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THE STUDY OF ELECTRIC VEHICLES IN INDIA

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ABSTRACT

Environmental pollution is currently a global concern. One of the primary air pollutants is toxic emissions from internal combustion engines. Electric vehicles (EVs) are being vigorously promoted all over the world in order to offset the effects of fossil fuel emissions and solve environmental concerns (ECS). Various governments are motivating consumers to switch to electric vehicles by providing financial incentives. According to previous research, the expensive cost of an electric car, the lack of charging infrastructure, and time and range anxiety are all barriers to customer acceptance. By 2030, the Indian government wants "only electric vehicles" on the road. This article is current and looks at the various aspects that influence a consumer's decision to buy an electric vehicle. The study's participants are Indian car owners. Structured Equation Modelling was used to examine the data (SEM). Attitude (ATT) emerged as a powerful mediator in the adoption of electric vehicles.

I. INTRODUCTION

The automobile business, which has been around for nearly a century, is undergoing a revolution. The rise in the price of fossil fuels, as well as the impact of their emissions on the environment, has prompted a shift in individual mobility habits. The internal combustion engine-powered sector is gradually shifting to electric automobiles (EVs). EVs are propelled by electric motors, with electricity supplied by a rechargeable battery or other portable energy storage device. These vehicles are energy efficient, emitting fewer greenhouse gases and producing less noise. The following are the various types of electric vehicles:

- HEV: Hybrid electric vehicles (HEVs) have an engine and an electric motor and are fueled by both gasoline and electricity. The battery is charged by the electricity generated by the braking system. PHEV: Plug-in hybrid electric vehicles (PHEVs) are similar to HEVs but feature a smaller engine and more powerful batteries. The batteries are recharged using either the braking system or an external electric charging outlet.
- BEV: They don't have an engine and instead rely on electric motors for propulsion, with batteries serving as energy storage. They charge the battery using external power outlets. Plug-in cars, EVs, or battery electric vehicles are other names for these vehicles (BEVs). Transportation accounts for almost a quarter of all GHG emissions. Automobiles are the major source of GHG emissions globally, with China accounting for 25.9%, the United States for 13.87 percent, and India for 7per cent. The slogan for the Eighth Clean Energy Ministerial, held in 2016, was "The EV30@30." The member countries reiterated their commitment to the introduction of electric vehicles. By 2030, the goal was for EVs to have a total market share of 30%, with a 10% market share in each of the four categories: passenger cars, light commercial vehicles, buses, and trucks. India's commitment to limiting pollution and lowering its carbon footprint is growing. By 2030, the country plans to transition to electric vehicles. The government wants carmakers to switch to electric vehicle production, which will save $60 billion in oil costs, reduce pollution by 37%, and reduce reliance on foreign fuel imports, protecting the country from crude price and currency swings. To tackle the barriers to EV adoption, the government is looking into the battery swapping option model. The swapping approach was successfully implemented in Israel and China. The battery size and power are the issues. These may differ depending on the manufacturer and model (e.g., Maruti Alto and Honda City). This complex condition necessitates a vehicle design that is identical to fit the same battery, which is challenging to execute. Another option is battery leasing, which could lower the cost of ownership. However, the easy availability of charging points throughout a city remains a key barrier that has yet to be addressed. In India, the transition to electric vehicles is necessary but not urgent. Unplanned growth and heavy pollution are plaguing some cities. They are severely degraded, with vehicular emissions being the principal cause. Figure 1 shows the EV projections for a few of the major countries. India's government

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has stated that all cars must be electrified by 2030. The Society of Indian Automobile Manufacturers (SIAM, 2017) followed up with a white paper predicting that electric vehicles would account for 40% of new automobile sales by 2030 and 100% by 2047. This historic date falls on the 100th anniversary of the country's independence.

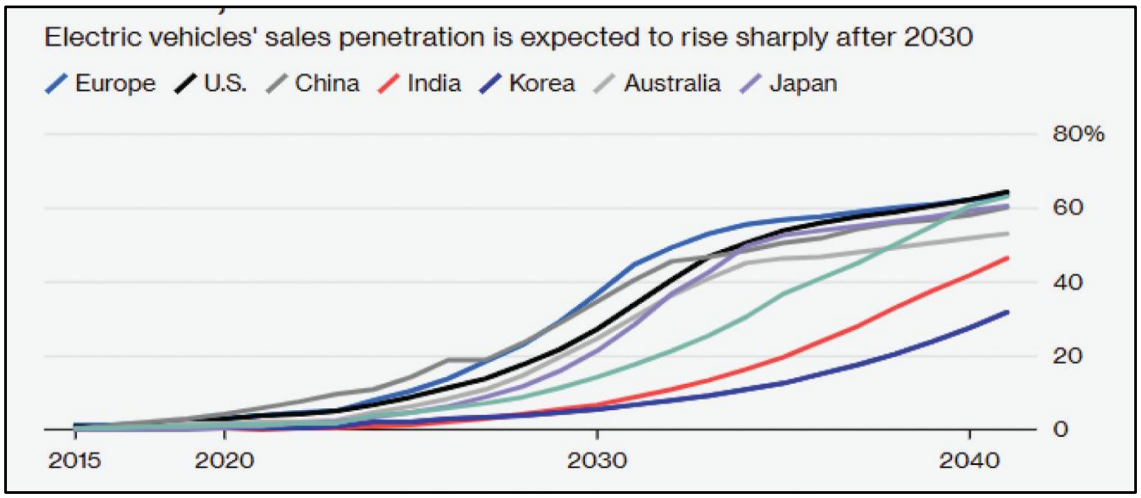

Figure 1. Projection of Electric Vehicles

II. LITERATURE REVIEW

Many studies have been conducted around the world to better understand consumer adoption of electric vehicles. Other variables explored in past studies include the cost of the EV, driving distance per charge, time to recharge the battery, and availability of incentives offered—both financial and non-financial. Table 1 lists some of the studies on the most studied characteristics. The technological aspects of a vehicle are referred to as technology. Range anxiety or the small distance travelled per full charge of the battery, has been identified as a major barrier to EV adoption in previous studies. Infrastructure qualities are concerned with the charging infrastructure that is available. This aspect has a favorable impact, according to research. Appropriate charging facilities will save time and money on searches, thus alleviating consumers' range concerns. The higher cost of electric vehicles may limit their adoption. Some policies including financial qualities, such as tax reduction or rebate, are well supported by evidence, whereas non-financial incentives, such as free parking and toll reduction, are not. Non-availability of EVs and a shortage of EV models were also discovered to be impediments to EV adoption. According to research, a lack of understanding and an unqualified vehicle dealership may deter EV adoption. The majority of the study is conducted in North America and Europe. Further research is needed to determine the impact of individual-specific characteristics on EV adoption. Psychological elements have an established and stable effect, according to studies. There are few studies in India, and this article focuses on an electric automobile, which is a subset of the EV.

Perception of Economic Benefits

When compared to a comparable conventional vehicle, the high cost of EVs is a disincentive to adoption. According to studies, the incentives provided encourage people to choose electric vehicles. Running costs are eight times higher than EVs. Lower operating costs derive from lower energy consumption and power tariffs. As a result, the overall cost of ownership is reduced, which offsets the higher cost of an EV. Consumers with vast driving ranges stand to benefit more than those who only drive on a daily basis. EV adoption is aided by lower operating costs. Maintenance expenses, it is said, increase BEV adoption. Other fuel cars have a higher energy expenditure. Economic incentives, according to the researchers, impact EV adoption. The following hypothesis is proposed in this study: H(i): Consumers' perceived economic gain is a key predictor of their BI of buying an electric vehicle.

Environmental Concern

An individual's knowledge of environmental problems and motivation to address these problems is defined as an environmental concern. Consumer adoption intentions are influenced by environmental benefits, according

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to studies. People who are concerned about environmental issues and energy conservation are more likely to adopt. Furthermore, environmental conservation served as a major incentive or a vital role in attracting customers. EVs should not only emphasize energy reduction; they should also emphasize environmental protection, which could boost adoption. The following hypothesis is proposed in this study:

H(ii): Consumers' BI of adopting an EV is significantly influenced by EC.

Authors	Study Variable	Attributes
Bahamonde-Birke and Hanappi (2016), Helveston et al. (2015),Peters and Dütschke (2014), Rasouli and Timmermans (2016), Valeri and Danielis (2015), Barth, Jugert, and Fritsche (2016), Adepetu and Keshav, (2015), Plötz, Funke, Jochem and Wietschel(2017)	Driving range	Technology
Axsen, Bailey, and Castro (2015), Rasouli and Timmermans (2016), Moon, Park, Jeong, and Lee (2018)	Charging time	
Valeri and Danielis (2015), Bockarjova and Steg (2014), Jensen, Cherchi, and Mabit (2013)	Charging station	Infrastructure
Chorus, Koetse, and Hoen (2013), Glerum, Stankovikj, Thémans, and Bierlaire (2014), Wang, Li, and Zhao (2017)	Financial incentives	Policy

Social Influence

As a concept, it covers peer pressure, subjective norms, neighbors, and cultural influence. charging points and battery cost. Individuals seek family members' and friends' approval of their actions. Families', relatives' or friends's opinions influence the consumer's decisions and consumers seek social approval using products acceptable to people whose opinions matter. The effect of people's behavior influences an individual's decisions in their social network. The paper proposes the following hypothesis is:

H(iii) SoC. It is a significant predictor of the consumers' BI of adopting an EV.

Self-image

Consumer's IM and product image consistency exhibit a positive ATT towards the

H(iv): Self-image (IM) is a significant predictor of the consumers' BI of adopting an EV. adoption. IM is an independent predictor of consumer behavior. Additionally, it evaluates factors, such as the symbolism of IM and social status. Individuals compare themselves with others to increase their self-recognition and IM Such individuals are inclined to buy an EV, meaning that the EV symbolizes high social status. The hypothesis postulated by this study is as follows:

H(v): ATT is a significant predictor of the consumers' BI of adopting an EV.

H(vi): ATT mediates the relationship between perceived economic benefit and BI of adopting an EV.

H(vii): ATT mediates the relationship between EC and BI of adopting an EV.

H(viii): ATT mediates the relationship between SoC

H(ix): ARTT mediates the relationship between SoC. In and BI of adopting an EV

Attitude

Different definitions of ATT include assessing a person, a thing, or an issue. A consistent response to a circumstance, an object, or a group of objects is known as ATT. ATT describes how to evaluate and judge a product or service. ATT is defined in the literature as an individual's evaluation of a brand, product, or service. The three components of ATT are cognitive, emotional, and behavioral. The cognitive element is concerned with a person's beliefs, thoughts, and characteristics relating to the object or issue. When it comes to electric vehicles, the cognitive component of ATT could include the perception that an EV is beneficial or bad for the environment. The most significant component of adoption is that it has a direct impact on customer intentions. The preceding analysis leads us to.

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Intentional Behavior

The measure, or strength, of an individual's intention to undertake a given behavior, is known as behavioral intention (BI) (Ajzen & Fishbein, 1977). Individual intentions toward the adoption of cleaner automobiles are influenced by psychological variables, according to studies. These influences include EC, specific attitudes, social and personal norms, and the desire to use cleaner vehicles. The adoption intention is influenced by the appraisal and use of an EV (i.e., ATT). Individuals also assess how their purchases will be received by others. This study suggests the research model shown in Figure 2 based on the literature review.

III. RESEARCH METHODOLOGY

In India, electric vehicles are hard to come by on the road, cheval. Many potential EV users have never seen, driven, or charged one. The characteristics of these vehicles are unknown to the general public. A systematic questionnaire was used to collect data. The instrument that was created contained data about constructions and their constituents. There were two parts to the questionnaire. The first section concentrated on information about the respondents' demographic features, such as gender, age, education, family income, and the number of cars in the home. The model variables are measured in the second section of the survey. One dependent variable, four independent variables, and a mediating variable were included in the study. For the six test variables in the pilot study, there were 26 items total. The list had been revised.

Sample Size

Structured equation modeling (SEM) lacks a defined formula to determine the appropriate sample size. This article has 214 valid filled responses. The selected respondents were existing car owners. They were residents of the National Capital Region (NCR) Delhi, Mumbai, and Pune. Out of the 450 respondents approached, 214 responded. There were no missing data and the responses were valid.

Measurement

The first part measures the demographic characteristics as categorical data. The second part measures the model variables using a 5-point Likert scale (1 as strongly disagree and 5 as strongly agree).

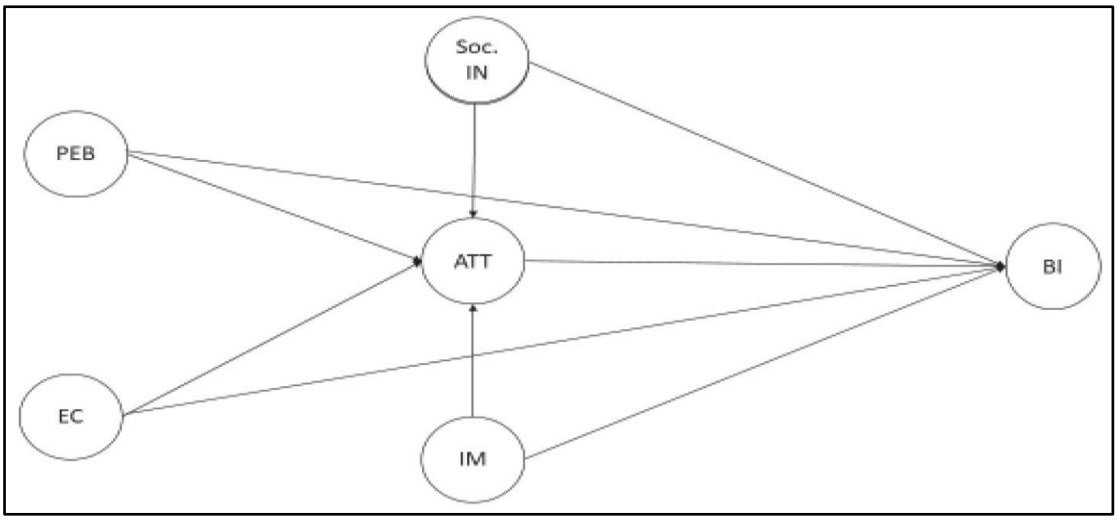

Figure 2. Proposed Model for Electric Vehicle Adoption (***Note*:** PEB: Perceived economic benefit; EC: environmental concern; IM: self-image; SoC.In: social influence; ATT: attitude; BI: behavioral intention.)SPSS version 21.0 (Software Package for Social Sciences) and AMOS version 21.0 (Analysis Moment of Structures) were used for data analysis. There are two components of the structural equation modeling the measurement model and the structural model. The first stage, of the two-stage structural equation model, validates the measurement model. The second stage measures the extent and direction of the relationship.

IV. DATA ANALYSIS AND RESULTS

The pilot questionnaire tested 33 respondents for reliability. Cronbach's alpha varied from 0.63 to 0.874, and overall, $\alpha = 0.889$. Hair, Anderson, Tatham, and Black (1998) stated that a value greater than 0.6 is reliable. The revised instrument had 22 test items. The study dropped one question each from EC and ATT and modified one

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question from EC. Out of 214 respondents, 24.3 percent were women, and the rest, 75.7 percentwise men. All respondents were existing car owners and Indian nationals. Figures 3 and 4 show the age and educational profile of the respondents. The structural equation model is an advanced technique used to study the relationship between several constructs simultaneously. It is a structure of equations and can handle several relationships in a single analysis. This study employed SEM to investigate the predictive relationship between the four exogenous variables In and IM. The endogenous variable was BI with ATT as a mediating variable. Mediation offers a reliable interpretation of the causal effect. It describes the effect antecedent has on the dependent variables and the rationale for the relationship. This article tests the mediation effect of ATT between exogenous and endogenous variables.

Construct Development and Measurement

The hypothesized model involves four exogenous variables and one endogenous variable. PEB, EC, IM and SoC.In are measured using four items for each variable. Three items measure endogenous variable BI. Three items measure the mediation effect of ATT. This study uses a 5-point Likert scale, with 5 as Strongly Agree to 1 as Strongly Disagree, to measure items. SEM is a two-step validation process. The first step validates the measurement model using confirmatory factor analysis (CFA) and the next step, the structural model validation using SEM. The measurement model can access the reliability and validity of the instrument used to measure the underline construct.

Construct Reliability and Validity

Reliability and Validity are quality assessment tools for the instrument measuring the construct of the hypothetical model. Reliability is the ability of the scale to produce consistent results. PEB: Perceived economic benefit; EC: environmental concern; IM: self-image; SoC.In: social influence; ATT: attitude; BI: behavioral intention. Cronbach's alpha of all the constructs is above the threshold limit of 0.6 (Hair et al., 1988) as seen in Table 2, thus supporting the reliability. AVE of three constructs is below the threshold of 0.5, and thus factor loading reaffirms the validity. Factor loading is an essential indicator of construct validity. Factor loading is significant for loading values above 0.5, indicating validity. Table 3 contains measured indicators, construct, and factor loading. PEB: Perceived economic benefit; EC: environmental concern; IM: self-image; SoC.In: social influence; ATT: attitude; BI:behavioral intention. Table 3 shows that all the measured indicators have loadings above the threshold point of 0.5. All are significant at a 0.1 percent level of significance. The exceptions are 'I think I am more likely to adopt an EV if my friends and relatives adopt it'.

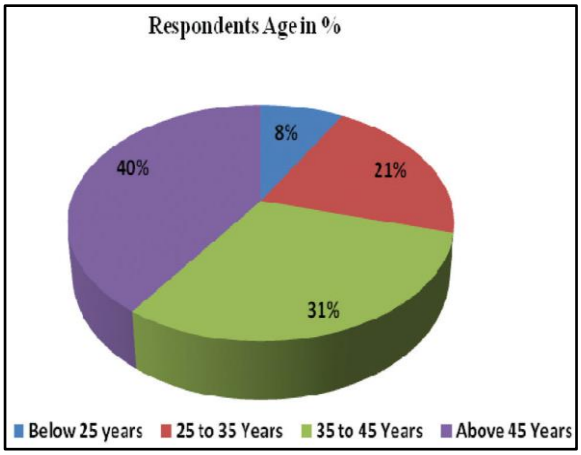

Figure 3. Age of the Respondents (Result of data collection tabulation)

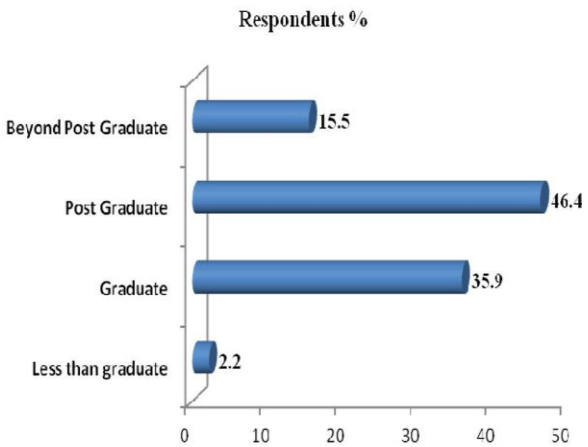

Figure 4. Educational Qualification of the Respondents(the result of data collection tabulation)

Table 2. Reliability and Validity

Construct	No. of Items	Cronbach's Alpha	AVE*(Construct Validity)
PEB	4	0.712	0.388

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EC	4	0.824	0.538
SoC.In	4	0.661	0.34
IM	4	0.736	0.435
ATT	3	0.895	0.75
BI	3	0.909	0.78

Table 3. Factor Loading (Result of data collection tabulation**)**

Measured Indicator	Construct	Factor Loading
PEB 1: I will save on fuel expenses, as running cost should be lower in case of an electric vehicle.	PEB	0.7***
PEB 2: The maintenance cost for an electric vehicle will be less.	PEB	0.6***
PEB 3: Overall cost of owning an electric vehicle will be low due to government incentives (incentives = lower road tax/less insurance premium/cheaper loan)	PEB	0.577***
PEB 4: I am fully familiar with the economic benefits offered by the electric vehicle.	PEB	0.609***
EC 1: I want to adopt an electric vehicle because of increased air pollution	EC	0.707***
EC 2: The Electric vehicle can contribute to the environment for saving the future generation.	EC	0.805***
EC 3: I am familiar with environmental benefits offered by the electric vehicle.	EC	0.62***
EC 4: I want to conserve the environment using the electric vehicle over the conventional vehicle.	EC	0.788***
SoC. In 1: People will react positively when they see an electric vehicle on the road	SoC. In	0.622***
SoC. In 2: I think I am more likely to adopt an electric vehicle if my friends and relatives adopt it.	SoC. In	0.466***
SoC. In 3: People whose opinions are important to me find electric vehicles good	SoC. In	0.634***
SoC. In 4: Possessing an electric vehicle would be a status symbol for me.	SoC. In	0.614***
M 1: Driving an electric vehicle fits my style.	IM	0.742***
IM 2: Driving an electric vehicle will reflect my personality.	IM	0.751***
IM 3: Eco-friendly people will opt an the electric vehicle.	IM	0.46***
IM 4: My knowledge about the electric vehicle will improve my image.	IM	0.646***
ATT 1: I am favourably inclined to switch to an electric vehicle.	ATT	0.792***
ATT 2: Driving an electric vehicle will be a wise decision.	ATT	0.914***
ATT 3: It makes sense to use an electric vehicle instead of a conventional vehicle.	ATT	0.888***
BI 1: I would recommend the adoption of an electric vehicle to others	BI	0.898***
BI 2: I would speak favourably about the electric vehicle to others.	BI	0.913***
BI 3: I would definitely adopt an electric vehicle.	BI	0.837***

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V. RESULT AND DISCUSSION

The goal of the study was to look into aspects that could influence EV adoption. Technical considerations, financial incentives, infrastructure, and ECs were the focus of previous studies. The PEB is unrelated to the BI to adopt EVs, according to the study. Instead, it has a significant favorable impact on ATT, the EC, and the SoC. In are just partial predictors of the BI, but they have a considerable impact on the ATT. EC was found to be a partial predictor of BI. As a result, all stakeholders must work together to promote EV adoption. To enhance acceptance, manufacturers, government agencies, dealers, and salespeople should advertise the benefits of electric vehicles. To do so, they need to demonstrate how EVs may reduce hazardous emissions produced by internal combustion engines in traditional automobiles, which could affect the ATT, which influences the BI. IM was found to be a reliable predictor of BI. It also has an impact on ATT's decision to purchase an electric vehicle. ATT was found to be a major predictor of BI.

Table 4. Hypothesis Results

Hypothesis Number	Construct	SRW	Significance	Result
(i) BI	PEB	–0.043	0.511	NS
(ii) BI	EC	0.18	0.07	PS
(iii) BI	SoC In	0.131	0.078	PS
(iv) BI	IM	0.261	***	Significant
(v) BI	ATT	0.617	***	Significant
(vi) ATT	PEB	0.271	***	Significant
(vi) ATT	EC	0.668	***	Significant
(viii) ATT	SoC In	0.34	***	Significant
(ix) ATT	IM	0.198	0.002	Significant

Table 6. Fit Indices (Structural Equation Model)

Fit Indices	Recommended	Observed	Result
CMIN/df (minimum discrepancy as indexed chi-square)	Less than 5	2.857	Acceptable fit
CFI (comparative fit index)	More than 0.9 good fit 0.8–0.9 borderline fit	0.848	Borderline fit
GFI (goodness of fit index)	More than 0.9	0.809	Marginally missed
PNFI (parsimonious normal fit)	More than 0.5	0.68	Acceptable fit
RMSEA (root mean square error of approximation)	Less than 0.08 for good fit 0.08–0.1 for acceptable fit	0.093	Acceptable fit

Managerial Implications

This study has several ramifications for not only EV marketers and manufacturers, but also the government. In India, EV adoption is still in its early stages; people are unfamiliar with electric vehicles and may be hesitant to switch. As technology progresses, as well as familiarity, penetration, and SoC, EV preference will evolve. In progress. Government policy on EV that is clear and well-articulated incentives for early adopters. The environment is a priority for everyone, including the federal and state governments, as well as every individual, regardless of their status. Green license plates on electric vehicles can signal environmental care, and financial incentives such as free or discounted tolls, parking, or precedence in public places can help increase adoption.

Hence, marketers' communication in addition to the above should highlight the expected features like

• Functional information such as range covered per battery charge, battery life, and maximum speed along with Quality specifications. However, additionally,

• How the customer can affect the environment positively by adopting EVs.

• Incentives as applicable for adopting EVs. These measures may fulfill the objective of bringing the members of the public closer to EVs. Senior politicians and members of parliament may switch to travel by EVs, thus setting examples for the common man. All stakeholders may launch a campaign on the lines of 'Swatch Bharat'. Celebrity endorsement is another means that may influence the adoption of EVs. Advertising should evoke the emotional appeal that depicts the EV driver in a positive light, for example,

• Care for the environment

• Association with a high-status group

• Proud technology adopter

Limitations and Suggestions for Future Research

The current study's limitations leave enough room for future research. The proposed conceptual model was empirically tested in India in this study. Similar investigations should be conducted under different conditions and in different regions. However, a 'intention to adopt' may not result in a purchase. Further examination may reveal whether the intention to adopt becomes reality. Other factors' effects could be investigated in future studies. Consumer effectiveness, information, scepticism, safety, risk, interest, and experience are examples of these. It would be useful to test this model with precise EV owners in the future. With global environmental concerns growing by the day, this field has a lot of room for future research.

VI. CONCLUSION

I'll be able to draw some conclusions after I've given all of the findings. Electric vehicles are becoming more and more practical for long-distance travel as technology advances. Many high-end electric vehicles, such as the Tesla Model S and Tata, can readily go long distances while also utilizing domestic electric power. These high-quality electric vehicles can not only go long distances, but they also save money on gas and contribute to sustainable transportation. These vehicles, however, come at a hefty cost, which may be prohibitive for most working-class families. However, because electric vehicles are advantageous to society and the environment, everyone will eventually accept them.

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