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Electric Vehicle Adoption Reluctance: A Consumer Perspective Using Logistic Regression Analysis

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Abstract
This research examines the ecological awareness and acceptance factors that shape the usage of electric vehicles (EVs). The study highlights the transition from "traditionally perceived usefulness" to "customer-perceived usefulness" driven by environmental benefits and emphasizes the role of batteries in EV adoption. Although prior studies have addressed problems with charging and related factors, this study empirically measures the impact of EV charging infrastructure on the adoption of electric vehicles and its role in fostering cleaner urban mobility and responsible consumption patterns. Using a logistic regression approach, the study considers charging time and comfort in mobility as predictor variables. The findings underscore charging time and comfort as important factors shaping consumer behaviour, based on a prospective consumer survey. The study also considers the role of policy in providing economic incentives for greener mobility and offers avenues for Asian nations to convert infrastructure challenges into strategic business opportunities for environmental sustainability.

Keywords: Electric Vehicle Batteries, Charging Infrastructure, Consumer Behaviour, Logistic Regression, SDG 11, SDG 12, Policy

1. Introduction

Electric vehicles (EVs) represent one of the most promising near-term technological solutions for reducing greenhouse gas emissions and decreasing reliance on the fossil fuels traditionally associated with conventional automobiles. Despite their environmental and consumer benefits, several barriers continue to hinder widespread adoption. Among these, customer hesitation towards new technologies remains a critical challenge, often reinforcing policies that reflect scepticism towards EVs.

EVs remain in the early stages of development, with adoption constrained by concerns over price and driving range. Battery technology plays a pivotal role in shaping EV costs, as high-capacity batteries significantly influence both pricing structures and subsidy mechanisms within the EV ecosystem. While EVs offer innovations capable of mitigating climate change by lowering emissions, externalities such as knowledge spill overs and pollution reduction generate broader societal and economic benefits that are not fully captured in vehicle pricing. Governance and policy interventions, together with industry initiatives, have sought to address these market inefficiencies, yet socioeconomic factors continue to shape adoption rates. This study highlights the substantial impact of EV development on environmental protection while recognising that public acceptance remains relatively low, presenting ongoing marketing challenges. Drawing on a questionnaire survey, this paper applies logistic regression modelling to identify key variables influencing consumer adoption of EVs.

In alignment with the United Nations Sustainable Development Goals, particularly SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production) EV adoption is positioned as a key driver of sustainable urban mobility and responsible consumer choices. Organisations have undertaken various initiatives to address market inefficiencies, yet socioeconomic factors continue to shape adoption rates; public acceptance nonetheless remains relatively low, presenting ongoing marketing challenges.

Electric and autonomous vehicles are increasingly recognised as a cost-effective solution for sustaining urban transportation by reducing dependence on fossil fuels and lowering carbon emissions, thereby contributing to ecological and public-health benefits [1]. Many countries have set ambitious targets and implemented strategies to encourage EV adoption, with projections suggesting that EVs will constitute a significant share of the future automotive industry [2]. Globally, EV registrations rose from roughly six thousand in 2010 to over seven hundred fifty thousand in 2016, and forecasts estimate that approximately one hundred fifty million EVs will be on the road by 2030 [3].

EVs are widely regarded as a technological innovation capable of addressing environmental challenges linked to global warming and greenhouse gas emissions. However, their acceptance remains limited without external drivers such as stricter pollution regulations, rising fuel prices, and financial incentives [4]. Public subsidies and incentives are consistently identified as critical to fostering widespread adoption; economic inefficiencies, including uneven product distribution and information spill overs, further slow the diffusion of EVs [5]. Market imperfections continue to distort EV pricing relative to internal combustion engine vehicles.

A growing body of empirical literature is emerging alongside the rapid expansion of the EV sector. While current research provides valuable insights into customer driving behaviour, social assistance programmes, delivery systems, and technological advancements, many studies continue to rely on similar assumptions. Most investigations into EV demand are based on surveys and decision-making experiments [6]. Descriptive studies, however, often focus on the experiences of existing EV owners, the potential benefits that could influence new buyers, and the barriers faced by individuals and organisations in adopting EVs [7]. In contrast, empirical work exploring the perspectives and rationales of non-owners or potential buyers remains limited. As highlighted elsewhere, there is a shortage of descriptive methodologies that connect reflective questionnaires and preference experiments to individual consumer attitudes and reasoning [8]. Similar critiques have been raised in EV marketing studies, which argue that an overemphasis on "mechanical rationality" neglects broader aspects of consumer behaviour [9]. A comprehensive market-modelling review similarly concludes that consumer adoption of plug-in hybrid and electric vehicles is shaped by an interacting set of psychological, infrastructural, and policy-related determinants rather than by any single factor reinforcing calls for broader, less mechanistic explanatory frameworks [10,11].

Carbon dioxide and other greenhouse gases are recognised as harmful atmospheric pollutants that threaten human health and welfare, and their excessive emission contributes to climate change and global warming. The combustion of fossil fuels in the transportation and electricity sectors remains the largest source of carbon emissions worldwide [11]. To counter this trend, governments are increasingly promoting EV adoption as a strategy to reduce emissions. While EVs offer significant ecological benefits, widespread adoption continues to face economic, infrastructural, and cultural challenges [12]. Emerging transportation issues have driven advancements in automotive technologies, particularly in propulsion systems and autonomous vehicles [13]. By reducing petroleum dependence and carbon emissions, EVs are widely acknowledged as an effective pathway towards sustainable urban transportation, with positive implications for both climate stability and human well-being.

In alignment with SDG 11 and SDG 12, EV adoption plays a critical role in building resilient, low-carbon urban transport systems and encouraging environmentally responsible consumer choices. The transportation sector accounts for nearly three-quarters of carbon dioxide emissions, representing roughly 23% of global emissions and addressing this requires substantial reductions in transportation-related emissions [14]. Consequently, the transition toward renewable energy sources in transport systems has become imperative [13]. By embedding EV adoption within the framework of SDG 11 and SDG 12, this study underscores how sustainable mobility and responsible consumption can jointly contribute to mitigating climate change and advancing global sustainability.

The expansion of plug-in electric vehicle (PEV) charging infrastructure, both at home and in public spaces, carries significant societal implications. Widespread accessibility of charging stations is expected to raise public awareness of PEV technology and improve perceptions of its functionality, potentially fostering progressive "green cultural branding" [15]. Consistent with this, a recent study grounded in the theory of planned behaviour found that charging infrastructure significantly improves the driving experience, which in turn strengthens behavioural intentions and ultimately raises consumers' willingness to pay for an EV [16]. Home charging remains a critical factor for consumers considering the purchase of a PEV, as drivers often face limited power supply after completing trips; for those constrained by vehicle range, knowledge of public charging options can encourage longer travel distances powered by electricity [17].

Nevertheless, prior studies have limitations, as they often rely on small samples of existing PEV owners and drivers without adequately addressing the perspectives or acceptance levels of non-owners. Projections suggest that increasing charger availability from 10% to 33% could boost EV demand by up to 50%. Simulations based on respondent data further indicate that a tenfold increase in charger accessibility could nearly double demand, raising estimated market share from 2.2% to 8.9%. Research also shows that greater recharge availability enhances consumers' willingness to pay for new vehicles, reduces time spent locating charging infrastructure, improves individual utility, and increases the likelihood of purchasing a PEV.

Numerous studies have identified consumer-related factors that influence the likelihood of acquiring an EV, including education, income, household vehicle ownership, environmental attitudes, and affinity for technology; however, the literature remains divided on which characteristics are most critical. Several studies suggest that higher education is associated with a greater probability of being "EV-oriented," while others report that neither education nor economic status significantly affects EV adoption rates across nations, and no consistent evidence links income to EV orientation.

Household vehicle ownership also plays a role: living in a multi-car household has been shown to reduce the probability of EV orientation, whereas actively buying or planning to buy a vehicle is a strong predictor of interest in EV ownership. Access to charging infrastructure is equally important; the absence of a dedicated charging outlet may hinder adoption, particularly among residents of apartments or shared housing. Participants in EV driving trials valued at-home charging for the autonomy it provided, although evidence regarding the influence of environmental preferences on EV purchase decisions remains mixed, leaving uncertainty about which consumer identifiers best predict long-term EV acceptance [18].

Research into EV adoption consistently highlights driving range as the most significant non-financial barrier; over 70% of respondents in prior surveys considered limited driving range a "significant disadvantage" or "somewhat of a disadvantage." Because these surveys were largely conducted in urban areas, the findings may underestimate concerns in suburban or rural contexts where longer travel distances are common. Trip-chaining and range-focused cost payback models suggest that plug-in hybrid electric vehicles (PHEVs) may be more appealing than battery electric vehicles (BEVs), whereas Monte Carlo simulations of alternative fuel vehicles indicate that BEVs are more likely to be chosen than PHEVs. Expanding charging infrastructure is argued to be a more effective strategy for alleviating range anxiety than simply extending vehicle range, underscoring the importance of charging time: when fast charging is unavailable, consumers place greater value on extended driving range, highlighting the interdependence of range and charging duration. A one-hour charging time discourages long-distance travel, whereas reducing charging time to roughly ten minutes would allow BEVs to compete with internal combustion engine vehicles on travel efficiency. Survey-based utility models confirm that EV competitiveness improves when adequate infrastructure is available, with overnight home charging emerging as a significant factor valued for its convenience, safety, and security.

Technological advancements have also introduced innovative powertrain systems. In EVs, the battery storage system is both the most critical and the most costly component; an accurate battery management system (BMS) is therefore essential for monitoring and controlling battery state and estimating the residual useful life (RUL) of the battery, helping to prevent safety hazards. Key parameters such as voltage, current, and temperature are typically collected through embedded systems and analysed using machine-learning techniques, including artificial neural networks, long short-term memory models, support vector regressors, random forest, and boosting methods, sometimes combined with optimisation algorithms such as particle swarm optimisation and the whale optimisation algorithm. Using root mean square error (RMSE) as the evaluation metric, hybrid PSO–ELM and WOA–ELM approaches have been shown to outperform other machine-learning methods, achieving RMSE values of 1.46% and 1.51% respectively, compared with higher RMSE values of 2.24–3.56% for Light GBM, random forest, AdaBoost, XGBoost, and CatBoost [19]. Predictive battery thermal-management strategies have also been developed and validated on a single state-of-the-art BEV platform; although the methodology is rigorous, reliance on a single vehicle architecture limits generalisability, since variations in battery chemistry, cooling-system design, and actuator configuration across manufacturers may influence controller effectiveness [20]. Analyses of heating strategies under cold conditions have similarly relied on controlled simulations and laboratory experiments, and real-world factors such as fluctuating ambient temperature, user behaviour, and grid constraints may limit the applicability of these results to diverse climates [21]. Hybrid computational approaches such as the Chimp Tangent Search Algorithm have likewise been tested primarily under simulated EV network conditions, and may not fully capture the complexity of real urban charging ecosystems, where unpredictable traffic patterns, demand surges, and infrastructure failures could affect scheduling efficiency in practice [22].

The behavioural analysis in the present study emphasises charging duration and comfort in mobility as predictors of sustainable transport adoption. Other potentially influential factors, such as the cost of charging, availability of renewable energy, policy incentives, and social norms were not included in the regression model, and this narrower scope may understate the multifactorial nature of adoption decisions.

Recent improvements in battery capacity and charging times have addressed some technological challenges, yet the development of widespread charging infrastructure remains essential. Broadly distributed charging facilities, supported by modern facility-management systems, can monitor charger status in real time, resolve technical issues, and optimise operational strategies; digital controllers further enable the creation of smart, city-wide transportation networks. Greater awareness of public charging facilities enhances driver confidence, encouraging longer travel distances powered by electricity and alleviating range concerns. EVs also play a pivotal role in the transition to a low-carbon energy system: by shifting charging demand over time, they help balance the intermittent nature of renewable energy sources, and by connecting directly to the grid they support the stability of renewable-dominated systems. Smart buildings are increasingly designed to incorporate EV technology, improving energy efficiency and long-term reductions in carbon emissions. EV ratings are typically based on product quality, perceived performance, and reliability, together with societal impact, government involvement, and infrastructure development; subcategories such as "perceived affordability" and "accessibility" are particularly influential in shaping public acceptance.

In alignment with SDG 11 and SDG 12, EV adoption supports cleaner, smarter, and more resilient urban transport systems while encouraging responsible consumer choices. To strengthen this connection, the present study employs a logistic regression model to identify the variables — charging time and comfort in mobility — that directly influence consumer behaviour, offering methodological insights that can be mapped to SDG indicators.

1.1. Research Objective and Hypotheses

The primary aim of this study is to identify the factors that influence the buying behaviour of EV consumers and to understand the barriers to EV adoption. A secondary aim is to assess the comfort and usability of electric vehicles within a 24 × 7 economy characterised by intense business competition. Based on the research objectives, the following hypotheses were formulated and tested:

H1 (alternative hypothesis): Charging time has a statistically significant effect on consumers' EV purchase decisions.
H01 (null hypothesis): Charging time has no statistically significant effect on consumers' EV purchase decisions.
H2 (alternative hypothesis): Comfort in mobility has a statistically significant effect on consumers' EV purchase decisions.
H02 (null hypothesis): Comfort in mobility has no statistically significant effect on consumers' EV purchase decisions.

2. Research Methodology

Existing literature clearly demonstrates that several factors influence consumer perceptions of EV adoption in developed markets, making it particularly important to examine consumer behaviour in one of the world's most populous countries, India. Building on prior research and addressing this gap, the present study seeks to identify the key factors shaping consumer satisfaction with EV usage and to evaluate how these dimensions affect consumer recommendations, thereby influencing potential new buyers in India's rapidly growing EV market. The study was conducted using a convenience sample.

Two critical factors were identified and categorised as Charging Time (CT) and Comfort in Mobility (CM). Data were collected using a standardised questionnaire administered through Google Forms to participants across the Bengaluru, Karnataka area. Respondents represented diverse demographics, including men and women of varying ages, income levels, and occupational backgrounds such as business, service, and other professions (Table 1). Each parameter was measured using an open-ended, 'Yes'/'No' questionnaire (Table 2). Logistic regression was employed to assess whether significant associations exist between the predictor variables and consumer recommendation of EVs.

3. Results

Age	%	Gender	%	Educational qualification	%	Occupation	%	Monthly income (INR)	%
>20	36%	Male	57%	Below graduate	7%	Service industry	27%	<15,000	35%
>25	24%	Female	43%	Undergraduate	47%	Entrepreneur	24%	15,000–25,000	18%
>30	19%			Postgraduate	24%	Students	47%	25,000–30,000	21%
>35	15%			Others	20%	Others	1%	30,000–35,000	13%
>40	6%			others	2%	Business community	1%	35,000–40,000	13%
>45	0%							40,000–45,000	0%
Primary data set / own source.									

Table 1: Demographic Characteristics of Survey Respondents

Predictor	Sample size	Yes	No
Charging time	200	106	94
Comfort in mobility	200	104	96
Yes/No values represent counts of respondents recommending (Yes) or not recommending (No) EV purchase for each predictor.			

Table 2: Survey Responses for the two Predictor Variables

Variable	B	S.E.	Wald	df	Sig.
Charging time	0.03	0.331	5.071	1	0.000
Comfort in mobility	0.05	0.315	4.403	1	0.000
Constant	0.05	0.227	3.840	1	0.000
B, unstandardized regression coefficient; S.E., standard error; df, degrees of freedom; Sig., significance value.					

Table 3: Results of the Binary Logistic Regression (SPSS v.26)

Because the significance value for charging time ($p = 0.000$) is below the 0.05 threshold and the Wald statistic (5.071) exceeds the chi-square critical value, charging time has a statistically significant effect on EV purchase decisions. Similarly, the significance value for comfort in mobility ($p = 0.000$) is below 0.05, indicating a statistically significant effect on EV purchase decisions. On this basis, both null hypotheses (H01 and H02) are rejected in favour of the corresponding alternative hypotheses (H1 and H2).

Logistic Regression Equation
From Table 3, the fitted logit model is:

$$logit(p) = \beta_0 + \beta_1(\text{Charging Time}) + \beta_2(\text{Comfort in Mobility})$$
$$logit(p) = 0.05 + 0.03(\text{Charging Time}) + 0.05(\text{Comfort in Mobility})$$

and the corresponding probability of purchase is:
$$P = 1 / [1 + e^{-}(0.05 + 0.03 \cdot CT + 0.05 \cdot CM)]$$

Both predictors are statistically significant, with small but positive effects on the likelihood of EV purchase.

3.1. Interpretation of Results

The Wald values (5.071 and 4.403) both exceed the chi-square critical value (≈ 3.84 at $\alpha = 0.05$), confirming that both predictors are statistically significant; the associated significance values ($p = 0.000$) reinforce this conclusion. The regression coefficients are small (0.03 and 0.05), indicating that charging time and comfort in mobility exert a modest but positive effect on the log-odds of EV purchase, while the constant term reflects the baseline log-odds when both predictors are zero.

At the behavioural level, the logistic regression analysis revealed that operational convenience and experiential satisfaction exert a measurable influence on individual decision-making. Although the coefficients associated with charging duration and comfort in mobility were modest, their consistent positive contribution underscores the importance of designing systems that align with user expectations. When travellers perceive reduced waiting times and smoother journeys, they are more inclined to embrace alternatives that mitigate ecological harm. This finding highlights the necessity of embedding human-centred design principles into infrastructure planning, ensuring that technological advancements resonate with everyday realities rather than remaining abstract improvements. The results are consistent with the alternative hypotheses (H1 and H2).

From a technical perspective, the predictive battery thermal-management strategy discussed earlier represents a meaningful step forward: by shifting from rigid temperature set points to dynamic zones, the controller gains elasticity, enabling actuators to balance safety with energy efficiency [20]. This approach conserves resources and prolongs component lifespan, thereby reducing lifecycle costs. The staged methodology offline optimisation through dynamic programming followed by experimental validation illustrates a rigorous pathway for bridging theoretical insights with practical implementation, ensuring that innovations extend beyond laboratory settings into real-world applications. Adoption of such technologies and supporting policies can contribute positively to user experience.

Studies conducted under extreme cold conditions add further depth to this discussion [21]. Cold environments pose unique challenges, as electrochemical reactions slow and internal resistance rises, leading to inefficiencies and potential safety risks; integrating heating strategies with charging has shown positive results under performance analysis. This underscores that, rather than focusing solely on reducing charging time, engineers must consider the broader thermal and electrochemical context to maintain performance under adverse conditions. A holistic perspective that provides actionable guidance for designing systems that remain reliable across diverse climates.

Beyond the hardware dimension, systemic coordination emerges as a critical factor. The Chimp Tangent Search Algorithm exemplifies how hybrid computational techniques can resolve complex optimisation problems inherent in charging networks [22]. By incorporating diverse criteria such as cost, distance, priority, and user preference, the algorithm supports equitable and efficient allocation of charging resources, reducing congestion at charging stations and enhancing user satisfaction, reinforcing the behavioural drivers identified earlier. The synergy between deep-learning models and evolutionary algorithms demonstrates the potential of artificial intelligence to orchestrate large-scale mobility ecosystems, ensuring that technological progress translates into systemic efficiency.

However, translating these technical advances into practice requires better infrastructure and continued adoption of emerging research. Electric vehicles have travelled a long way over the last few decades, and early studies on charging efficiency provide a foundation for the path forward.

4. Conclusion

This research highlights the intricate interplay between technological innovation, behavioural dynamics, and systemic coordination in advancing environmentally responsible mobility. Its strength lies in weaving together empirical analysis, predictive modelling, and algorithmic optimisation. The findings demonstrate that sustainable transport adoption is not merely a matter of engineering progress but a holistic endeavour requiring attention to user experience, infrastructure efficiency, and intelligent system design.

The broader societal implications resonate strongly with global sustainability agenda. Within the framework of SDG 11, the emphasis on infrastructure quality and user experience aligns with the vision of inclusive and resilient urban environments: cities that invest in reliable charging networks and prioritise ease of movement can reduce emissions, improve accessibility, and foster healthier living conditions. Equally, in relation to SDG 12, shortening charging durations and enhancing travel comfort nudge individuals toward choices that reduce dependence on fossil fuels, contributing to cleaner production cycles and the principles of a circular economy.

For policymakers and industry stakeholders, the implications are substantial. Adoption of sustainable mobility depends not only on technological feasibility but also on human perception and systemic coordination; investments in advanced thermal management, intelligent scheduling algorithms, and user-friendly infrastructure are likely to yield dividends in environmental, social, and economic terms. Urban planners should integrate these insights into long-term strategies that harmonise technological progress with human needs.

The study also underscores the value of interdisciplinary collaboration among engineers, data scientists, behavioural researchers, and policymakers in designing solutions that are technically robust, socially acceptable, and environmentally beneficial. Future research could extend the predictive thermal-management strategy to incorporate real-time adaptive learning, integrate scheduling algorithms with broader energy-management systems so that charging demand aligns with renewable energy availability, and further explore user behaviour across different cultural and geographic contexts to better understand how comfort and convenience influence adoption globally.

In summary, this study provides evidence that targeted improvements in charging technology and infrastructure can meaningfully enhance the mobility experience and advance sustainable transport adoption. By combining statistical analysis, technical innovation, and algorithmic optimisation, the research offers a holistic perspective on accelerating the transition toward environmentally responsible mobility systems, underscoring that sustainability is achieved not through isolated interventions but through integrated strategies addressing both human and technical dimensions.

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