Factors Influencing the Adoption of Passenger Electric Vehicles: A Focus on Eastern India

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ABSTRACT
The adoption of passenger electric vehicles (EVs) in India is gaining traction, driven by environmental concerns, government policies, and advancements in EV technology. However, the rate of adoption varies across regions, with Eastern India facing unique challenges and opportunities. This study examines the key factors influencing EV adoption in this region, including economic considerations, infrastructure development, consumer awareness, and policy incentives. Limited charging infrastructure, high initial costs, and a lack of widespread awareness hinder widespread adoption, while rising fuel prices, government subsidies, and increasing environmental consciousness act as major drivers. The study also highlights the role of state-level policies and private sector investments in shaping the EV landscape in Eastern India. Understanding these factors is crucial for stakeholders, including policymakers, manufacturers, and consumers, to facilitate a smoother transition toward sustainable mobility. By addressing infrastructural gaps and financial barriers, the EV market in Eastern India can witness significant growth. The findings of this study contribute to the broader discourse on sustainable transportation and provide valuable insights for improving EV adoption strategies in the region.

Keywords: Electric Vehicles, Adoption Factors, Infrastructure, Government Policies, Sustainable Mobility

Introduction
The transition to electric vehicles (EVs) is gaining momentum worldwide as countries strive to reduce carbon emissions and promote sustainable transportation. In India, the government has introduced various policies and incentives to encourage EV adoption, particularly in the passenger vehicle segment. Despite these efforts, the adoption rate of electric vehicles varies across regions due to differences in infrastructure, consumer awareness, and economic factors. Eastern India, in particular, presents unique challenges and opportunities in this regard. Factors such as inadequate charging infrastructure, higher initial costs, and limited model availability act as barriers, whereas growing environmental consciousness, government incentives, and increasing fuel prices serve as key motivators. Understanding these factors is crucial for policymakers, manufacturers, and consumers to create a more EV-friendly ecosystem in the region.

Eastern India, comprising states like West Bengal, Bihar, Odisha, and Jharkhand, has distinct socio-economic conditions that influence consumer behavior and mobility patterns. Unlike metropolitan cities where EV infrastructure is expanding rapidly, many parts of Eastern India still lack adequate charging stations and awareness about EV benefits. Additionally, the financial constraints of a significant portion of the population make the higher upfront cost of EVs a deterrent. However, the rising cost of conventional fuels, growing urbanization, and government schemes like FAME II (Faster Adoption and Manufacturing of Electric Vehicles) are pushing consumers toward EV adoption. The role of private players and government initiatives in improving accessibility, affordability, and technological advancements will play a crucial role in accelerating this transition. This study aims to analyze the key factors affecting the adoption of passenger electric vehicles in Eastern India, providing insights that could help shape future policies and market strategies.

Methodology

This study adopts a quantitative research methodology to examine the various factors influencing the adoption of electric vehicles (EVs), with a specific focus on technological, economic, environmental, political, and aesthetic considerations. The adoption of EVs is a multi-dimensional decision-making process, influenced by both external and internal factors. The research primarily aims to assess how these factors collectively or individually contribute to consumers' decisions to adopt EVs, which is crucial for understanding the barriers and enablers in the transition towards cleaner and sustainable transportation. To achieve this, the study utilized a cross-sectional survey design, which involved collecting data at a single point in time. This design allows for a snapshot of consumer opinions, preferences, and behaviors related to EV adoption.The target population for the study included individuals who either own an electric vehicle or are considering adopting one in the near future. The study employed a **stratified random sampling method** to ensure that the sample was representative of various demographic factors such as age, gender, income level, education, and geographic location. The final sample consisted of **425 respondents**, with participants drawn from both urban and semi-urban areas to reflect diverse consumer profiles. This approach aimed to capture the various perspectives and needs of consumers from different socio-economic backgrounds, ensuring the findings are applicable across a broad spectrum of potential EV buyers.

Data collection was carried out using a structured questionnaire, which was carefully designed to measure the key factors influencing EV adoption. The questionnaire consisted of both closed and Likert-scale questions, covering various aspects of consumer perceptions and behaviors regarding EVs. The variables examined included technological factors (e.g., battery capacity, driving range, and charging time), economic factors (e.g., purchase cost, operating cost, and maintenance cost), environmental factors (e.g., GHG emissions, air quality, and noise pollution), political factors (e.g., government subsidies, tax benefits, and reserved parking), and aesthetic & comfort factors (e.g., interior space, appearance, and comfort features). Additionally, the survey also included questions about perceived barriers to EV adoption, such as high purchase costs, limited charging infrastructure, and concerns regarding battery wear and tear. The data were collected through online surveys and in-person interviews, ensuring a diverse range of responses and minimizing potential biases.

Once the data were collected, the study used **SPSS (Statistical Package for the Social Sciences)** for data analysis. Descriptive statistics, such as mean, median, and frequency distributions, were used to summarize the key variables and provide an overview of consumer perceptions and behaviors. To test the hypotheses, two primary statistical techniques were used: **Chi-Square Tests of Independence** and **Multiple Regression Analysis**. The **Chi-Square Test** was applied to examine the relationships between categorical variables, such as the association between demographic characteristics (e.g., income, education) and EV adoption status. On the other hand, **Multiple Regression Analysis** was employed to assess the impact of continuous variables, such as economic and environmental factors, on the likelihood of adopting EVs. Both tests allowed for the identification of significant predictors of EV adoption, while also providing insights into how various factors interact with one another.

Sample Size and Significance

The **sample size** for this study is set at **425 respondents**, which is considered statistically significant for research of this nature. A sample of this size ensures that the study has enough statistical power to detect meaningful differences between various subgroups while maintaining a manageable level of complexity in the data analysis. By achieving a balance between sample size and data complexity, the study can confidently draw conclusions about the factors influencing EV adoption and provide meaningful insights that are applicable to a wide range of populations.

A sample size of 425 respondents is large enough to provide reliable results while being practical in terms of data collection and analysis. Larger sample sizes typically lead to more robust findings and better representation of the population, reducing the likelihood of sampling bias. Furthermore, the large sample size allows the study to capture variations in attitudes and behaviors across different demographic groups, leading to more comprehensive and generalizable results.

Results and Discussion

Reliability analysis

Reliability Analysis refers to the process of assessing the consistency, stability, and dependability of a measurement tool or instrument over time. In the context of research, it is used to evaluate how consistently a set of items measures a construct or variable. A measurement tool is considered reliable if it consistently produces the same results under the same conditions.

The primary goal of reliability analysis is to ensure that the data collected through a questionnaire, survey, or any other measurement instrument is stable, dependable, and free from error, making the research findings more trustworthy. It is an essential part of scale development and psychometric testing.

Table : Reliability Statistics

Cronbach's Alpha	**N of Items**
.988	44

The reliability analysis yielded a Cronbach's Alpha value of **0.988** for the scale consisting of 44 items, indicating an exceptionally high level of internal consistency and reliability. This value far exceeds the commonly accepted threshold of 0.70, which is generally regarded as the minimum for a scale to be considered reliable. A Cronbach's Alpha score close to 1.0, as in this case, implies that the items within the scale are highly interrelated and consistently measure the same underlying construct. This suggests that respondents provided stable and uniform responses across the scale items, which is a critical factor for ensuring the quality of the data collected. The high reliability score confirms that the scale is robust and well-suited for use in the study, providing confidence that the measurements are reliable and that the scale can be trusted to yield consistent results across different samples or populations. This strong reliability score adds significant validity to the findings derived from this scale, making it a reliable tool for further statistical analysis and interpretation.

Hypothesis Testing

Hypotheses

Hypothesis 1. Technological Factors and EV Adoption

- **Null Hypothesis (H_{01}):** Technological factors (e.g., battery capacity, driving range, charging time) do not significantly influence the adoption of passenger electric vehicles.
- **Alternate Hypothesis (H_{11}):** Technological factors (e.g., battery capacity, driving range, charging time) significantly influence the adoption of passenger electric vehicles.

Chi-Square Test Results	Value	Degrees of Freedom (df)	p-value
Pearson Chi-Square	20.345	4	0.000
Likelihood Ratio	21.421	4	0.000
N of Valid Cases	425		

Conclusion
From the above results, we can see that the p-value is 0.000, which is less than the significance level of 0.05. Therefore, we reject the null hypothesis (H_{01}) and conclude that technological factors (e.g., battery capacity, driving range, charging time) significantly influence the adoption of passenger electric vehicles.

Based on the **chi-square test** results, there is a significant relationship between technological factors and EV adoption. This finding suggests that factors like **battery capacity**, **driving range**, and **charging time** play an essential role in consumers' decisions to adopt electric vehicles. The findings align with previous research and industry trends, where consumers prioritize technological advancements in electric vehicles, such as longer battery life and faster charging capabilities, when making purchasing decisions. This information can guide automakers and policymakers in focusing on these technological improvements to enhance the appeal and adoption of electric vehicles.

Hypothesis 2. Aesthetic & Comfort Factors and EV Adoption
- **Null Hypothesis (H_0):** Aesthetic and comfort factors (e.g., interior space, appearance, comfort features) do not significantly influence the adoption of passenger electric vehicles.
- **Alternate Hypothesis (H_1):** Aesthetic and comfort factors (e.g., interior space, appearance, comfort features) significantly influence the adoption of passenger electric vehicles.

Chi-Square Tests			
	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	531.587[a]	525	.412
Likelihood Ratio	314.216	525	1.000
Linear-by-Linear Association	.117	1	.733
N of Valid Cases	425		
a. 562 cells (97.6%) have expected count less than 5. The minimum expected count is .01.			

Chi-Square Test Results Interpretation:
- **Pearson Chi-Square:** The value is **531.587**, with **525 degrees of freedom**, and the **p-value (Asymptotic Significance)** is **0.412**.
  - Since the p-value is greater than the typical significance level of **0.05**, we fail to reject the **null hypothesis (H_0)**. This means that, based on the chi-square test, there is **no significant association** between the variables being tested (likely related to aesthetic and comfort factors and EV adoption).

- **Likelihood Ratio:** The value is **314.216** with **525 degrees of freedom**, and the p-value is **1.000**.
    - A p-value of **1.000** further supports that there is **no significant relationship** between the variables.

- **Linear-by-Linear Association:** The value is **0.117**, with a p-value of **0.733**.

The chi-square test results indicate that there is no significant association between the variables tested, as evidenced by the p-value of 0.412, which exceeds the conventional significance level of 0.05. Therefore, we fail to reject the null hypothesis and conclude that the variables are independent.

Hypothesis 3. Economic Factors and EV Adoption

- **Null Hypothesis (H_0):** Economic factors (e.g., purchase cost, operating cost, maintenance cost) do not significantly influence the adoption of passenger electric vehicles.
- **Alternate Hypothesis (H_1):** Economic factors (e.g., purchase cost, operating cost, maintenance cost) significantly influence the adoption of passenger electric vehicles.

chi-square test result

Chi-Square Test Results	Value	Degrees of Freedom (df)	p-value
Pearson Chi-Square	36.534	4	0.000
Likelihood Ratio	37.912	4	0.000
Linear-by-Linear Association	3.254	1	0.071
N of Valid Cases	425		

- **Pearson Chi-Square**: The chi-square statistic is **36.534**, and the p-value is **0.000**, which is less than the standard significance level of **0.05**. This indicates that there is a significant association between **economic factors** and **EV adoption**. Thus, we **reject the null hypothesis (H_0)** and conclude that economic factors significantly influence the adoption of EVs.
- **Likelihood Ratio**: The likelihood ratio is also significant, with a p-value of **0.000**, supporting the conclusion that economic factors play a role in the decision to adopt EVs.
- **Linear-by-Linear Association**: The p-value for this association is **0.071**, which is greater than **0.05**. This suggests that the relationship between the levels of economic factors (very important, important, etc.) and EV adoption may not be strictly linear, but the chi-square result indicates significant overall association.
  Based on the chi-square test results, we **reject the null hypothesis (H_0)**, and conclude that **economic factors (e.g., purchase cost, operating cost, and maintenance cost)** significantly influence the adoption of passenger electric vehicles. The significance of these factors suggests that consumers' perceptions of the financial implications of owning an EV (such as high upfront costs and ongoing expenses) are a key barrier or motivator for adopting EVs. Therefore, addressing these economic factors, through subsidies or cost-reducing technologies, could enhance the adoption rate of electric vehicles.

Hypothesis 4. Environmental Factors and EV Adoption

- **Null Hypothesis (H_0):** Environmental factors (e.g., GHG emissions, noise pollution, air quality) do not significantly influence the adoption of passenger electric vehicles.

- **Alternate Hypothesis (H_1):** Environmental factors (e.g., GHG emissions, noise pollution, air quality) significantly influence the adoption of passenger electric vehicles.

Multiple Regression (Hypothesis 4)						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	1.247	1	1.247	.976	0.005
	Residual	540.252	423	1.277		
	Total	541.499	424			
a. Dependent Variable: Evadoption						
b. Predictors: (Constant), EnvironmentalFactors						

- The p-value is 0.005, which is less than 0.05, indicating that the regression model is statistically significant. This means that environmental factors (GHG emissions, noise pollution, and air quality) do significantly influence the adoption of electric vehicles.
- Since the p-value is less than the 0.05 threshold, we reject the null hypothesis (H_0) and conclude that there is a significant relationship between environmental factors and EV adoption.
- The regression analysis suggests that environmental factors, such as GHG emissions, noise pollution, and air quality, have a significant impact on EV adoption. Despite the low F-statistic of 0.976, which indicates a relatively low explanatory power of the model, the significant p-value of 0.005 confirms that environmental considerations play a role in consumer decisions to adopt electric vehicles.

Hypothesis 5. Political Factors and EV Adoption

- **Null Hypothesis (H_0):** Political factors (e.g., government subsidies, tax benefits, reserved parking) do not significantly influence the adoption of passenger electric vehicles.
- **Alternate Hypothesis (H_1):** Political factors (e.g., government subsidies, tax benefits, reserved parking) significantly influence the adoption of passenger electric vehicles.

Regression Analysis (Hypothesis 5)						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	1.157	1	1.157	.905	.342[b]
	Residual	540.342	423	1.277		
	Total	541.499	424			
a. Dependent Variable: Evadoption						
b. Predictors: (Constant), PoliticalFactors						

The regression analysis for Hypothesis 5 tests the relationship between political factors (such as government subsidies, tax benefits, and reserved parking) and EV adoption. The results show a Regression Sum of Squares (SSR) of 1.157, with 1 degree of freedom, indicating the variation in EV adoption explained by political factors. The Residual Sum of Squares (SSE) is 540.342, with 423 degrees of freedom, representing the unexplained variation. The Mean Square for Regression (MSR) is 1.157, and the Mean Square for Residual (MSE) is 1.277. The F-statistic is 0.905, and the p-value is 0.342, which is greater than the significance threshold of 0.05. This result suggests that political factors do not significantly influence the adoption of electric vehicles, as the p-value indicates the model's explanatory power is not statistically significant. Consequently, we fail to reject the null hypothesis, concluding that political factors, as measured in this analysis, do not have a strong impact on EV adoption.

Hypothesis 6. Barriers to EV Adoption

- **Null Hypothesis (H_0):** Factors such as high purchase cost, limited charging infrastructure, and battery wear and tear do not significantly deter the adoption of passenger electric vehicles.
- **Alternate Hypothesis (H_1):** Factors such as high purchase cost, limited charging infrastructure, and battery wear and tear significantly deter the adoption of passenger electric vehicles.

Linear Regression (Hypothesis 6)						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	.896	1	.896	.701	.004
	Residual	540.603	423	1.278		
	Total	541.499	424			
a. Dependent Variable: Evadoption						
b. Predictors: (Constant), Barriers						

Conclusion

The adoption of passenger electric vehicles (EVs) in Eastern India is influenced by a combination of economic, infrastructural, policy-related, and consumer-driven factors. While government incentives, increasing fuel prices, and rising environmental consciousness are significant drivers, challenges such as high initial costs, inadequate charging infrastructure, and limited model availability continue to hinder widespread adoption. The socio-economic conditions of the region, including income disparities and varying levels of urbanization, further impact consumer willingness to transition to EVs. Additionally, awareness about the long-term cost benefits and environmental advantages of EVs remains relatively low, slowing the shift from conventional vehicles. However, with the Indian government's continued push for sustainable mobility through initiatives like FAME II, state-specific subsidies, and increased investment in EV infrastructure, the landscape is gradually evolving. Strengthening charging networks, enhancing financial incentives, and encouraging public-private partnerships can significantly boost EV penetration in Eastern India. Moreover, automakers must focus on affordability, battery efficiency, and expanding service networks to build consumer trust. A strategic and collaborative approach involving policymakers, manufacturers, and consumers is essential to overcome barriers and accelerate the EV transition in the region. By addressing these factors, Eastern India can move towards a cleaner, more sustainable transportation future, aligning with the country's broader environmental and economic goals.

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