Analyzing the Key Factors Influencing Electric Vehicle Adoption in India

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Abstract:

The adoption of electric vehicles (EVs) in India is growing rapidly due to rising fuel prices, environmental awareness, technological improvements, and supportive government policies. This study analyzes the key factors influencing EV adoption using a dataset of 10,000 observations. Various statistical techniques, including data visualization, multiple linear regression, correlation analysis, and the Kruskal–Wallis test, were applied.

The results indicate significant growth in EV sales and charging infrastructure. Regression analysis shows that EV price is strongly influenced by battery capacity, range, charging time, subsidies, maintenance cost, and resale value, explaining over 83% of price variation. Another model reveals that battery capacity and energy efficiency are the main determinants of driving range. Safety rating was found to have no significant impact on sales. Overall, affordability, technological efficiency, and infrastructure development are the major drivers of EV adoption in India.

Keywords: EV market in India, Battery Capacity, Driving Range, Safety.

Introduction:

Electric vehicles (EVs) are becoming an important part of the global shift toward clean and sustainable transportation. In India, the demand for EVs has increased in recent years due to rising fuel prices, growing environmental concerns, and strong government support through schemes such as the FAME India Scheme. India aims to reduce carbon emissions and promote green mobility under national initiatives led by NITI Aayog.

Despite this progress, EV adoption in India still faces challenges such as high initial cost, limited charging infrastructure, range anxiety, and lack of consumer awareness. Understanding the factors that influence the adoption of electric vehicles is therefore essential for policymakers, manufacturers, and consumers.

This study examines the technological, economic, and environmental factors affecting EV adoption in India using statistical analysis to identify the most significant determinants influencing consumer decisions.

Literature Review:

1)Sriram K. V. and his co-authors (2022) studied EV adoption in Bengaluru and reported that financial issues are one of the strongest barriers. They explained that the high initial price of EVs and battery replacement cost discourage many consumers. Their study also pointed out that limited charging stations and long charging time reduce consumer confidence. In addition, buyers are concerned about driving range and overall vehicle performance. The authors suggested that improving infrastructure and reducing cost can increase adoption.

2) **Abhishek Raj and his co-authors (2023)** in Kerala found that environmental concern plays a

very important role in influencing EV purchase decisions. People who are more aware of pollution and climate change are more willing to adopt EVs. Their research also showed that social influence, economic benefits, performance, and after-sales service significantly affect consumer decisions.

3) According to researchers government subsidies, fuel savings, and technological improvement positively influence EV adoption, while high cost and range anxiety act as major challenges. Overall, previous studies conclude that EV adoption in India depends on affordability, infrastructure development, environmental awareness, and supportive government policies. However, many studies focus on limited regions, which creates a need for broader and more detailed research.

Objectives of the Study:

1. To examine the major economic factors influencing the adoption of electric vehicles in India.
2. To analyze the impact of technological factors such as battery capacity, driving range, and charging time on EV adoption.
3. To study the role of charging infrastructure in influencing consumer decisions to purchase EVs.
4. To examine the relationship between EV price and its performance-related features using statistical methods.

Research Methodology:

1. Research Design:

This study is based on a **quantitative research design**. It uses statistical techniques to examine the factors influencing the adoption of electric vehicles (EVs) in India.

2. Data Source:

The study is based on **secondary data**, collected from EV-related datasets, industry reports, and publicly available sources. The dataset consists of 10,000 observations including technical, economic, and sales-related variables.

3. Variables Used:

Dependent Variables: EV Price, Range, Units Sold in 2024

Independent Variables: Battery Capacity (kWh), Charging Time (hours), Efficiency (Wh/km), Safety Rating, Government Subsidy, Maintenance Cost, Insurance Cost, Resale Value.
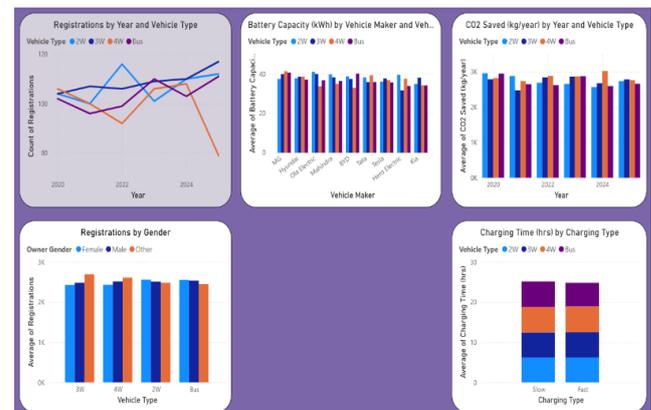
4. Statistical Tools Applied: The following statistical methods were used:

1. Correlation Analysis
2. Multiple Linear Regression (to identify significant predictors)
3. Kruskal–Wallis Test (for non-parametric comparison)

5. Software Used:

The data analysis was performed using **R statistical software**.

Data Visualization:

This Graph shows a steady growth in electric vehicle adoption, particularly in the 2W and 3W segments, while 4W registrations show some fluctuations and a recent decline. Battery capacity across different manufacturers appears comparable, suggesting similar technological standards in the market. In terms of environmental impact, 4W and buses contribute slightly higher CO_2 savings compared to 2W and 3W, highlighting the positive role of EVs in reducing emissions over time. Gender-wise, male

registrations are marginally higher than female registrations across most vehicle types. Additionally, the availability of fast charging enhances user convenience, supporting greater adoption of electric vehicles.
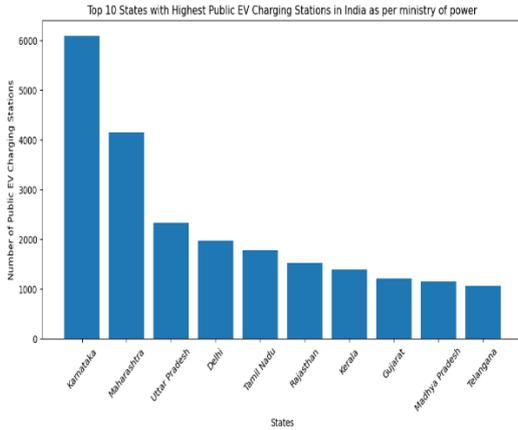
The distribution of public EV charging infrastructure in India shows a clear regional concentration. Karnataka leads with the highest number of charging stations, followed by Maharashtra and Uttar Pradesh, Delhi ranks next, while Tamil Nadu benefits from its well-established automobile industry. Other states such as Rajasthan, Kerala, Gujarat, Madhya Pradesh, and Telangana also demonstrate steady growth, indicating a gradual and widespread expansion of EV charging infrastructure across the country.

Data Analysis:

Table 1: Correlation between Battery Capacity and Charging Time

Vehicle Type	Correlation Coefficient
2W	-0.014
3W	0.035
4W	0.002
Bus	-0.037

This result show that there is no relationship battery size and the time required to charge the vehicle. Which implies that bigger battery does not necessarily mean that the vehicle will take more time to charge. Charging time mainly depends on other factors such as charger

capacity, charging technology, and battery management system rather than battery size alone.

Table 2: Correlation between Range and Price

Variables	Correlation
Range & Price	-0.008

This result shows that there is no relationship between how far a vehicle can travel and how much it costs. This means that a vehicle with a longer range is not always more expensive. Price is influenced by many other factors such as brand value, features, battery technology, design, and performance.

Multiple Linear Regression (Model I & II)

The general form of the model is:
$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n + \varepsilon$$

Model I)

Dependent Variable: Price
Independent Variable : Battery capacity, Range, Charging time, Subsidy amount   Maintainance, Insurance cost, Resale Value, Co2 saved Milage.

Price=4.969−0.001062 (Battery Capacity) + 0.0001333(Range) − 0.1600(Charging Type) − 0.000001078(Subsidy Amount) − 0.0000008707(Maintenance Cost) − 0.0000001151(Insurance Cost) + 1.385(Resale Value) − 0.00003873(CO₂ Saved) + 0.002294(Mileage).

Model II)

Dependent Variable: Range
Independent Variable: Battery Capacity (kWh), Efficiency (Wh/km),Torque (Nm),Fast Charging Power (kW DC)

Range (km) = 190.9526 + 4.7522(Battery Capacity) − 1.0632(Efficiency) + 0.001833(Torque) + 0.1776(Fast Charging Power).

Table 3: Regression Model Summary

Statistic	Model I	Model II
R²	0.8332	0.895
Adjusted R²	0.8331	0.894

Interpretation For Model I: The regression model explains **83.3%** of the variation in EV price, indicating a strong model fit. Since the p-value is less than 0.05, the model is statistically significant. Therefore, EV price depends on technical and economic factors such as battery capacity, range, charging time, subsidy, maintenance cost, insurance cost, resale value, CO_2 savings.

Interpretation for Model II: The model explains **89%** of the variation in EV range, showing a very strong fit. The F-statistic is very high and the p-value is extremely small (<0.05), confirming that battery capacity, efficiency, torque, and fast charging power significantly affect EV driving range.

Kruskal–Wallis test: In this study, EV sales were compared across three safety rating groups (3-star, 4-star, and 5-star)

Null Hypothesis (H_0): There is no significant difference in EV units sold across different safety rating levels.

Alternative Hypothesis (H_1): There is a significant difference in EV units sold across safety rating levels.

Table 4: Kruskal–Wallis Test Result

Statistic	Value
Chi-square	3.145
df	2
p-value	0.2075
Decision	Fail to reject H_0

This result shows that, safety rating does not appear to strongly influence the number of EV units sold in 2024. Other factors such as price, battery performance, charging facilities, or brand value may have a greater impact on consumer purchasing decisions.

Conclusion:

This study examined the key factors influencing the adoption of electric vehicles (EVs) in India. The findings show that the price of electric vehicles is influenced by several important technical and economic factors such as battery capacity, driving range, charging time, subsidy support, maintenance cost, insurance cost, resale value, and mileage. This indicates that EV pricing depends on a combination of features rather than a single characteristic.

The results also show that the driving range of electric vehicles mainly depends on battery capacity, energy efficiency, and fast charging power. Vehicles with better battery performance and efficiency tend to provide longer driving range, which increases consumer preference.

It was further observed that battery size does not necessarily determine charging time, and driving range alone does not decide the price of a vehicle. In addition, safety rating does not significantly affect EV sales, suggesting that consumers may give more importance to affordability, performance, and charging infrastructure.

Overall, the growth of electric vehicles in India is mainly driven by technological improvement, cost-effectiveness, infrastructure development.

Limitations of the Study:

1. The study is based mainly on secondary data, which may not fully capture real consumer opinions and behavior.
2. The analysis is based on data from a specific time period, so future market changes may produce different results.

3. Rapid technological developments in the EV sector may change the influence of certain factors over time.

Future Scope of the Study:

1. Future research can include primary data collection through surveys or interviews to better understand consumer attitudes and buying behavior toward electric vehicles.
2. Future studies can examine the impact of psychological factors, brand perception, and consumer trust on EV adoption.
3. With rapid technological development, future research can explore the role of battery innovation, fast-charging networks, and renewable energy integration in promoting EV adoption.

References:

1. Sriram K V, Lidwin Kenneth Michael, Sumukh S. Hungund & Mabelle Fernandes (2022)- Factors influencing adoption of electric vehicles – A case in India
2. Abhishek Raj, Gouri Anand & Sujith.T.S (2023)- Factors influencing the adoption of electric vehicles: A Study with special references to Kerala
3. Data Sources: EV specifications and performance dataset (2024). Collected from official automobile company websites and EV databases.
4. Ministry of Heavy Industries. (2023). National Electric Mobility Mission Plan (NEMMP) 2020 and FAME India Scheme. Government of India.
5. NITI Aayog & Rocky Mountain Institute. (2022). India's Electric Mobility Transformation: Pathways to 2030. New Delhi.