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# Factors Shaping Electric Vehicle Adoption: A Comprehensive Statistical Investigation

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## Abstract

While the transition towards electric mobility is happening across India, studying the state-level dynamics towards the adoption of electric vehicles has a crucial role. The study analyses the key variables that can influence sales of electric cars in Uttar Pradesh in recent years. The study uses regression and correlation analysis, finding out which variables have a stronger influence on the adoption of electric cars. The variables taken for study are government subsidy amounts, number of public charging stations, average driving range of electric vehicles (EVs), and average petrol prices. The study provides actionable insights for policymakers and stakeholders aiming to accelerate the EV transition.

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**KEYWORDS:** Electric Vehicle, Charging Infrastructure, Driving Range, Subsidy, Petrol price.

## 1. INTRODUCTION

The transportation sector is moving towards the adoption of cleaner energy resources to reduce greenhouse gases produced via the utilization of fossil fuels. Therefore, there is gaining adoption towards electric vehicles as a mainstay for sustainable mobility. From Europe to China, countries are setting targets and making policies to reduce dependency on combustion engines. Recently, the sales of electric cars in 2024 reached seventeen million, making one in five cars sold as electric vehicles. The first quarter of 2024 showed drastic growth of 25 percent compared to that of 2023. Regions with the highest adoption of EVs: China holds the highest share, around 45 percent, followed by Europe at 25 percent and the USA at 11 percent. In 2023, 14 million electric cars sold, up 14 percent from 2022. The majority of EVs sold were in China, around 60 percent, followed by Europe, 25 percent, and then the US, 10 percent. But the global success can be determined when the sales pick up outside this region of the US, Europe, and China, that is, in emerging and developing countries. Although the share of electric cars picked up in Southeast Asian countries like Vietnam 15 percent and Thailand 10 percent in 2023. Policies measuring such purchase subsidies, technological changes, and incentives on electric vehicle manufacturing are playing a key role.

In recent years, India has come forward to take initiative in the green mobility transition. Being the fastest-growing automobile market in the world, India has the challenge of rising vehicular emissions and, at the same time, the opportunity to transition to clean transportation. The launch of schemes like Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) and the PM E-Drive schemes provides incentives for manufacture, subsidies, and infrastructure development for EVs. The schemes supported by providing incentives of tax exemption, like 5 percent goods and services tax (GST) for electric vehicles compared to 28 percent for other vehicles. The total electric vehicle registrations increased from around two thousand in budget year (FY) 2014-15 to around 2.03 million in FY 2024-25. Two- and three-wheelers are at the forefront in the adoption of EVs because of their low driving cost, small battery, and competitive commercial use. And as per the NITI Aayog report, India aspires for 80% of the two-wheeler and three-wheeler segment to be EVs, 70% for all commercial cars, 30% for private cars, and 40% for public transport buses to become fossil-free by the year 2030, keeping in line with India's target to become net zero carbon emission by the year 2070.

Uttar Pradesh (UP), being India's most populated state with a population of 241 million and one of the top five states with the highest consumer base in the automobile market, is the fourth-highest economy in the country, contributing 8% to the country's GDP. With rising population size and continuous growth in the urban sector comes the challenge of alarming levels of air pollution. The state has launched its own EV policy, aiming to become a centre for electric mobility and manufacturing, launching a New Electric Vehicle Manufacturing & Mobility Policy in 2019, and updating it in 2022 according to the current needs. To promote adoption of sustainable and clean mobility solutions and infrastructure, this policy aims to make UP one of India's leading states for EV acquisition.With support of policy and needed infrastructure, UP has the most electric vehicles of all states. holding the highest share in EVs sold in 2024-25, with the number of units sold across all segments of vehicles reaching 377,526, dominated by three-wheeler segments joining the nation's effort to curb pollution by transitioning away from fossil fuel-powered vehicles.

Understanding which of the main government incentives has a considerable influence on EV car sales is vital as the government supports the adoption of EVs following the rules outlined in policy documents. Subsidies, the construction of charging stations, and incentives to produce EV parts are all included in policy documents. Other factors that are outside the government's control include driving range, which is dependent on upcoming technological advancements in the EV industry, and petrol prices, which are influenced by the global market because India is a significant importer of crude oil. The study looks at these variables and how they affect sales of EV cars while taking these considerations into account.

This research paper goes through the analysis of electric car adoption in Uttar Pradesh over the decade, analysing the role of government via policy by providing subsidies, infrastructure availability, and other factors influencing adoption, such as petrol price and driving range.

## 2. RESEARCH OBJECTIVE

To analyze trends in the number of electric car registrations since the launch of the policy.

To find the impact of charging infrastructure and subsidies as provided by policy on electric car sales.

To find out impact of driving range and petrol price variables outside scope of policy on electric car sales

### Hypothesis development

### Charging station

The study empirically investigates the bidirectional connection between EV sales and public charging stations across 95 Chinese cities, showing that charging infrastructure significantly paces up EV sales (Zhang, X. 2023). Analysing data over five years, this paper also finds a positive long-run relationship between EV charging infrastructure and consumers' willingness to buy EVs (Illmann, U., & Kluge, J. 2020). The study on the French market finds that the introduction of public charging station units is positively correlated with both battery electric vehicle (BEV) and plug-in hybrid electric vehicle (PHEV) sales (Haidar, B., & Aguilar Rojas, M. T. 2022). Current research leads to the following hypothesis:

**H1:** Growing charging stations positively impacts electric car sales.

### Petrol

This research investigates the impact of rising energy prices on the demand for electric vehicles (EVs). By matching a detailed

dataset of monthly EV registrations with records of gasoline. The study's findings suggest that higher gas or petrol prices encourage people to switch to EVs (D. S. 2022). This paper examines how record-high gasoline prices influence consumers' intentions to purchase new energy vehicles (NEVs). The results indicate a strong positive correlation between rising gasoline prices and the intention to purchase NEVs, suggesting that higher fuel costs have a significant impact on the intention to consider electric alternatives. (M. 2023). The study shows rising gasoline prices have a substantial effect. The estimates suggest that consumers are highly responsive to fuel cost when considering hybrid and electric vehicles. The results imply that increasing fuel prices could be more effective in promoting green vehicle adoption than direct subsidies (Muehlegger, E. 2011). Based on the literature, following hypothesis:

**H2:** There is a positive relationship between petrol prices and electric car sales.

**Subsidy**

The research assesses the cost-effectiveness of EV incentives. Findings show that subsidies not only increase sales in the year they but also have positive effects in subsequent years. While incentive policies are costly, their effects enhance cost-effectiveness, suggesting that subsidies remain an important driver of EV adoption (Hardman, 2024). Utilizing a system dynamics model that captures the relation among government, manufacturers, and consumers, telling the effects of various subsidy schemes on the EV industry. The acquisition subsidy stimulates short-term sales more rapidly, whereas the R&D subsidy is more effective in promoting long-term EV sales (Liang, Y. 2023). This study examines the direct and indirect effects of government financial incentives on consumer adoption of electric cars in India. Employing a quantitative method with a survey questionnaire, the findings reveal that financial incentives indirectly influence adoption intention by positively affecting attitude and perceived behavioural control (K. V., & Kumar, S. P., 2021).

Based on the literature, the following hypothesis:

**H3:** There is a positive relationship between subsidy amount a nd electric car sales.

**Driving Range**

The variable assesses the average distance that an EV can travel on one full charge. It is a well-recognized barrier, adding range anxiety, thus acting as both a practical constraint and a psychological barrier to consumer adoption of EVs. A research survey of thirty-one countries has found that driving range has a statistically significant positive relationship with EV market share (Kim et al. 2017).Nazari et al. (2023) researched with stated-preference data from California and demonstrated that range anxiety significantly reduces adoption of battery electric vehicles, particularly when replacing existing combustion vehicles. In the Indian context (Dixit et al. 2022), it found that driving range is among the top three challenges impacting EV adoption, as rated by consumers. Based on literature, the hypothesis is:

H4: Rising range of electric car positively influence consumer adoption of EVs.

**Method of data collection**

This study is based on secondary data from various government websites and reports. The data pertains to the state of Uttar Pradesh, primarily focusing on examining the influence of infrastructural and other economic factors on the adoption of electric cars.

Data collected and analysed for the budget years 2019-20 to 2024-25 to capture current trends and see recent policy impacts in electric vehicle (EV) adoption. The time selected as per Uttar Pradesh's recent launch of the EV policy in 2019-20.

**Sources of Data**

The data was retrieved from the following official and verified sources:

**Table 1**: Contains details of dependent and independent variables: EV car sales, charging stations, petrol price, subsidy, and driving range, along with their data sources.

| Variables | Description | Sources |
|---|---|---|
| Number of electric vehicles car sold | The total annual sales registration of electric cars | Vahan dashboard, ministry of road & transport and ministry of heavy industries |
| Data on charging stations | The total number of public electric vehicle charging station | Ministry of Power, UPNEDA, and various magazines and reports such as EV Reporter, NITI Aayog, PIB, and EV Outlook. |
| Petrol price | Data used for petrol price calculated from averaging first and last day of budget year | Petrol Previous Historical Price Trend in, Uttar Pradesh from the websites of IOC and HPCL |
| Subsidy | The maximum subsidy that a four-wheeler can attain during a purchase, 150,000 by the central government and 100,000 by Uttar Pradesh government | FAME India portal of the Ministry of Heavy Industries and the Transport Department of Uttar Pradesh, and from various websites and reports, such as from the Ministry of Power. EV reporter and EV outlook. |
| Driving range | A maximum of five cars taken for each period, and four major companies targeted: Hyundai, MG, Tata, and Mahindra. The car taken has a maximum price limit of twenty-five lakhs. | Official automobile company websites consulted to obtain information regarding driving ranges. Also, to verify data, the website of the Automotive Research Association of India also considered. |

**Variables Collected**

**Dependent Variable:**

EV Car Sales: Total number of electric car registrations per year.

**Independent Variables:**

Number of Charging Stations: Indicator of electric vehicle infrastructure availability.

**Petrol Price:** Refers to the operating cost of a combustion vehicle, based on the average petrol price in Lucknow city.

Subsidy Amount: Direct government support influencing sales. The total direct subsidies from FAME and the Uttar Pradesh government (introduced November 2022).

**Average Driving Range:** Indicates the distance that car can travel on a single charge. Cars taken to calculate average driving range in the study during different time periods are the Hyundai Kona, MG eZ, Tata Tigor, Mahindra KUV100, Tata Curvv, Mahindra e-Verito, XUV400, Mahindra 6be, and Tata Nexon.

**Data collected.**

**Table 2**: Annual dataset of EV sales, charging stations, petrol prices, subsidies, and driving ranges in Uttar Pradesh (2019–2025).

| YEAR | EV CAR SALES | CHARGING STATIONS | AVERAGE PETROL PRICE | SUBSIDY | AVERAGE DRIVING RANGE |
|---|---|---|---|---|---|
| 2024-25 | 5671 | 2113 | 97.11 | 250000 | 482 |
| 2023-24 | 4007 | 1989 | 96.55 | 250000 | 453 |
| 2022-23 | 629 | 406 | 99.15 | 150000 | 344 |
| 2021-22 | 117 | 207 | 91.98 | 150000 | 300 |
| 2020-21 | 110 | 108 | 80.5 | 100000 | 278 |
| 2019-20 | 57 | 108 | 74.65 | 100000 | 175 |

## 3. RESEARCH METHODOLOGY

**Research Design**

The research adopts a quantitative approach using secondary data to explore the relationship between electric vehicle car sales and key determined factors: charging stations, average petrol prices, and subsidies. Following an explanatory research design, aiming to determine causal relationships through statistical analysis. The multiple linear regression model assesses the individual and combined impact of independent variables on the dependent variable.

**Statistical Techniques Used**

**Statistical techniques used to examine the relationship between variables are:**

**1.** Descriptive Statistics—Used for making a summary of data and describing the key variable of the dataset (mean, median, standard deviation).

**2.** Correlation Analysis – For measuring the degree and direction of association between each independent variable and the dependent variable.

**3.** Multiple Linear Regression—A multivariate regression model applied to understand how the three independent variables impact electric car sales.

**Model specifications made for research based on previously reviewed literature:**

$Y = B_0 + B_1.X_1 + B_{2.X4} + e$

$Y = B_0 + B_1.X_2 + B_2.X_3 + e$

$Y = B_0 + B_1.X_4 + B_2.X_3 + e$

**Where:**

Y = Electric Car Sales

$X_1$ = Number of Charging Stations

$X_2$ = Petrol Price

$X_3$ = Subsidy Amount

X4 = Driving Range

e = Error Term

Software Used: RStudio and MS Excel used for data analysis and interpretation. Various codes used for regression, structuring, and plotting of data.

## 4. RESULTS

Using the codes on RStudio for descriptive statistics, the results came in for each variable:

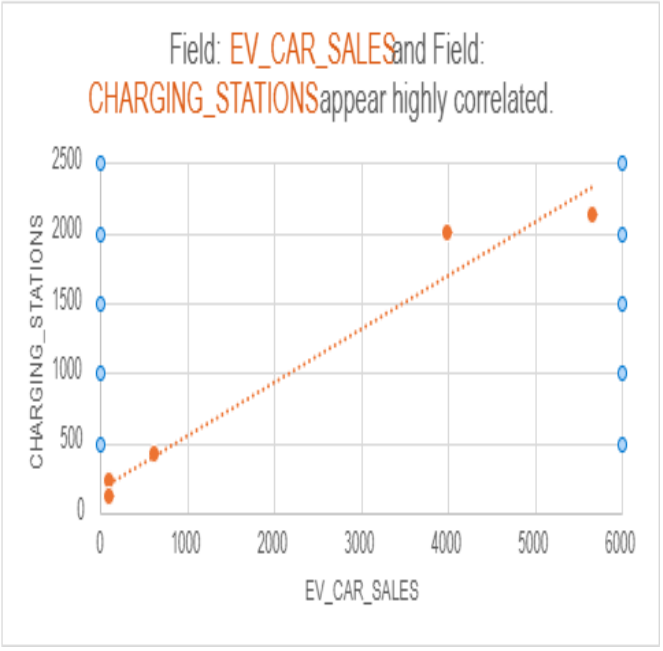
**Table 3**: Descriptive statistics of study variables (2019–2025).

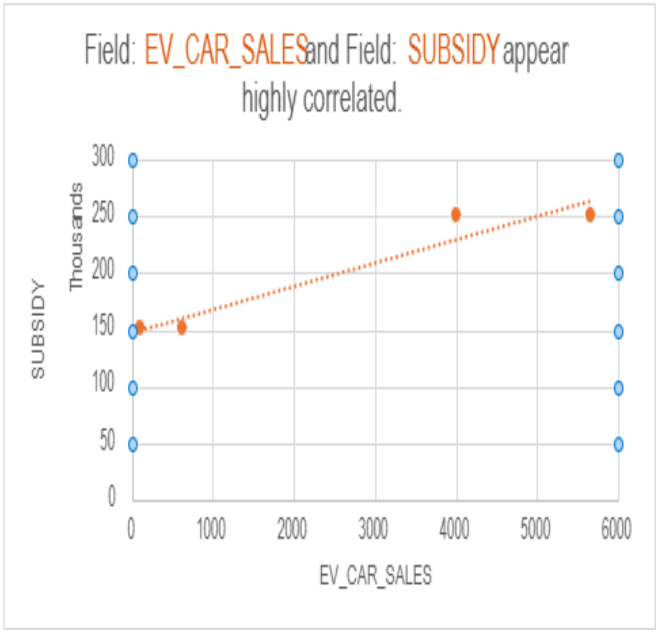
| | Ev_Car_Sales | Charging_Stations | Average_Petrol_Price | Subsidy | Average_Driving_Range |
|---|---|---|---|---|---|
| Min | 19 | 35 | 73.83 | 100000 | 185 |
| 1st qu. | 83.5 | 1.8 | 79.00 | 150000 | 261.5 |
| Median | 117 | 207 | 91.98 | 150000 | 300 |
| Mean | 1515 | 709.4 | 88.09 | 190000 | 326 |
| 3rd qu. | 2318 | 1197.5 | 96.83 | 250000 | 397 |
| Max | 5671 | 2113 | 99.15 | 250000 | 482 |

**Correlation Matrix**


**Fig. 1.** Correlation matrix of variables (figure created with R software)

The correlation between the independent and dependent variables can be seen from the figure, which shows that charging stations and subsidies are most highly correlated with EV car sales, that is, 0.98 and 0.97; then the driving range shows a high correlation of 0.89 with EV car sales; and the least correlated variable as per the matrix is petrol price with EV car sales, showing a correlation of 0.51 only.



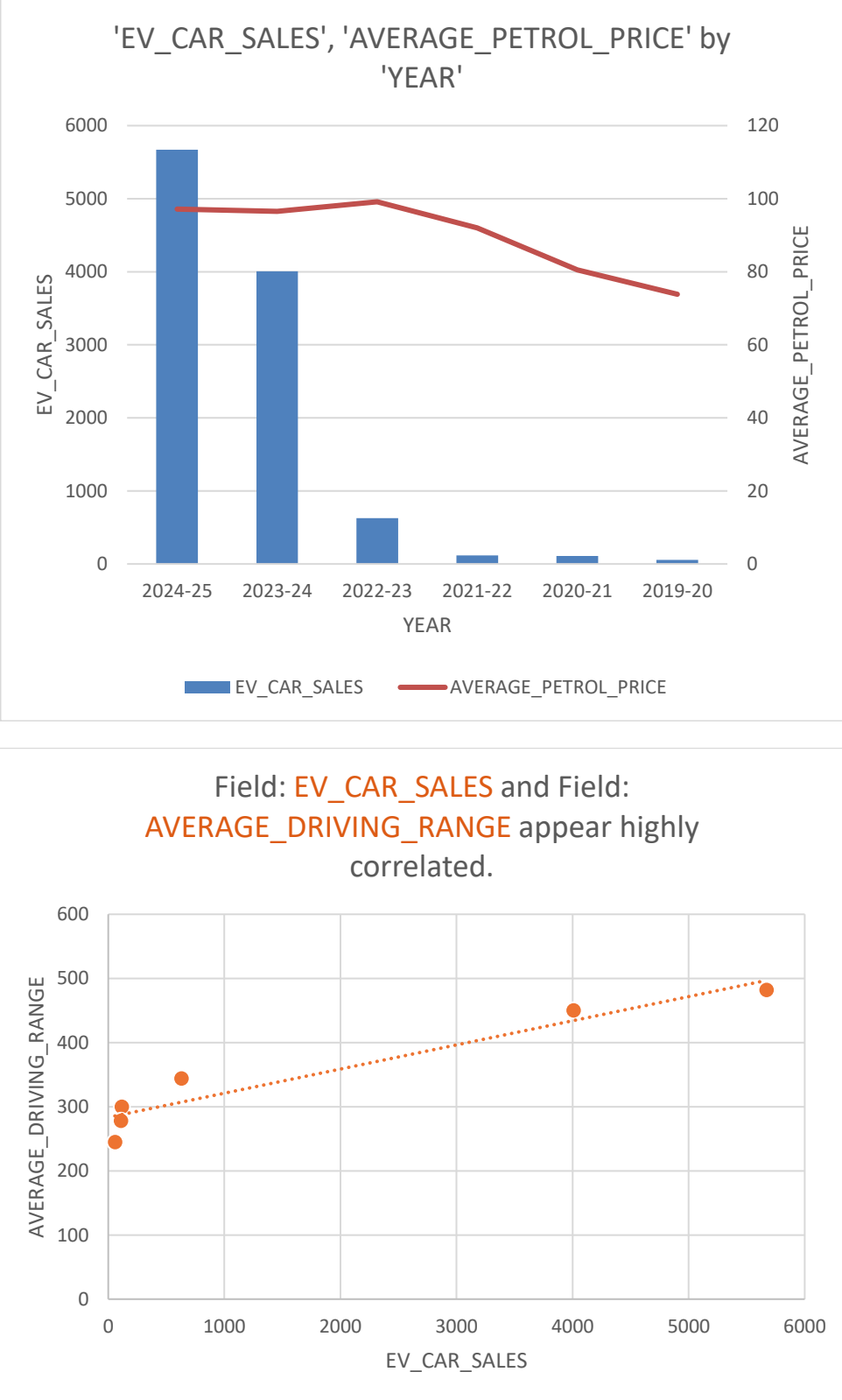



**Fig. 2.** Trend of EV car sales, charging stations, subsidies, petrol prices, and average driving range in Uttar Pradesh (2019–2025).

**Regression results**

$Y = B_0 + B_1.X_4 + B_2.X_3 + e$

EV CAR SALES = −3562 + 4.756 × AVERAGE DRIVING RANGE + 0.02474 × SUBSIDY

- AVERAGE DRIVING RANGE: Indicates that for every 1 km increase in average EV driving range, EV car sales expected to increase by approximately 4.76 units.
- SUBSIDY: Suggests that for every ₹1 increase in subsidy, EV car sales increase by around 0.025 units.
- Adjusted R-squared = 0.9285, showing 92 percent of changes explained by the independent variable.
- F-statistic = 33.48, p-value = 0.008881, which shows the overall model is statistically significant, meaning at least one of the variables is meaningfully predicting EV car sales.

$Y = B_0 + B_1.X_2 + B_2.X_3 + e$

EV CAR SALES = −4448 + 0.02933 × SUBSIDY + 20.19 × AVERAGE PETROL PRICE

- SUBSIDY: For every ₹1 increase in subsidy, EV car sales predicted to increase by around 0.029 units. This means a ₹10,000 increase in subsidy would lead to an increase of about 293 units in EV car sales.
- AVERAGE PETROL PRICE: Having a p = 0.6072, although the coefficient is positive, it is not statistically significant. This suggests that the petrol price has a positive but weak and uncertain relationship with the EV car sales dataset.
- Adjusted R-squared = 0.9197, showing a strong relationship, accounting for the number of predictors.
- F-statistic = 29.62, p-value = 0.01058 suggest that the overall model is statistically significant.

$Y = B_0 + B_1.X_1 + B_2.X_4 + e$

EV CAR SALES = −324.21 + 2.4993 × CHARGING STATIONS + 0.1041 × AVERAGE DRIVING RANGE

- CHARGING STATIONS (2.4993, p = 0.0333): shows statistical significance at the 5% level. For each additional public charging station, EV car sales predicted to increase by around 2.5 units, holding driving range constant.
- AVERAGE DRIVING RANGE (0.1041, p = 0.9867): The effect of average driving range is minimal in this dataset.
- Adjusted R-squared = 0.9466: tells that the model having an independent variable is statistically having a strong effect with a high explanatory power.
- F-statistic = 45.28, p-value = 0.005743: This shows that the model is overall statistically significant, meaning it reliably predicts EV sales using the two independent variables.

**Table 5:** Summary of regression models.

| Model | Variables Included | Adjusted $R^2$ | Most Significant Predictor |
|---|---|---|---|
| Model one | Driving Range, Subsidy | 0.9285 | Subsidy ($p \approx 0.05$) |
| Model two | Subsidy, Petrol Price | 0.9197 | Subsidy ($p < 0.01$) |
| Model three | Charging Stations, Driving Range | 0.9466 | Charging Stations (p = 0.03) |

**Analysis**

The findings in the analysis shows which of the variables having highest impact on EV adoption, among all the variables the government subsidies as a variable has emerged as the strongest influencer towards EV car adoption, having the significant positive coefficients aligning with the previously reviewed literature, showing that financial incentives contribute towards EV adoption via lowering of upfront costs and further reducing barriers to EV adoption in early-stage EV market. After subsidies, charging infrastructure as a variable showed strong explanatory power towards adoption of EVs, particularly in the third model it emerged as a statistically significant predictor. Results showing that EVs are not just a function of affordability alone, the consumers appear to adopt more EVs when they see the visibility of a network of charging stations matching the previous reviewed literature findings.

Thereafter, the variable average driving range of EVs showed its positive corelation with rising but its predictor in the regression model is weak. Result analysis can be that consumers may be prioritizing affordability and charging infrastructure over range improvements, or it could be limitation of study taking limited variety of EVs in the dataset, else. At last, the role of petrol price had the weakest predictor for EV car sales, can be due to two possibilities: that petrol price fluctuations were modest during the study period for consumers or in the consumers adoption towards EVs variable subsidies and infrastructure availability have greater influence.

## 5. CONCLUSION

The regression analysis shows strong associations between key variables such as charging stations, driving range, subsidy, and electric vehicle adoption in Uttar Pradesh. But subsidy showed the strongest association for stimulating EV car adoption, whereas charging infrastructure provides support to consumer rising confidence with rising visibility and accessibility of charging stations, playing a key role in adopting EVs. Together they showed 90% of variation in EV sales as shown by adjusted $R^2$. Driving range, though, contributes positively yet does not dominate the consumer decision to adopt EVs. Petrol price is not yet a strong driver; that could be due to the small sample size, the lag effect (consumers take time to react), and limited variation in the period of petrol prices over time in the dataset.

However, the findings are exploratory because of the recent launch of EVs and point out that Uttar Pradesh's EV market is still in its policy-driven infancy stage and requires sustained government intervention to reach critical mass. As electric car's

recent introduction into the market, the policymakers must continue providing incentives in the short run and later restructure towards efficiency via providing large-scale investment in charging infrastructure to enable sustainable long-term adoption.

**Future Research Directions and limitations of study**

Although the two out of variables matched results with previous findings of study, the rest two variable petrol price and driving range did not have stronger explanatory power. As with recent introduction of electric car in India and specifically in UP analysis has a small sample size limited to only six years of annual data, limiting the statistical power, also having limited category of EVs, solely on four-wheelers. The study does not account long term dynamics like battery cost and technological upgradation. It goes through the short-term analysis of the recent launched policy.

Future work could use monthly sales data to better capture short-term dynamics. With that incorporation of other segments of two-wheelers, three-wheelers, and buses would provide a fuller picture of EV adoption in Uttar Pradesh. And variables such as consumer perception, and urban-rural divides to understand the demand side of EV adoption more comprehensively. Comparison of UP's EV adoption against other leading states (Maharashtra, Karnataka, and Tamil Nadu) could provide better insights into EV adoption.

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