# Critical Factors in Adoption of Electric Vehicles in India: A Study

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## ABSTRACT

Rising fuel costs and growing environmental concerns are two big challenges for India. As is common knowledge, the environmental impact of automobiles is mostly caused by their fuel consumption, air pollution, and greenhouse gas emissions. The best solution to these issues is electric vehicles. The purpose of this study is to identify the key factors influencing the widespread adoption of electric vehicles (EVs) in India and to provide solutions to these problems in favour of sustainable development. The methodology used for this study, exploratory factor analysis (EFA) to identify and validate the key variables influencing EV adoption. IBM SPSS, AMOS and MS Excel were the tools used in this study. The study collected responses from 200 people using a questionnaire. The Cronbach alpha test was performed to identify the reliability of questionnaire. In Cronbach Alpha Test the questionnaire got rating of 0.957. This means that the questionnaire is 95.7% accurate and able to give the answer of objective. The finding reveals that there are many factors that influence EV adoption in India, including charging infrastructure, costs, customer attitudes, self-image, perception, learning and awareness. The study recommends to improve charging infrastructure, lowering EV costs, increasing consumer awareness and education, and strengthening regulation support for EV adoption. According to the study's findings, addressing these important variables can aid in accelerating the adoption and penetration of EVs in India and encouraging long-term sustainable development.

## Keywords

Sustainable Development, Carbon Emission, EV Adoption, Factors in EV Adoption and EVs in India.

## 1. INTRODUCTION

India has been moving up the motorization curve at a high rate in the previous ten years. As a result, in all large metropolitan areas and towns, urban traffic and air quality deteriorate. The transport industry in India contributes about 18% of the country's $CO_2$ emissions. India is growing more and more dependent on foreign nations to operate its economy because almost 70% of its petroleum usage is imported, which might either directly or indirectly impede the country's prosperity. The Indian government is working to enhance the technology of alternative fuel-based vehicles. One of the alternate options to deal with problems is the electric vehicle (EV). It is necessary to assess every type of socioeconomic and environmental aspect that can have an impact on the adoption of new vehicle technology. Debriefing and analysis should be done properly. India's EV market is still in its infancy when compared to other industrialized and developing nations and have lot of barriers in adoption. **[G Giridhar, 2011 and A. K. Digalwar, 2012].**

Nuclear power, hydrogen fuel and solar power are highly developed and cannot be produced in large quantities quickly. Electricity, which is already a viable energy option, could reduce the country's dependence on petroleum resources to some extent. **[Y.L. Xu et al 2008]**

When the entire vehicle lifecycle (manufacture, use and disposal) is considered, purely electric vehicles have around 30% less greenhouse gas emissions than internal combustion engines in European power generation structure. Considering the full vehicle lifecycle, the reductions could be even greater in countries with carbon-intensive power generation structures (such as China and India). **[Ellingsen et al., 2016]**

To fill a research gap, the purpose of this paper is to identify the factors that influence the social acceptability of EVs. Develop a strategy to address the challenges of EV adoption.

## 2. LITERATURE REVIEW

India is one of the world's largest oil importers, so alternative energy options are urgently needed**. [ Sahoo et al., 2019]**

Compared to conventional fuel based vehicles, EVs have a lower carbon footprint, which is one of their main advantages. **According to a Brand et al. (2018)** study, using electric cars (EVs) in Europe can reduce greenhouse gas emissions by up to 70% compared to using fuel based vehicles. When compared to gasoline-powered vehicles, the adoption of EVs in China can reduce carbon dioxide emissions by up to 40%, according to a different study by **Wang et al. (2020).** The reductions could be even greater in countries with carbon-intensive power generation structures (such India). **[Ellingsen et al., 2016]**

The economic viability of EVs is also a crucial factor. According to a study by **Cicala et al. (2019),** the long-term cost of owning and operating an electric vehicle is less than that of a gasoline-powered vehicle. However, many people continue to be discouraged by the initial expense of buying an EV.

Adoption of EVs is also influenced by the infrastructure for charging them being accessible and readily available. According to a study by **Zheng et al. (2020),** the number of public charging stations in China is positively connected with the number of EVs sold there. The installation of public charging stations in the United States, according to a study by **Hidrue et al. (2016),** increased the number of EV sales.

Government incentives and policies also affect the uptake of EVs. For instance, a study by **Zhou et al. (2019)** discovered that the introduction of a tax exemption policy for electric vehicles (EVs) in China increased the sales of those vehicles. Similar to this, **Chandan et al.'s (2018)** study discovered that the introduction of a tax credit programme in the United States resulted in a rise in EV sales.

**According to Arpit Rastogi et al., 2021**, Research on consumer EV adoption has been undertaken in several different countries. The price of the EV, the driving range per charge, and the recharging time are some of the variables observed studied. Battery price, battery size, and accessibility to charging stations. In past studies, range anxiety and the financial and non-financial incentives offered were other factors addressed.

The following studies on some of the most extensively researched aspects are displayed:

## 2.1 Financial Factors
**According to Bennett et.al (2016),** Electric vehicle markets and the required infrastructure coexist. Original equipment producers won't produce charging stations if there isn't a market for them, and vice versa. India's EV industry is still growing. As a result, it becomes more expensive to produce EVs, which obviously raises the price to purchase one. As it known that India lacks in resources domestically to manufacture EVs. So resources are imported due to this the price raises, which indirectly affects the adoption of EVs. **According to Schmidt et. al (2015)**

## 2.2 Vehicle Performance Factors
**According to Kumar et. al (2015),** The range of EVs is their major issue. Range and seating capacity can be compromised. The range narrows as seating capacity rises. A standard four-wheeler EV with seats for four people typically has mileage of 130 km, sufficient for a customer's daily drive. Due to the need for battery charging for long-distance journeys, this could not be able to meet their needs. Additionally, using standard 220 V AC power to charge the battery takes about 10 hours. Since it has been seen that EV batteries explode when they crash, EV safety is likewise a delicate issue. EV acceleration and top speed are also directly related to the battery. Reliability, consistency in performance, and trustworthiness are a few crucial aspects to take into account when it comes to EVs, **According to Saxena et. al (2014)**

## 2.3 Infrastructure Related Factors
**According to Yang et. al (2018),** There must be nationwide access to charging infrastructure for the deployment of EVs to be successful. There are two different kinds of charging stations: fast charging grid systems and slow speed charging systems. Highways and city streets must both have rapid charging stations. Because there are few restrictions on the charging duration, slow chargers can be installed in both households and offices. India should place the highest priority on building charging infrastructure in order to allay consumer fears regarding charging. If policies are taken into account, consumer response to policies and their perception of them may also hinder the adoption of EVs **(Bruckmann et al., 2021).** Adoption will be impacted by government regulations and incentives relating to fuel pricing and infrastructure development that are tied to the environment **(David Diamond et al., 2009).** On occasion, customers don't fully understand these policies. Constant policy changes that unnerve

customers may be to blame for this. As a result, they might be hesitant to adopt EVs **(Kester et al 2018).**

## 2.4 Environmental Related Factors
The use of concrete in construction, the removal of forests, man-made heat, noise pollution, and congested roads have all been linked to rising temperatures in cities **(Sampson et al., 2021).** Few of the peoples are really affected by the environment related concerns and they are interested in environment conservation. **(Heffner et al. 2007, Mohamed et al. 2018).** The majority of peoples find that there is a connection between their decision to have a vehicle and their environmental sentiments. **(Flamm et al. 2012). According to Asadi et al. (2021),** EVs are anticipated to be the solution of environmental issues in the future. The transition to electric vehicles would greatly cut pollution, according to customers and the general public **(Skippon et al., 2011).** In order to "live lighter," that is, to consume less natural resources, this motivates people to buy an EV **(Ozaki et al. 2011 and Mohamed et al. 2018).** The Environmental Index for this study was used to measure respondents' environmental awareness. The social groups most likely to utilize electric vehicles at the moment include early adopters, those with higher incomes and young people who live in cities **(Axsen et al. 2015 & Talantsev, 2017). Skerlos et al., (2010)** look at the societal benefits of EV use, such as a reduction in GHG emissions and other air pollutants.

## 2.5 Other Factors
**According to Ajzen, 1991,** humans make decisions based on logic and stimuli and the effects those actions are anticipated to have. **Attitude** is influenced by customer **knowledge** and experience **(Ajzen & Fishbein, 1980).** Additional factors that influence EV adoption include "**gender, age, income, education level, preferences, and environmental conscience".** Customers who adopt electric vehicles quickly tend to be educated and environmentally conscientious. People's responses to societal pressure and expectations can be seen in phrases like "socially acceptable behavior," "considering others," "representing shared ideals," and "social responsibility." Driving a fuel-inefficient car can make you feel embarrassed and excluded in the environmentalist community. This might persuade someone to purchase an EV while under the influence. In several cases, EVs' performance, appearance, size, and safety have been identified as obstacles. More individuals may be reluctant to purchase EVs because they are unaware of their benefits **(Wang et al. 2017). Lack of knowledge** of prospective future markets limits innovators in the multi-manufacturer EV market **(Lieven et al. 2011).** Additionally, it is crucial that marketers and designers of electric cars position their goods to elicit positive **emotions** in consumers **(Moons et al., 2012).** Better **information** dissemination would lead to a greater understanding of the environment. (**Lane & Potter et al., 2007).** The link between education and environmental awareness is typically considered to be poor. Higher education may make it easier to comprehend how one vehicle purchase might help to reduce climate change. However, because there is a favorable relationship between greater education and employment, highly educated consumers prefer to drive more expensive cars which emits carbon. **(Peters et al. 2015).**

## 3. OBJECTIVE
- Identifying the factors that influence social acceptance for EVs.
- Identifying the main factors that act as a challenge in purchase intention of EVs.
- Develop strategies to combat challenges which helps in adoption and penetration of EVs for sustainable Development.

## 4. METHODOLOGY

Data is gathered from two ways - Primary and Secondary sources. For primary data collection the survey questionnaire was created using the information gathered from the literature study as well as feedback from the project advisers. The goal of this survey was to gather information on how the public reacts towards adoption of EVs. The questions in the poll were separated into demographics, respondents' willingness to pay for EV and other related questions. Closed-ended multiple choice and five point Likert scale questions were used to construct the questionnaire. Secondary data was gathered from government records and reports, research papers that has already been published, articles, books, journals and other useful resources. Simple Convenient Sampling Technique has been used in study so that researcher can select most accessible population. The total number of sample size was 200. The Exploratory factor analysis methodology have been used in the study. To achieve this, the KMO sampling adequacy test and Bartlett's test for correlation adequacy were applied. In the study MS – EXCEL, IBM SPSS Statistics Version 25, AMOS Version 23 used for data analysis.

## 5. ANALYSIS & DISCUSSION

On the basis of responses, the findings were as following –

**TABLE 1:** The given table shows gender distribution of respondents.

| Gender | Total Numbers | Percent |
|---|---|---|
| Male | 110 | 55% |
| Female | 90 | 45% |

The participation of male as well as female were 55% and 45% respectively.

**TABLE 2:** The Mentioned table shows qualification of respondents.

| Qualification | Gender | | Percent |
|---|---|---|---|
| | Female | Male | |
| Higher Secondary | 7 | 15 | 11% |
| Secondary Education | 3 | 2 | 2.5% |
| UG | 20 | 44 | 32% |
| PG | 43 | 45 | 44% |
| PhD | 17 | 4 | 10.5% |
| Total | 90 | 110 | 100% |

According to the survey qualification of respondents, 32% respondents were under graduate, 44% respondents were post graduate, 10.5% respondents were PhD. Details of qualification of respondents has been mentioned in table.

**TABLE 3**: Customers future plan for EVs.

| Are you planning to own an EV | Gender | | Percent |
|---|---|---|---|
| | Female | Male | |
| Yes | 64 | 44 | 54% |
| No | 7 | 31 | 19% |
| Maybe | 19 | 35 | 27% |

According to the survey 54% respondents are planning to own Electric vehicle in near future, 27% respondents are in dilemma whether to go for EV or not and 19% respondents are not planning to own EV.

**TABLE 4:** Customers willingness to pay for two wheelers

| Want to Spend on 2 Wheeler | Gender | | Percent |
|---|---|---|---|
| | Female | Male | |
| More than INR 3,00,000 | 3 | 3 | 3% |
| INR 1,50,000 to 3,00,000 | 1 | 3 | 2% |
| INR 1,00,000 to 1,50,000 | 13 | 15 | 14% |
| INR 50,000 to 1,00,000 | 54 | 54 | 54% |
| Less than INR 50,000 | 19 | 35 | 27% |

The survey shows that 54% respondents wants to spend between INR 50,000 to INR 1,00,000, 27% respondents wants to spend less than INR 50,000, 14% respondents wants to spend between INR 1,00,000 to INR 1,50,000 and only 3% respondents wants to spend more than INR 3,00,000 two wheeler Electric Vehicle.

**TABLE 5:** Customers willingness to pay for four wheelers

| Want to Spend on 4 Wheeler | Gender | | Percent |
|---|---|---|---|
| | Female | Male | |
| More than INR 15,00,000 | 0 | 4 | 2% |
| INR 10,00,000 to 15,00,000 | 9 | 13 | 11% |
| INR 8,00,000 to 10,00,000 | 14 | 24 | 19% |
| INR 5,00,000 to 8,00,000 | 47 | 43 | 45% |
| Less than INR 5,00,000 | 20 | 26 | 23% |

The survey shows that 45% respondents wants to spend between INR 5,00,000 to INR 8,00,000, 23% respondents wants to spend less than INR 5,00,000, 19% respondents wants to spend between INR 8,00,000 to INR 10,00,000 and only 2% respondents wants to spend more than INR 15,00,000 four wheeler Electric Vehicle.

### KMO and Bartlett's Test

**TABLE 6:** The table shows the result of KMO and Bartlett Test.

| KMO and Bartlett's Test | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy | | 0.918 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 6661.396 |
| | Df | 561 |
| | Sig. | .000 |

**According to Williams et al., (2010),** The study's findings here show that the KMO value is higher than the acceptable index of 0.5, at 0.918. Therefore, it is accepted that the quantity of samples used was adequate. This suggests that the statistics exhibit some pattern of correlations. Since the correlation matrix is not an identity matrix and the significance level is 0.000, which is significant ($P < 0.05$), it is possible that groups of items are correlated. The Bartlett's Test of Sphericity is test used to determine the suitability of data for factor analysis. In this case, the Bartlett's Test has a chi-square value of 6661.396 with 561 degrees of freedom and a p-value of 0.000, indicating that the null hypothesis should be rejected, and the data is suitable for factor analysis.

### Scree Plot:

A graph of the eigenvalues vs the number of elements in the research is called a scree plot. A line's flattening factor reveals a reduction in the variance's size. The graphic illustrates that the top three factors account for the most variance.

Scree Plot
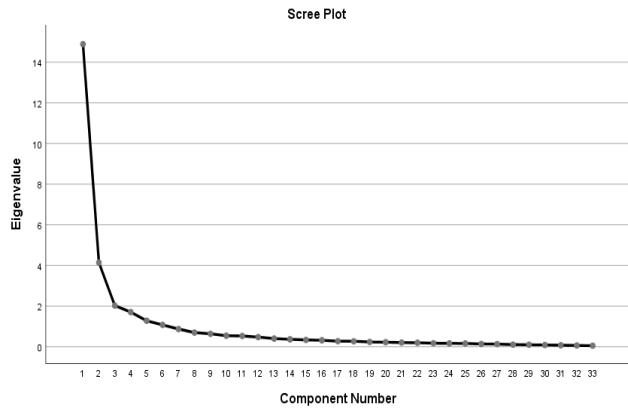
## Structure Matrix

The Structure Matrix shows the correlations between each variable and each extracted factor. In this case, the matrix shows the factor loadings for each variable after extraction using principal component analysis. The values in the matrix represent the correlation between each variable and each factor.

**TABLE 7:** The table shows the structure matrix

| Structure Matrix | | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **FF1** | | 0.803 | |
| **FF2** | | 0.684 | |
| **FF3** | | 0.827 | |
| **FF5** | | 0.749 | |
| **FV6** | | 0.794 | |
| **FV7** | | 0.736 | |
| **FV11** | | 0.722 | |
| **FI12** | | 0.716 | |
| **FI13** | | 0.760 | |
| **FI14** | | 0.827 | |
| **FI15** | | | 0.737 |
| **FE16** | | | 0.904 |
| **FE17** | | | 0.930 |
| **FE18** | | | 0.917 |
| **F19** | | | 0.730 |
| **F20** | | | 0.800 |
| **F23** | | | 0.898 |
| **F24** | | | 0.890 |
| **F25** | 0.703 | | |
| **F26** | 0.823 | | |
| **F27** | 0.836 | | |
| **F28** | 0.875 | | |
| **F29** | 0.854 | | |
| **F30** | 0.834 | | |
| **F31** | 0.905 | | |
| **F32** | 0.868 | | |

| | | | |
|---|---|---|---|
| **F33** | 0.832 | | |
| **F34** | 0.885 | | |
| **F35** | 0.883 | | |
| **F36** | 0.876 | | |

From the matrix, it can be observed that most variables have high loadings on specific factors, indicating that they are strongly associated with those factors. For example, the loadings of each variable on different factors can also be used to interpret the underlying factors. For example, Variables F25, 26, F27, F28, F29, F30, F31, F32, F33, F34, F35, F36 loading in Factor 1, Variables FF1, FF2, FF3, FF5, FV6, FV7, FV11, FI12, FI13, and FI14 all have high loadings on Factor 2, suggesting that this factor represents a construct that is related to these variables. Similarly, Variables FI15, FE16, FE17, FE18, F19, F20, F23, F24 have high loadings on Factor 3, indicating that this factor represents a different construct that is related to these variables.

## 6. FINDINGS
### Factor Grouping Result

**TABLE 8:** On the basis of survey, the factors were grouped in following table-

| Sr. No. | Factor Type | Factors |
|---|---|---|
| 1 | Financial Factors | Purchase cost |
| 2 | | Battery cost/Warranty |
| 3 | | Maintenance cost |
| 4 | | Fuel Cost |
| 5 | | Other Miscellaneous cost (Tax & Policy) |
| 6 | Vehicle Performance Related Factors | Mileage |
| 7 | | Charging Time |
| 8 | | Safety |
| 9 | | Battery Power/Life of battery |
| 10 | | Reliability |
| 11 | | Vehicle Strength |
| 12 | Infrastructure Related Factors | Public charging infrastructure |
| 13 | | Charging infrastructure on highways |
| 14 | | Charging infrastructure at work |
| 15 | | Charging infrastructure at home |
| 16 | Environmental Related Factors | Carbon Emission/Climate change |
| 17 | | Energy Saving |
| 18 | | Crude Oil & Bio Fuel |
| 19 | Other Factors | Social Influence |
| 20 | | Social Responsibility |
| 21 | | Perception & Emotion |
| 22 | | Learning & Knowledge |
| 23 | | Awareness |
| 24 | | Status |
| 25 | | Style |

| 26 | | Personality |
| 27 | | Self-Image |

According to the survey, total five major factors were identified under which total 27 sub factors were find. In which there are three major factors which shows the strong correlation among factors. And these factors are following -

**FACTOR 1**

Under factor 1 study reveals that the social influence, perception, emotions, learning & Knowledge, awareness, status, style, personality and self-image are major factors in adoption of Electric Vehicles in India.

**FACTOR 2**

Under factor 2 the study reveals that the Purchase cost, battery cost, battery warranty, maintenance cost, fuel cost and other miscellaneous cost including tax, registration cost and government policy are influencing highly. In addition, the infrastructure related issues are highly influencing factors in adoption of EVs in India.

**FACTOR 3**

Under factor 3 the study reveals that the environmental concern and awareness are influencing acceptability. The elements like increasing carbon emission, climate change, crude oil are major factors in adoption of EVs. And technology awareness is influencing the adoption of EVs in India.

The result shows that there is a correlation among factors. The factors are influencing each other which is defined by following graph.
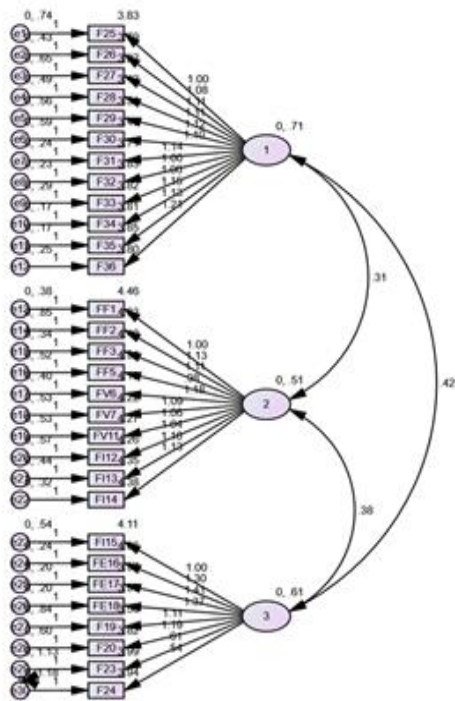


**TABLE 9:** Table shows that there are several factors which showing acceptance behaviour and there are many factors which showing challenge and they are working as barrier in adoption of Electric Vehicles in India.

| Factors | Showing Acceptance Behaviour | Showing Challenge In Adoption |
|---|---|---|
| **Financial Factors** | Fuel Cost | Purchase cost, Battery Cost/ Warranty, Unknown, Maintenance cost |
| **Vehicle Performance Related Factors** | Hybrid Model | Range, safety & Reliability |
| **Infrastructure Related Factors** | Charging Facility at home | Charging Infrastructure at city, at highway, at work |
| **Environmental Related Factors** | Carbon Emission, Crude Oil & Bio Fuel Price, Energy Saving | |
| **Other Factors** | Learning & Knowledge, Self-Image, Emotion | Social Influence, Awareness, Perception |

## 7. STRATEGY

This strategy involves competing in existing markets through cost-cutting and price competition. For the adoption of EVs in India, manufacturers could focus on reducing the cost of EVs through increased production and streamlined supply chains, while also providing incentives for EV purchases, such as tax breaks and subsidies. This Strategy involves competing in existing markets by improving existing products or services or lowering prices to gain market share. In the context of EVs in India improving the existing EV models and offering models at reasonable price to attract Indian customers in the market, and Improving the product involves such as increasing their range or reducing the cost, and competing with existing fossil-fuel vehicles to capture market share.

Public transportation, including buses, taxis, and rickshaws, represents a significant opportunity for EV adoption. Governments can incentivize the adoption of EVs by public transportation operators, which can help to reduce air pollution and provide a reliable and eco-friendly transportation option.

Encouraging research and development can lead to innovations in technology, infrastructure, and design, making EVs more efficient, reliable, and affordable.

The Indian government could provide incentives to EV manufacturers, such as subsidies for R&D, tax breaks, and reduced tariffs on EV parts. Additionally, the government could provide funding for the development of charging infrastructure, as well as promoting the use of EVs through awareness campaigns and education.

With the help of Government support the Education and Awareness program must be there to increase the knowledge of end customers. Through this program spread awareness about long term benefits of EVs and ease of use.

Enhance charging infrastructure is basic necessity of India and it needs a lot of investment to support the infrastructure program. With increasing infrastructure, the adoption of EVs will also be increased.

With respect to Marketing view point the strategy must be as follow:

Research and Segment Target Audience
Develop a Unique Value Proposition
Create Brand Awareness / Campaigns
Build a Strong Online Presence
Partner with Influencers and Experts
Offer Test Drives and Promotions
Create Financing and Leasing Options
Develop a Loyalty Program
Provide Excellent Customer Service
Monitor and Evaluate Results

## 8. RECOMMENDATION

1. Encourage the production and purchase of EVs by providing incentives such as tax exemptions, subsidies, and reduced registration fees.

2. Establish charging infrastructure in cities, highways, and public places such as shopping malls, airports, and parking lots to ensure easy access to charging for EV users.

3. Develop policies to support the growth of EV battery manufacturing and recycling industries in India, which can help reduce the cost of EVs and create job opportunities.

4. Implement awareness campaigns to educate the public about the benefits of EVs and dispel myths about their limitations.

5. Encourage the use of EVs in public transportation such as buses and taxis, which can help reduce air pollution and congestion in cities.

6. Develop a comprehensive national EV policy that provides a roadmap for the phased adoption of EVs and addresses issues such as battery recycling, charging infrastructure, and manufacturing incentives.

7. Increase awareness of the health and environmental benefits of EVs: Educate the public about the negative impacts of traditional vehicles on health and the environment, and how EVs can help mitigate these issues. Highlight the positive impact that EVs can have on air quality, reducing noise pollution, and conserving natural resources.

8. Address the range anxiety issue: One of the main concerns that customers have with EVs is their limited range. To address this, highlight the availability of charging infrastructure in key locations such as highways, major cities, and public places, and emphasize the convenience of home charging.

9. Highlight the long-term cost savings of EVs: Although the upfront cost of EVs may be higher than traditional vehicles, Emphasize the long-term cost savings of EVs to customers to help them see the value proposition of investing in an EV.

10. Address concerns around battery life: Battery life is a concern for many customers considering an EV purchase. To address this, highlight the warranty and lifespan of EV batteries and assure customers that battery replacement costs are decreasing as the technology continues to improve.

11. Encourage peer-to-peer recommendations: Encourage existing EV owners to share their positive experiences with others and provide opportunities for potential customers to test drive EVs to alleviate any concerns they may have. Because the social influence is higher on customers.

## 9. CONCLUSION

The research on the critical factors in the adoption of EVs in India may have identified a range of factors that are important for promoting the widespread adoption of EVs in the country. These may include factors such as government policies and incentives, charging infrastructure availability and reliability, cost-

effectiveness and affordability, consumer awareness and education, and the role of the automobile industry in promoting EVs. Further research in this area may be necessary to fully understand the critical factors involved in the adoption of EVs because of changing behaviour of consumers. The use of factor analysis has helped to identify and prioritize these factors, providing valuable insights for policymakers, manufacturers, and other stakeholders in the electric vehicle industry.

Overall, the research suggests that a comprehensive approach is needed to promote the adoption of electric vehicles in India. This could include a combination of policy incentives, investments in charging infrastructure, public education campaigns, and technological innovations to address issues such as range anxiety and battery technology. By addressing these critical factors, it may be possible to accelerate the adoption of electric vehicles and help India achieve its goals for sustainable mobility and reduced emissions.

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