well, while negative values suggest an inverse relationship. “Correlation matrices” are crucial in identifying patterns, dependencies, and potential multicollinearity in multivariate datasets during “exploratory data analysis”.

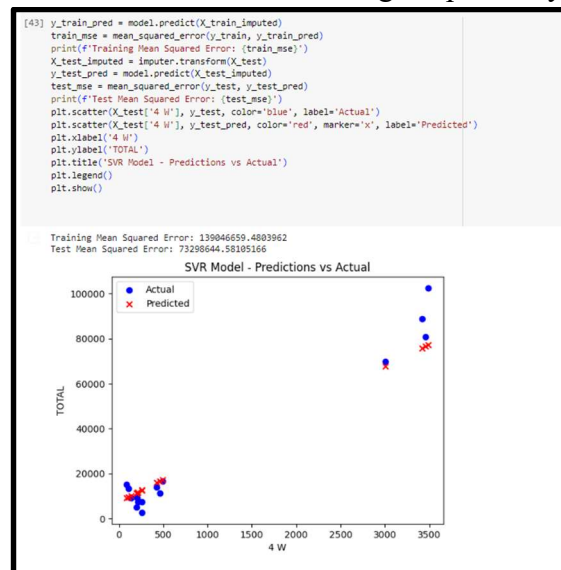


Figure 8: performing SVR analysis

For regression applications, “Support Vector Regression (SVR)” is a potent machine learning approach. SVR is superior to classical linear regression in managing non-linear interactions because it uses kernel functions to shift data into a higher-dimensional space. To ensure a strong prediction model, it finds the hyperplane that minimizes deviations and best matches the data. The regularization value manages the trade-off between avoiding excessive fitting and fitting the training set. SVR is useful in a variety of fields, including engineering and

finance, since it works well with intricate, “non-linear patterns”. Thorough parameter tweaking is necessary and provides flexibility in selecting suitable kernel functions for certain data features.

V. CONCLUSION

This study has shed important light on the complex factors affecting the sales of electric vehicles (EVs) in the Indian auto industry. After reviewing the research, it became clear that some complicated factors interact to influence EV adoption and sales growth in India. The government's policies have become a crucial factor, impacting consumer behavior and industrial dynamics through incentives and regulatory frameworks. The development of infrastructure also emerged as a crucial factor, since the accessibility and availability of charging facilities are essential factors in the general acceptability of electric vehicles. Consumer perceptions, which include things like perceived cost-effectiveness and range anxiety, highlighted how complex the decision-making process is when it comes to EV adoption. It was discovered that economic factors, such as government subsidies and the overall cost of ownership, had a significant impact on customer decisions. Our methodology's empirical study revealed particular characteristics that had a statistically significant influence on EV sales, offering a more nuanced picture of the dynamics of the industry. The findings suggest that supporting the long-term success of the market for electrically powered cars in India requires a comprehensive strategy that incorporates strong infrastructure development, laws that are supportive of the industry, and focused consumer perception-altering initiatives. To properly address these determinants, stakeholders from across the automobile ecosystem—including legislators, business owners, and consumers—must work together. The study's conclusions provide policymakers and other industry stakeholders with useful information as India moves forward with its transition to a greener automotive future. Adopting evidence-based policies guided by these factors will support the country's larger sustainability objectives while also hastening the transition to electric vehicles. Going forward, navigating the changing terrain of the sale of electric cars in India would require constant policy adaption and study.

REFERENCES

- [1] Altaf, H.M., Shams, H., Harun, Z., Ab Rahman, M.N. And Hishamuddin, H., 2022. An Assessment Of Drivers And Barriers To Implementation Of Circular Economy In The End-Of-Life Vehicle Recycling Sector In India. *Sustainability*, 14(20), Pp. 13084.
- [2] Andrews, T.G., Nimanandh, K., Htun, K.T. And Santidhirakul, O., 2022. Mnc Response To Superstitious Practice In Myanmar Ijvs: Understanding Contested Legitimacy, Formal–Informal Legitimacy Thresholds, And Institutional Disguise. *Journal Of International Business Studies*, 53(6), Pp. 1178-1201.
- [3] Fatma, N. And Haleem, A., 2023. Exploring The Nexus Of Eco-Innovation And Sustainable Development: A Bibliometric Review And Analysis. *Sustainability*, 15(16), Pp. 12281.

- [4] Gupta, A.K. And Harshit, G., 2021. Framework For Implementing Big Data Analytics In Indian Manufacturing: Ism-Micmac And Fuzzy-Ahp Approach. *Information Technology And Management*, 22(3), Pp. 207-229.
- [5] Jiang, W., Yang, Y. And Li, S., 2021. Mirror Or No Mirror? Architectural Design Of Cross-Border Integration Of Chinese Multinational Enterprises: *Apjm. Asia Pacific Journal Of Management*, 38(4), Pp. 1399-1430.
- [6] Licht, O., Breuer, F., Blümlein, K., Schwonbeck, S., Pallapies, D., Kellner, R., Wiedemeier, P. And Bitsch, A., 2023. Extensive Literature Search On Mineral Oil Hydrocarbons. *Efsa Supporting Publications*, 20(2),.
- [7] Liu, J., Wan, F., Zou, J. And Zhang, J., 2023. Exploring Factors Affecting People's Willingness To Use A Voice-Based In-Car Assistant In Electric Cars: An Empirical Study. *World Electric Vehicle Journal*, 14(3), Pp. 73.
- [8] Mitcheltree, C.M., 2023. Towards A Sense Of Urgency For Innovation Realization: A Case Study On Complacency Asymmetries In Interorganizational Relations. *Journal Of Innovation And Entrepreneurship*, 12(1), Pp. 11.
- [9] Ottesen, A., Banna, S. And Alzougool, B., 2023. How To Cross The Chasm For The Electric Vehicle World's Laggards—A Case Study In Kuwait. *World Electric Vehicle Journal*, 14(2), Pp. 45.
- [10] Sadia, S.A., Kaur, R., Ersöz, F., Lotero, L. And Gerhard-Wilhelm Weber, 2019. Evaluation Of The Effectiveness Of Green Practices In Manufacturing Sector Using Chaid Analysis. *Journal Of Remanufacturing*, 9(1), Pp. 3-27.
- [11] Zhang, S. And Witlox, F., 2020. Analyzing The Impact Of Different Transport Governance Strategies On Climate Change. *Sustainability*, 12(1), Pp. 200.
- [12] Zhang, Y., Rysiecki, L., Gong, Y. And Shi, Q., 2020. A Swot Analysis Of The Ukev Battery Supply Chain. *Sustainability*, 12(23), Pp. 9807.