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Evaluating Consumer-Oriented Government Policies for Promoting Electric Vehicle Adoption in the Indian Market

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Abstract

India's current transportation system, dominated by conventional vehicles especially two wheelers, faces significant challenges, including severe air pollution, health hazards, escalating oil prices, and heavy dependence on oil imports. To address these issues, electric vehicles (EVs) have been introduced as a sustainable alternative. However, EV adoption in India remains modest compared to other nations, despite various government incentives. This study critically examines consumer-oriented policies, particularly the Faster Adoption and Manufacturing of Electric Vehicles (FAME), Phases 1 and 2, focusing on two-wheeler and four-wheeler adoption from 2015 to 2024. The findings reveal that the existing government initiatives are insufficient to drive substantial consumer adoption of EVs. The study also underscores the significant impact of CO_2 emissions and petrol prices as key determinants of EV adoption. In line with the analysis, policy recommendations are provided to enhance the effectiveness of existing measures and support policymakers in formulating strategies to accelerate EV penetration in India. These findings aim to contribute to achieving sustainable transportation and reducing India's environmental and energy challenges.

Keywords: Electric Vehicles, Policy Analysis, Generalized Linear Model, India, Carbon Emission

1. Introduction

The global ecological system is shaking due to excessive greenhouse gas emissions, that is the byproduct of rapid expansion of the world economy in which the main contribution is coming from the increasing consumption of fossil fuels (Yang et al., 2022). By 2022, global transportation utilized over 120 exajoules, in which crude oil alone produced 106.41 exajoules (Statista, 2024). In this sector, particularly road transportation, which is integral to economic and social development, is grappling with significant issues related to energy security, dependence, and air pollution (Kong et al., 2020). EVs give consumers several benefits, improve environmental sustainability, more energy-efficient, less polluting transportation, and an economical alternative. EVs show better efficiency, better well-to-wheel energy performance, and no tailpipe emissions as opposed to internal combustion engine vehicles (ICEVs) (Hardman et al., 2017; Nordelöf et al., 2014).

In 2024, India is the third-largest economy in the world based on purchasing power parity (PPP), following the United States and China. The country accounts for approximately 8.23% of the global GDP (PPP), reflecting its significant contribution to the world economy (IMF, 2024) and India is anticipated to become the world's most populous country, with a projected population of 1.44 billion in 2023 (World Bank, 2024). With this growing rate India has manifest to achieve a 30% market penetration of EVs in private cars and 80% in two-wheelers by 2030. Reaching these adoption levels could result in cumulative savings of 846 million tons of Carbon Dioxide (CO_2) emissions over the operational lifetimes of these vehicles, along with significant reductions in oil consumption (PIB, 2019).

Currently, India's transport sector is responsible for approximately 142 million tons of CO_2 emissions annually, with road transport alone contributing 123 million tons. The adoption of EVs is anticipated to play a pivotal role in transitioning to a low-emission transportation system. Depending on the energy mix of the local electrical grid, EVs can reduce emissions by 45% to 98% compared to gasoline-powered vehicles (Tyagi & Vishwakarma,

2022). Aligning with global climate initiatives, India committed to achieving net-zero carbon emissions by 2070, as announced during the 26th United Nations Climate Change Conference in November 2021 (MoEFCC, 2023). Plenty of research has been conducted with various methodologies to examine prior and contemporary national or sub-national vehicle policy initiatives. Through a global analysis of incentive policies, it is concluded that direct subsidy is an effective way to promote EV in different nations (Butt & Singh, 2023; Wang et al., 2019). By implementation of the purchase incentive to minimize the cost difference between EVs that are still in their infancy stage and ICEVs that have reached maturity (Ma et al., 2017). According to a study conducted in 50 US cities, a $1,000 increase in the value of EV policies raises registrations of EV up to 5-11% (Wee et al., 2018). Hardman et al., 2017 in his study shows that the incentives should be implemented at the time an EV is purchased, not after. EV adoption relies on incentives being timely and orderly implemented. Premature incentive withdrawal could have an adverse impact on EV registrations; nonetheless, present study indicates that bigger subsidy amounts do not always ensure higher EV adoption (Liu et al., 2021; Qiu et al., 2019; Yang et al., 2016).

By means of a targeted policy analysis on the adoption of electric two-wheelers (E2Ws) and electric four-wheelers (E4Ws) in India, this paper attempts to bridge significant gaps in the research. With a glance toward both financial incentives such as subsidies and Goods and Service Tax (GST) exemptions and non-financial incentives like road tax exemption, campaigns and green policies, the study evaluates national EV policies implemented between 2015 and 2024 on EV adoption. Additionally, the non-financial incentives accelerate the EV adoption especially in two-wheeler segment that is the dominating segment in Indian household under automobile sector. Apart from the policy initiatives, the study also focusses on socio-economic factors such as fuel price fluctuations and environmental concern influencing the EV adoption among consumers. By positioning these findings within India's distinct socio-economic and policy context, this study enriches reader understanding by establishing correlation between policy framework and EV adoption trends. Though a growing pool of research on EV policies exists, no empirical study has methodically assessed how India's national EV regulations affect the adoption of E2Ws and E4Ws. This study thus makes a major contribution to the area by providing policy insights that might guide future initiatives for supporting sustainable modes of transportation.

The study structure is divided into seven parts. The first part presents the introduction and summarizes India's EV policy structure, therefore serving a basic framework for the study. Reviewing existing research, the second part forms the hypotheses to be investigated. The third and fourth sections cover the research methodology and data sources, together with the models employed for empirical analysis. The results are presented in the fifth section followed by an in-depth investigation. While the sixth section summarizes the main conclusions from the study and the last part describes the practical implications for researchers, industry players, and legislators.

1.1 India’s EV Policy Status

In India, a noteworthy initiative began in the transport sector in 2013 with the introduction of the National Electric Mobility Mission Plan (NEMMP), aimed at promoting the adoption of EVs and hybrids. Additionally, FAME Scheme was initiated in 2015 with lucrative incentives to enhance the use and manufacturing of environmentally sustainable vehicles (Sreeram et al., 2019). These incentives are spread through a virtual portal that is both effective and efficient. The scheme encourages the transportation sector to move toward the electricity and reduce the dependency from fossil fuels (Das & Bhat, 2022).

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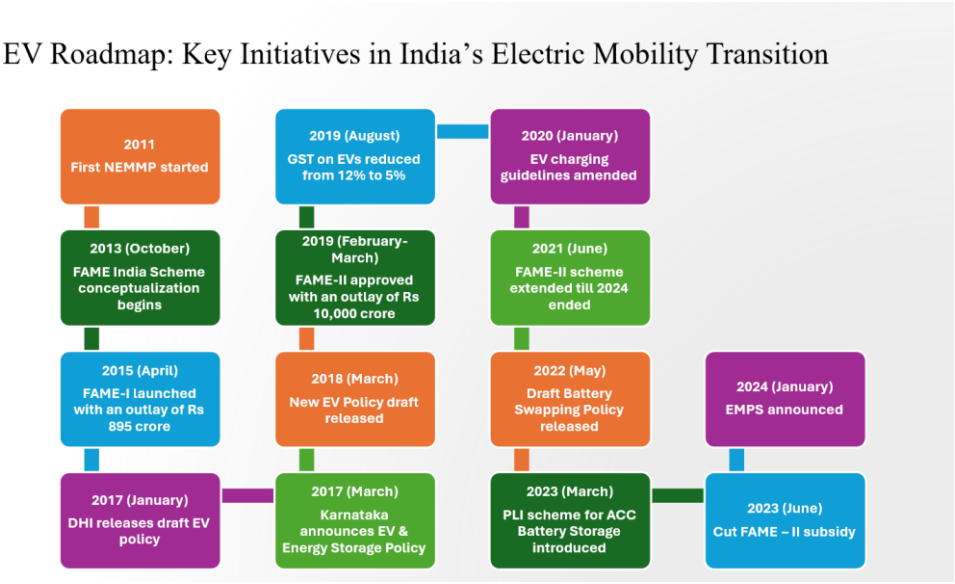

Figure:1 EV Roadmap

Source: Compilation by the author by using data obtained from E-Amrit

India's EV initiative environment has grown to accelerate technology advancement, take advantage of market opportunities, and maximize manufacturing capacity. The FAME-I initiative promoted electric and hybrid vehicle technology, establishing an industry growth ecosystem. FAME-II offered various financial incentives, improved EV charging infrastructure, and awareness campaigns to boost EV and hybrid adoption. Modern automobile technologies, such as EVs and hydrogen fuel cell vehicles are strengthened by the Product Link Incentive (PLI) scheme. Additionally, the PLI Scheme for the National Programme on Advanced Chemistry Cell (ACC) Battery Storage aimed to enhance India's domestic capacity for ACC and battery production by supporting the establishment of large-scale facilities. More recently, the Electric Mobility Promotion Scheme was introduced to sustain the growth of the EV market while addressing fiscal challenges. It reflects a balanced approach to market development, emphasizing continued adoption while managing the financial implications of subsidies, as illustrated in **Figure 1 and 2**.

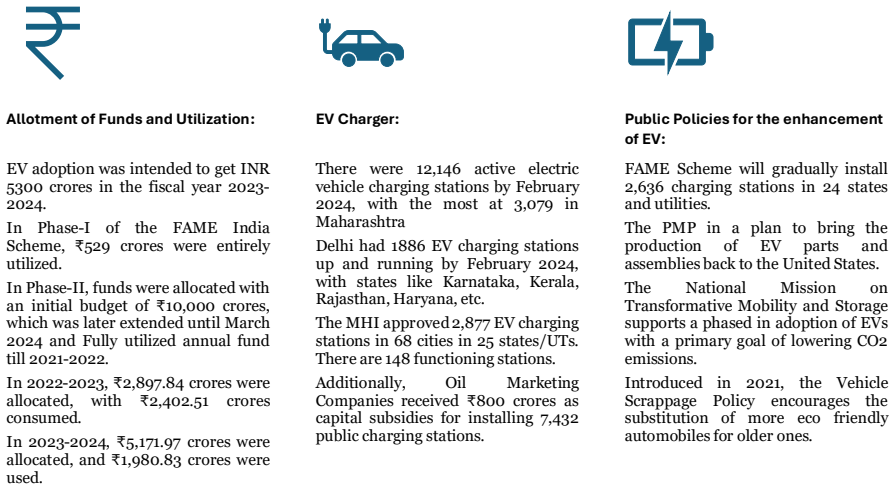

Figure: 2 Policies and their Corresponding outcomes

Source: Author's compilation based on the data extracted from E- Amrit, BEE, and MoHI

The Central Electricity Authority plays a vital role in advising policy issues, offering technical assistance, and establishing regulatory standards for the EV ecosystem. These collaborative initiatives seek to establish favorable circumstances to realizing India's ambitious EV adoption objectives. (BEE, 2024; E- Amrit, 2024; MoHI, 2024a, 2024b; PIB, 2023)

2. Literature Review

The implementation of financial and non-financial incentives by policymakers aims to enhance the market acceptance of EVs. Financial incentives encompass measures such as grants, income tax deduction, and purchase tax exemptions. Similarly, High-occupancy vehicle lane access, bus lane usage, and driving limitation exemptions are non-financial incentives (Abdul Qadir et al., 2024; Hardman, 2019).

The policy that investigation the EV adoption by applying several policy programmes is primarily conducted employing econometric methods and simulation-based models. Studies that utilize simulation models have shown policy effectiveness. Simulation-based studies in China indicate the disparity between current EV sales and upcoming production demands under the dual-credits policy, highlighting market challenges (Wu et al., 2021). Financial incentives are also significant in encouraging EV adoption. According to Vidyattama, targeted financial assistance for lower-income households, particularly for EVs with average purchase prices around $50,000, could increase EV adoption while marking sales volumes (Vidyattama et al., 2024). Moreover, License plate restrictions have a greater impact on EV adoption than direct expenditures on research and development (Deng et al., 2024). A multifaceted policy approach has been facilitated by European countries. A study conducted through agent-based modeling revealed that acquisition incentives, charging infrastructure expansion, and energy pricing adjustments accelerate the EV market penetration. Integration of numerous policy instruments is more effective than isolated initiatives due to heterogeneous behavior among consumer and their preferences (Neshat et al., 2023; Qiu et al., 2022; Shao & Mišić, 2023). By providing infrastructure subsidies and discounts on charging services have increased EV sales. However, purchase subsidies, parking incentives, and incentives for model development have exhibited comparatively limited effectiveness in China (Qiu et al., 2019). Contrastingly, other studies indicate that a 1% increase in purchase subsidies corresponds to a 1.36% rise in EV sales and a 2.31% increase in overall market share. Additionally, non-financial measures such as parking incentives, promotional targets, and vehicle restrictions—have been identified as significant drivers of EV adoption. The effectiveness of these measures varies across cities, as socio-economic factors play a crucial role in determining policy outcomes. In certain cases, non-monetary incentives have been found to amplify the impact of financial subsidies, reinforcing the need for a well-balanced policy framework (Shang et al., 2024).

For EV owners in Norway, over 80% attribute their purchase decisions to exemptions from purchase taxes and value-added taxes (VAT). However, a smaller percentage prioritizes toll tax exemptions or access to bus lanes (Mersky et al., 2016). Government policy incentives, including preferential taxation, reduced parking fees, driving privileges, electricity subsidies, and exemptions from road and fossil fuel taxes, have substantially influenced EV adoption (Habich-Sobiegalla et al., 2018; Shang et al., 2024). Notably, tax incentives tend to benefit larger BEVs more significantly than smaller ones, enhancing environmental benefits by reducing CO_2 emissions in the transport sector (Yan, 2018).

2.1 Financial Assistance

Government policies worldwide have introduced various financial incentive schemes to accelerate the adoption of EVs. Among these, purchase subsidy programmes stand out as highly effective measures in influencing consumer purchasing behavior (Kalpana, 2025; Lu et al., 2022). To improve the accessibility and popularity of EVs for the general market, it's crucial to lower their relative costs. Research indicates that reducing EV pricing during the initial adoption phase is the most significant incentive for promoting broad adoption (Bjerkan et al., 2016). Developing attractive and cost-effective EV options is an essential approach for governments and manufacturers striving to increase EV sales (Nykvist & Nilsson, 2015). Research frequently demonstrates an inverse relationship between the cost of EVs and their adoption rates. Excessive upfront costs discourage

consumers from acquiring EVs, but reduced prices notably increase their willingness to purchase (Cui et al., 2021; Junquera et al., 2016). Consumers possess significant price sensitivity, making pricing an essential consideration in their purchasing decisions (Lee Weisstein et al., 2014). Moreover, perceived economic advantages, including long-term cost reductions associated with ownership, favorably impact consumer choices (Nazari et al., 2019). This highlights the necessity of financial incentives to mitigate the principal obstacle to EV adoption: hefty initial costs. This is especially noticeable in areas like Germany, where both EV professionals and general consumers consider initial pricing a pivotal component for EV acceptability (Barth et al., 2016). Research from Canada indicates the efficacy of financial incentives, revealing that purchase subsidies raise new EV sales by an average of 5% to 8%, representing roughly 35% of overall sales (Azarafshar & Vermeulen, 2020). Although reduced operating costs are frequently regarded as a benefit of EVs, the initial acquisition cost is perceived as a significant barrier for consumers (Habich-Sobiegalla et al., 2019) . A study in India by Chhikara et al. (2021), applying semi-structured interviews with diverse stakeholders such as EV owners, prospective buyers, automakers, suppliers, and government officials, revealed that financial incentives significantly enhance EV sales. These incentives significantly influence impatient consumers who emphasize considerable immediate savings (Chhikara et al., 2021). Moreover, alternative forms of direct financial assistance, such interest rate waivers, have demonstrated efficacy in encouraging EV adoption among consumers unwilling to spend the entire upfront expense on EVs in a single payment. Drawing from the existing research, the subsequent hypotheses are suggested:

- **H1**: Financial assistance impacts the adoption rate of E4Ws positively.
- **H2**: Financial assistance impacts the adoption rate of E2Ws positively.

2.2 Non-Financial Assistance

Alongside offering financial support, governments might introduce non-monetary incentives to promote the adoption of new technology or limit the utilization of competitive alternatives. Non-monetary incentives encompass several periodic and situational advantages, including access to bus lanes, parking rights, the establishment of charging infrastructure, exemptions from toll costs, and licensing benefits. These approaches have been shown to enhance the adoption of EVs (Hardman, 2019). Furthermore, new measures like green license plates have demonstrated both economic and statistical significance in facilitating EV adoption. The green license plate policy in China has developed as a significant program, promoting customer preference for EVs over ICEVs (S. Li et al., 2022). In addition to these logistical steps, awareness campaigns are essential for informing and educating the public about the advantages of EVs, mitigating consumer skepticism fostering trust, and highlighting the environmental and economic benefits of EV adoption. These initiatives serve as excellent transitional support systems for promoting EV adoption in emerging markets such as India (Chhikara et al., 2021). Standards and regulations are commonly employed mechanisms for promoting the adoption of eco-innovations, aiding in environmental and technical progress (Kalthaus & Sun, 2021). Drawing from the existing research, the subsequent hypotheses are suggested:

- **H3**: Non-financial assistance impacts the adoption rate of E4Ws positively.
- **H4**: Non-financial assistance impacts the adoption rate of E2Ws positively.

2.3 GST Rates on EV registration

The GST was implemented to merge and simplify India's indirect tax system, amalgamating various taxes, including the Central Excise Tax, VAT/Sales Tax, and Service Tax into a cohesive framework (Nayyar & Singh, 2018). One of the goals of this consolidation is to increase economic efficiency while also improving the accuracy of taxation. Research suggests that reductions or exemptions in indirect taxes, such as VAT, have a positive impact on the growth of EV sales over the long run. Furthermore, it has been established that exemptions from VAT is upto 20% can greatly increase the market share of EVs in the United Kingdom (Ma et al., 2017; Santos & Rembalski, 2021; Xue et al., 2021). These findings highlight the necessity of specific tax

measures in easing the financial burden that must be carried on by consumers in order to facilitate the adoption of EVs. Based on this premise, the subsequent hypotheses are proposed:

- **H5**: GST rates impact the adoption rate of E4Ws negatively.
- **H6**: GST rates impact the adoption rate of E2Ws negatively.

2. 4 Effect of CO_2 on EV registration

Along with industry and energy, transportation is one of the three main sectors that contribute drastically to global carbon emissions. The sector ought to simultaneously move toward zero-carbon solutions and preserve economic growth (Y. Li et al., 2019; Zahoor et al., 2023). Vehicle usage restrictions, the phase-out of outdated vehicles, fuel taxes, and the reduction of subsidies are just a few of the measures that have been put in place to address this issue. Because of their low or zero exhaust emissions, EVs have become a feasible way to combat pollution generated by transportation (Zhang & Bai, 2017). EV adoption has the potential to drastically lower carbon emissions in India with robust policy support, which would result in notable long-term improvements in air quality (Hossain et al., 2023). Identically, a notable rise in EV demand indicates that Pakistan may be able to reduce transportation-related emissions significantly by 2040 (Butt & Singh, 2023). In comparison to ICEVs, moving to EVs in Brazil may result in CO2 emissions that are 10–12 times lower (Teixeira & Sodré, 2018). The essential role of CO2 concerns when promoting EV adoption is emphasized by the increased awareness of climate change and the effective implementation of government regulations that minimize emissions. People perceived that EVs are a greener and more sustainable option than ICEVs. Considering this, the following hypotheses are outlined:

- **H7**: Concern about the CO_2 impact the adoption rate of E4Ws positively.
- **H8**: Concern about the CO_2 impact the adoption rate of E2Ws positively.

2.5 Fuel Price's impact on EV Registration

The primary factors shaping consumer choices are the initial cost of EVs as well as fluctuations in fuel prices. Subsidies aid in encouraging the adoption of EVs, although Dong et al. (2020) highlighted that factor apart from cost influence EV adoption. Nonetheless, the reduction or elimination of subsidies, coupled with a growing variation in fuel price, has become increasingly apparent (Dong et al., 2020). Several studies have investigated the effect of fuel price fluctuations on EV adoption, even though government policies do not directly regulate fuel prices or deliberately manipulate them to promote EV sales. These studies consistently reveal that increases in fuel prices for ICEVs positively influence the market share of EVs (Adepetu et al., 2016; Javid & Nejat, 2017; Liu et al., 2021; Wee et al., 2018). Rising gasoline prices primarily impact the demand for fuel-efficient vehicles and accelerate the shift towards electric mobility (Gallagher & Muehlegger, 2011). Conversely, electricity prices exhibit a negative correlation with the expansion of the EV market. High electricity costs may deter potential EV buyers, undermining the financial advantage of operating EVs compared to ICEVs (Wang et al., 2019). Based on these findings, the following hypotheses are proposed:

- **H9**: Petrol price impact the adoption rate of E4Ws positively.
- **H10**: Petrol price impact the adoption rate of E2Ws positively.

3. Data

The data included in this study contains a comprehensive time series that accurately and objectively represents EV registrations over the past nine years. To address the complexity of analysing we transform the data into log value to measure the individual impacts of various EV policy instruments implemented by the government over time as in **Figure 2**:

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Volume 2026, No. 1

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Figure:2 Incentives offered by Government to consumers

Source: Author's compilation based on the data extracted from E- Amrit

So, we combine two variables: L4WS/L2WS and BIN. L4WS/L2WS represents the combined value of the vehicle purchase incentives and the tax deduction for interest paid on loans specifically taken for EV purchases(MoF, 2024). Meanwhile, BIN is a binary variable that aggregates the presence of policies such as implementation campaigns, green license plates, permit exemptions, and road tax waivers. These constructs enable a streamlined approach to capture the collective effects of multiple policies within the model analysis through SPSS. All the data was collected from distinct publicly available sources, the EV registration data comes from Vahan Dashboard, National Level Policy for all types of financial and non-financial policies, the Emissions of CO_2 from the transport sector captured through world bank database as shown in **table:1**

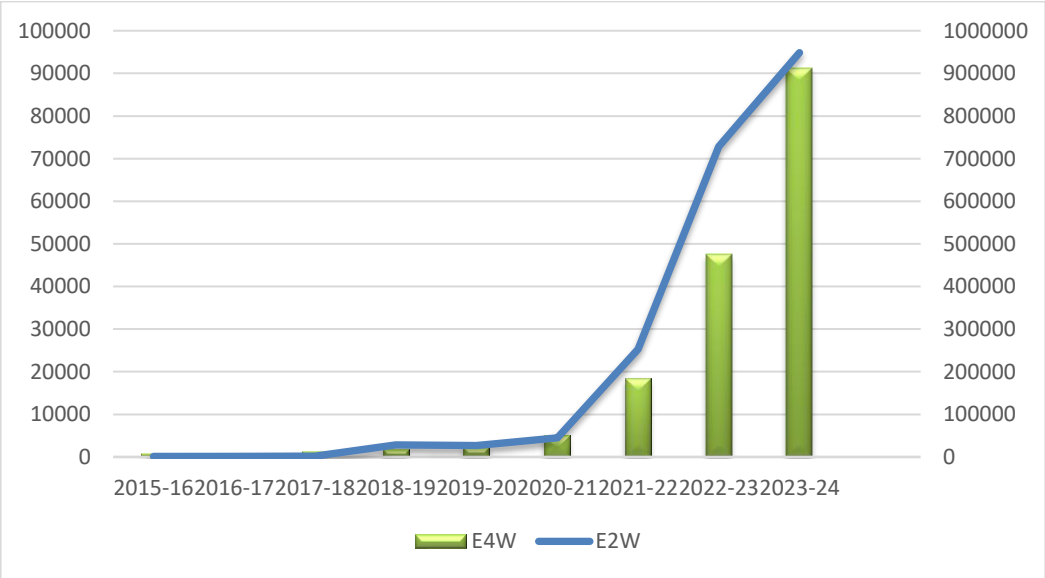

Figure:3 Adoption rate of E2W and E4W

Source: Author's compilation based on the data extracted from CEEW

In 2023, around 0.9 million E2W were sold in India representing 5% of total sales, respectively (IEA, 2024). After doubling subsidies for E2Ws, their sales experienced exponential growth. This trend became particularly evident in the post-COVID-19 period, during which the demand for personal vehicles witnessed a significant surge presented in **Figure 3**. The data highlights a substantial increase in the sales of E4Ws in recent years, reflecting the growing acceptance of EVs in the Indian market (CEEW, 2025). The Indian automotive sector has prioritized reducing reliance on fossil fuels and minimizing carbon emissions, aligning with broader sustainability goals. EVs emerge as a compelling solution, offering an environmentally sustainable alternative capable of addressing both energy security concerns and environmental challenges. The observed sales growth underscores the potential of targeted subsidies and policy initiatives to accelerate the transition to cleaner mobility solutions.

Table:1 Description of Variables

Dependent Variable	**Variables**	**Details**	**Sources**
	E2W registration	Monthly registration data of 2W from April 2015 to March, 2024	Vahan Dashboard, 2024
	E4W registration	Monthly Registration data of 4W from April 2015 to March 2024	Vahan Dashboard, 2024
Independent Variables	E2W Subsidy	The maximum value provided by the government to encourage the adoption of EVs with interest exemption	BEE, 2024; E- Amrit, 2024; MoF, 2024
	E4W Subsidy	The maximum value provided by the government to encourage the adoption of EVs with interest exemption	E- Amrit, 2024; MoF, 2024
	GST	To minimize the expenses associated with EV usage, the government decreased the GST rate available to all EVs.	MoF, 2019
	BIN Campaign	Binary Number 1 for each policy used to show the implementation campaign, green license plates, permit exemptions, and road tax waivers policy otherwise 0	BEE, 2024; PIB, 2023
	CO_2	Carbon Emission from transportation sector	WDI, 2024
	Petrol Price	The monthly rate of petrol per liter	PPAC, 2024; Team, 2024

4. Methodology

Data transformations are traditionally used to fit non-normal data into a normal linear regression framework or to identify response variable transformations (such as discrete, categorical, or continuous scales) that maintain a linear relationship with predictors. However, such transformations are no longer a strict necessity. Instead, generalized linear models (GLMs) offer a more flexible framework by accommodating response variables that follow non-normal distributions, such as positively skewed distributions constrained to positive real numbers (Ng & Cribbie, 2017). GLMs extend the capabilities of traditional linear models, recognizing that response variables may not adhere to normality, may exhibit heteroscedasticity, and may involve a non-continuous scale. They establish a linear link between the mean of the response variable and the predictors through an appropriate link function (Myers & Montgomery, 1997). Introduced by Nelder and Wedderburn in 1974, GLMs have broad

applicability across various statistical contexts, encompassing regression, ANOVA, logistic, probit models, Gamma, and more (Nelder & Wedderburn, 1972).

The effects of different variables on the adoption rates of E4W and E2W were assessed using the GLM approach. It extends traditional linear regression by allowing the dependent variable to follow distributions other than the normal distribution. For this case, the Gamma distribution is used due to the non-negative, continuous, and skewed nature of the response variables. The systematic component of a GLM represents the fixed structural part that explains the variability in the means of the response variable. This component, often referred to as the linear predictor, is a linear combination of predictor variables. These variables can either be numerical (continuous or dummy-coded) or discrete (categorical). In the model's specification, the linear predictor is positioned on the right-hand side of the equation, forming the foundation of both linear and nonlinear regression models. Let x_1, x_2, …, xp represent the explanatory variables, where p denotes their count; the linear predictor integrates these variables to model systematic relationships within the data(Salinas Ruíz et al., 2023).

GLM Framework:

$$g(\mu_i) = \eta_i = \beta_0 + \sum_{j=1}^{\rho} \beta_j x_{ij} \qquad \text{……..(1)}$$

$g(\mu_i)$: link function transforming the expected value of the dependent variable (μ_i) to the liner predictor (ηi): Linear predictor for observation *i,* represent a linear combination of predictors, β_0*:* Intercept term β_j*:* coefficient for the *j* predictor variable x_{ij}*:* independent variable *j* for observation *i, p:* number of predictors in the model demonstrating in Equation (1).

Link function:

A log link is applied to ensure the mean $\mu_i > 0$

$$\eta_i = \log(\mu i)$$

This implies that: $\mu_i = e^{\eta i}$

Model For LE4

$$g(\mu_i) = \eta_i = \beta_0 + \beta_1 BIN + \beta_2 GST + \beta_3 L4WS + \beta_4 LCO_2 + \beta_5 LP \qquad \text{……..(2)}$$

Model for L2W

$$g(\mu_i) = \eta_i = \beta_0 + \beta_1 BIN + \beta_2 GST + \beta_3 L2WS + \beta_4 LCO_2 + \beta_5 LP \qquad \text{……..(3)}$$

Where:

In equation (2) and (3) $g(\mu_i)$ is link function that connects the mean of the dependent variable to the linear predictor, η_i is the linear predictor representing systematic variability, β_0 is the intercept term, capturing the baseline level of LE4W adoption in the absence of predictors, $\beta_1 BIN$ is the coefficient associated with BIN, a composite variable representing non-monetary policies, $\beta_2 GST$ is the impact of GST on vehicle adoption, $\beta_3 L4WS$ is the Monetary subsidies and financial incentives tailored for four-wheelers, $\beta_4 LCO_2$ is the impact of lower CO_2 emissions, acting as a motivator for adoption, $\beta_5 LP$ is the Petrol Price linked to encourage EV purchases and $\beta_3 L2WS$ include incentives and subsidies specifically aimed for two-wheelers, substituting $L4WS$ in the prior model.

5. Results and discussion

This section provides an in-depth analysis of national EV policies implemented over a nine-year period, alongside a discussion of the descriptive statistics for EV-specific factors. It also presents the results of the empirical analysis conducted using a GLM with a gamma distribution. The results indicate how the adoption of E2Ws and E4Ws in the Indian market is impacted by a number of consumer-oriented policy initiatives, including financial and non-financial incentives, when combined with other influencing factors. Omnibus tests

and goodness-of-fit measures were used for validation with the intention of ensuring the results' reliability and robustness.

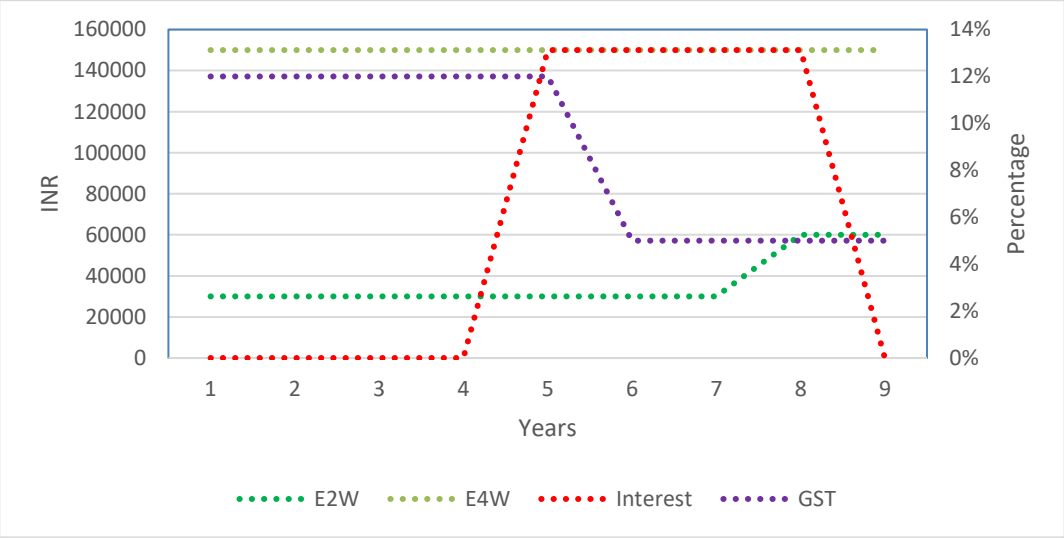

Figure 4: Incentives Policies over time

Source: Author's compilation based on the data extracted from E-Amrit

Various incentive programmes that the government has put forward for promoting EV adoption during a nine-year period, from 2015 to 2024, appear in **Figure 4**. Throughout this time, the direct subsidy for E4Ws stood at INR 150,000. But in 2021, the E2W subsidy doubled from INR 30,000 to INR 60,000, a significant increase that indicates a deliberate attempt to promote adoption in this sector. Customers were also given an interest exemption of INR 1,50,000 between 2019 and 2022, which further encouraged EV purchases by reducing the burden of financing. In 2020, the GST rate on EVs was also drastically reduced from 12% to 5% to increase affordability and boost market demand. These measures collectively reflect a comprehensive policy framework designed to address financial barriers and accelerate the adoption of EVs in the market.

Table: 2 Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness
LE4W	108	.47712	3.97266	2.62350	.74588	.328
LE2W	108	1.8750	5.13852	3.34415	1.07828	.131
BIN	108	1	4	2.09	1.437	.566
L4WS	108	5.17609	5.47712	5.30988	.15028	.227
L2WS	108	4.47712	5.32221	4.87005	.38510	.100
LCO_2	108	2.41119	2.48835	2.45422	.025747	.195
GST	108	.05	.12	.0837	.03514	.075
LP	108	1.75289	2.04016	1.89366	.076065	.148

Source: Calculated by SPSS

In the GLM framework, the dependent variables LE4W and LE2W are non-negative, aligning with the requirement for non-negativity in the model. Furthermore, the Gamma distribution is suitable for this analysis as it effectively handles right-skewed data, a characteristic observed in residual analysis comes from linear regression or all variables presented in **Table 2**.

Table: 3 Parameter Estimates GLM analysis under Gamma distribution

Variables	*LE4W β*	t-value	Sig.	*LE2W β*	t-value	Sig.
Intercept	-3.102	-2.10878	.035	-11.020	-10.8733	.000
(BIN=1)	-.199	-2.69865	.007	-.105	-1.85185	.064
(BIN=3)	-.032	-0.29572	.767	.031	0.376257	.707
L4WS	-.511	-3.76773	.000	-	-	-
L2WS	-	-	-	.015	0.29694	.767
LCO_2	1.634	2.575739	.010	3.285	6.633025	.000
GST	-2.256	-2.69138	.007	-2.094	-2.99816	.003
LP	1.610	2.928735	.003	2.263	5.353564	.000
Scale	.019	7.222132		.012	7.635888	

Source: Calculated by SPSS

The results of Gamma distribution as in table 3 for the LE4W model generates important insights regarding the impact of different policy measures on the adoption of LE4W in India. In the analysis conducted, the BIN policy, which consists of four separate non-monetary interventions, reveals that only one element, BIN 1, holds statistical significance. The p-value of 0.007 indicates that BIN 1 has a marginally negative effect on the adoption rates of LE4W vehicles. The remaining BIN policies do not demonstrate statistical significance, suggesting that these measures may not play a substantial role in influencing adoption rates within the context of this study and reject the H3 hypothesis. The limited impact may be attributed to broader structural or behavioral factors that influence the market for LE4Ws.

The aggregated incentive variable L4WS indicates a notable and inverse relationship with LE4W adoption, evidenced by rejecting the H1. In a similar vein, GST demonstrates a pronounced negative correlation with LE4W adoption, indicating that a decrease in the GST rate is likely to enhance the market share of EVs, as evidenced by a significance level of p = 0.007 and accept the H5.

$$\eta LE4W_i = -3.102 - 2.256\ GST - .511 L4WS + 1.634 LCO_2 + 1.610\ LP$$

The variables indicating LCO_2 and LP exhibit notable positive correlations with the adoption of LE4Ws. The analysis reveals that both variables exhibit robust statistical significance, indicated by p-values of 0.010 and 0.003, respectively and accept both the hypothesis H7 and H9.

$$\eta LE2W_i = -11.020 - 2.094\ GST + 3.285 LCO_2 + 2.263 LP$$

The findings for the LE2W model indicate that BIN policies lack statistical significance across all levels, and similarly, L2WS, which denotes direct monetary incentives for LE2Ws, also does not show significance, as the results are in line with the above model and reject both the hypothesis H2 and H4. Variables associated with environmental benefits LCO_2 and LP demonstrate significant positive correlations with LE2W adoption. The analysis reveals that both variables exhibit p-values of 0.000, underscoring the importance of promoting environmental benefits as a crucial factor in facilitating the adoption of LE2Ws and accepting both the hypothesis H8 and H10. On the other hand, GST exerts a significantly adverse effect on LE2W adoption, indicating that an increase in the GST rate will reduce the market share of E2W, with a p-value of 0.003 and accept the H6. This underscores the potential constraining influence of the tax structure on market expansion.

Table: 4 Goodness-of-Fit Metrics

Matrices	*LE4W*	*LE2W*
Deviance	2.101	1.252
Pearson Chi-Square	1.296	1.224
Log Likelihood	-40.175	-37.149
AIC	96.350	90.297
AICC	97.804	91.752
BIC	117.807	111.754

Source: Calculated by SPSS

The Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) provided compressive evidence for the robustness for model selection and evaluation. The criteria are based on the maximum likelihood estimates of model parameters, providing a balance between model fitness and complexity (Akaike, 1974; Schwarz, 1978). As the value demonstrated in **table 4** a range of diagnostic metrics, such as AIC, BIC, Deviance, and Log Likelihood, provide significant support for the reliability of the LE4W and LE2W models.

Table: 5 Omnibus Test

	LE4W	Sig.	*LE2W*	Sig.
Likelihood Ratio Chi-Square	162.486	.000	243.690	.000

Source: Calculated by SPSS

The likelihood ratio of Chi Square for model LE4W is 162.486 and LE2W is 243.690 that is statistically significant for both with p value .000 that established metrics are utilized for model selection, especially in evaluating goodness-of-fit and predictive accuracy in **table 5**.

Discussion

The findings of the study suggest that while non-monetary policies may influence EV adoption, their overall effectiveness appears limited. This could be attributed to insufficient public awareness or indifference, as indicated by non-significant results. In the Indian context, the widespread presence of two-wheelers may reduce the potential impact of non-monetary incentives, indicating that additional policies in this category may not substantially alter consumer behavior. Contrary to expectations, financial incentives were not found to be especially conducive to EV adoption. Subsidies are intended to reduce upfront costs and encourage the adoption of EVs, however their impact appears constrained. The analysis primarily showed a negative correlation between the adoption of E4Ws and direct financial subsidies, indicating inefficiencies in the current subsidy frameworks. This may be due to the limitations imposed by FAME I and FAME II policies, which primarily serve early adopters rather than serving the requirements of broader consumers. Although insufficient incentives may operate as deterrents, so that tax structures and subsidies must be carefully designed and directed to ensure the effective promote EV adoption. The findings of this study are consistent with previous research. Customers' sensitivity to price, especially those with lower incomes, emphasizes how crucial subsidies are to encouraging the adoption of EVs.

Existing research indicates that significant influence of financial incentives in persuading lower-income consumers to buy EVs (Helveston et al., 2015; Lu et al., 2022). In the Indian context, financial incentive policies seem to have a moderating effect on consumer choices, interacting with attitudes, perceived utility, convenience, and perceived risks (Jaiswal et al., 2021). However, the efficiency of subsidies may be reduced due to the

comparatively lower incremental cost of EVs in comparison to ICEVs (Narassimhan & Johnson, 2018). It also highlight significant variations in the effectiveness of subsidy programmes among various customer groups. This study supports the diminishing marginal effect of subsidies in increasing EV adoption, which is in line with previous research that looked at financial incentives across 13 countries (2015–2018) (Yao et al., 2020). According to the law of diminishing marginal utility, the benefits from additional subsidies get lower with time. In several cases, EV sales have surged because of reduced subsidies, which have redirected public attention on the inherent worth of EVs (Yang et al., 2022). Efforts to encourage EV adoption have increased as India's energy and transportation sectors undergo major reforms to reduce petroleum dependency (Yadav et al., 2024). Meanwhile, rising petrol prices were found to significantly boost EV adoption, driving increased demand for both E2Ws and LE4Ws. The disparity between electricity rates and fuel prices strongly influences consumer decisions, with higher fuel costs driving greater EV adoption. Subsidizing gasoline prices to encourage EV adoption must account for income disparities (Jiang & Gao, 2023). Finally, studies in California have highlighted the sensitivity of consumers to fuel price fluctuations, given their visibility and significant share of household budgets. Changes in incentives and the emergence of alternative transportation options are expected to interact predictably, as economic theory suggests (Bushnell et al., 2022). On the opposing side, EV adoption was significantly hampered by the GST; both E2Ws and LE4Ws saw a twofold decline in market share because of higher GST rates. Furthermore, EV adoption is more significantly impacted by tax credits and CO2 emission reductions than by direct rebates or financial subsidies (Mekky & Collins, 2024). The study emphasizes how essential environmental advantages are in encouraging EV adoption. Improving air quality and lowering carbon footprints are becoming exponentially important to consumers and legislators. According to the analysis, there was a favorable correlation between EV adoption and variables connected to environmental advantages, like CO2 emissions. Specifically, a 3.2-fold hike in E2W adoption and a 1.6-fold rise in LE4W adoption have been associated with CO2 reductions. The outcomes underline how crucial it is to highlight EVs' environmental benefits as a key driver accelerating market growth. As it continues to be a key attraction for consumers. EVs are acknowledged as a cleaner alternative to ICEVs by both experts and non-specialists (Barth et al., 2016). EV adoption is greatly influenced by regional policy frameworks and environmental factors. Pollution can be mitigated locally and globally by integrating EV support measures into broader environmental policies (Kalthaus & Sun, 2021).

6. Conclusion

India, as a rapidly developing nation, has been actively addressing transportation sector emissions through a range of government initiatives. This study fills a critical gap in the existing literature by providing the first empirical evidence on the effectiveness of consumer-oriented policies, particularly the FAME initiatives in Phases 1 and 2, with a focus on the adoption of E2Ws and E4Ws from 2015 to 2024. Despite these efforts, the findings reveal that these policies have not significantly influenced the adoption of EVs. Both direct subsidies and non-monetary incentives appear to exert limited or negligible effects on consumer behavior, emphasizing the need for a comprehensive reassessment of current strategies. Environmental concerns, particularly the reduction of carbon emissions, strongly support the transition to EVs as a viable solution to mitigate transportation-related environmental challenges. However, the analysis of petrol prices and electricity rates highlights a nuanced dynamic, where rising fuel costs and electricity tariffs jointly influence EV adoption. These factors underscore the complex cost considerations that shape consumer preferences and market trends. Moreover, the role of tax policies, such as the GST, emerges as a critical determinant in influencing EV adoption across vehicle segments, demonstrating their significance in accelerating the transition to sustainable mobility. The findings underscore the urgent need for better alignment between government policies and consumer expectations to enhance the appeal of EVs. Effective strategies should address the perceived barriers to adoption and promote the shift of ICEVs to environmentally friendly alternatives. This necessitates the formulation of well-targeted and comprehensive policies that integrate financial incentives, environmental awareness campaigns, and non-monetary measures. Such a multifaceted approach would not only bolster the adoption of EVs but also support India’s broader goals of sustainable urbanization, reduced reliance on fossil fuels, and

improved air quality. In conclusion, a holistic framework that bridges the gap between policy design and market realities is essential to foster a sustainable EV ecosystem in India, ensuring that consumer needs are met while addressing pressing environmental concerns.

7. Practical Implications

The financial incentives for E2W, provide cash subsidy for each vehicle model offered in Indian market and offer microfinancing facility and for E4W, Direct Tax subsidy like GST reduction and promoting Leasing facilities by offering incentives and the non-financial incentives should be reframed as the current policies are vague and do not create value to the consumers in E2W segment and reassess the policy and concentrate on the targeted E4W consumers requirement. Environment awareness (CO_2) campaigning regarding Environment concern to increase the knowledge of potential E2W consumers and offer substantial effects of emission reduction on ICEVs, encouraging a transition to E4Ws. Further the steps to educate consumers by awareness about EV's benefits for short distance travelers, or among low income households or consider E2W as secondary vehicle and Create exhibition for potential E4W consumer and create awareness among them by test driving or benefits of taxes. By making strategics for industry growth for creating Public Private Partnership to robust the production capacity of E2W with technical advancement and provide concessional loan and create government partnership research and development centers for E4Ws. Focus should be moved towards infrastructural development by promoting Battery Swapping, develop large number of low cost charging stations for E2Ws and facilitating fast charging availability at highways for long distance traveler to reduce rang anxiety among E4W users.

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Supplementary **Table 1.**

Variable	Description	Logarithmic Form	Unit
E4W	Electric four vehicle	*LE4W*	Numbers
E2W	Electric two vehicle	*LE2W*	Numbers
BIN	Binary Variables	-	Binary Number
4WS	Four vehicle subsidies	*L4WS*	INR
2WS	Two vehicle subsidies	*L2WS*	INR
CO_2	Carbon dioxide from transportation	LCO_2	Metric ton
GST	Goods and Service Tax	-	%
P	Petrol Price	*LP*	INR