Factors influencing adoption of electric vehicles – A case in India

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Abstract: The ever-growing environmental concerns caused due to fossil fuel depletion and greenhouse gas (GHG) emissions has paved way for consumers to consider Electric Vehicles (EV) as a rapidly emerging operational alternative to vehicles that run on fossil fuels like petrol, diesel and CNG. The paper aims to identify the possible factors in consumers’ intention of Electric Vehicle adoption. A quantitative approach is adopted and the data is collected from 172 respondents from Bengaluru through an online survey method using snowball sampling method. A robust statistical method, such as exploratory factor analysis is conducted using IBM SPSS 23 to identify the factors. The study identified factors such as Financial Barriers, Vehicle Performance Barriers, Lack of charging infrastructure, Environmental Conservation, Societal Influence, Social Awareness of Electric Vehicles as influencers towards electric vehicle adoption. The outcome of the study helps the policymakers to modify the current policy with respect to electric vehicle in the emerging nations.

Subjects: Transport & Vehicle Engineering; Clean Tech; Environment & the Developing World

Keywords: electric vehicles; adoption; consumers’ intention; financial barriers; vehicle performance; charging infrastructure

1. Introduction

Climate change issues and its consequences have gained a lot of importance on political agendas worldwide. Carbon dioxide, one of the greenhouse gases has had a magnanimous impact on our environment that has resulted in water supply reduction, rise in coastal flooding and an increase in malnutrition. Due to the increasing awareness of environmental concerns, in view of climatic changes and global warming, consumers have been adopting green measures in order to improve air quality by reducing greenhouse gas (GHG) emissions. About 12 percent of the greenhouse gas emissions across the globe are contributed by private vehicles. On the whole, the transportation sector contributes to an approximate value of 22 percent of the GHG emissions. Efforts to reduce these emissions from this sector are growing at a fast pace (Moataz Mohamed et al., 2016). The automobile industry has begun to rethink the conventional forms of mobility due to the climate change and resource shortage. One such measure that is gaining popularity among consumers is the switch from using internal combustion engines (ICE) to electric vehicles, EVs (Degirmenci & Breitner, 2017).

The re-emergence of electric vehicles in the market are due to reasons such as improved battery technology and governments’ policies to maintain vehicle efficiency and the air quality standards. Electric Vehicles are an important technology which would help in reducing greenhouse gas emissions, local air pollution and vehicular noise pollution (Brady & O’Mahony, 2011; Hawkins et al., 2013). Being cognizant of these benefits, countries around the world are setting EV adoption targets (Coffman et al., 2016).
When compared to internal combustion engine vehicles (ICEVs), it is observed that EVs offer substantial environmental and economic benefits by substituting fossil fuels with electricity (Jaramillo et al., 2009; Larson et al., 2014). The transportation fuel used in EVs is electricity, a clean fuel, which powers a battery, which is bulky. Having limited energy storage capacity, the EVs must be recharged by plugging into an electrical source. Based on the technology used EVs are classified into different types which include plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), extended-range battery electric vehicles (E-REVs) and hybrid electric vehicles (HEVs).

Despite them being eco-friendly and providing environmental benefits, there are several barriers that prevent the consumers from accepting and adopting EVs. While a lot of effort has been put into the research and development of improving the technology used in EVs, less consideration was shown towards the factors affecting the acceptance of this technology by customers (Yeh & Liu, 2007). A majority of the consumers still consider Electric Vehicles as disadvantageous as compared to the conventional cars. However, there will be no technological shift and long-term success of transport systems that are sustainable, without consumer acceptance (Wiedmann et al., 2011). It is therefore, indeed important to understand how consumers perceive electric vehicles and what the possible drivers for and barriers against consumer Electric Vehicle Adoption are. This will further enable better promotion of electric vehicle adoption by understanding the influence the factors have on consumers’ intention of purchasing electric vehicles.

Achieving high environmental benefits offered by EVs relies thoroughly on the consumers’ adoption and preferable understanding of the influential factors that lead to diffusion of EVs in the market. Some of the previously identified factors include economical, technological, political, social and environmental factors. Driving range anxiety, charging time, price sensitivity, lack of infrastructure (charging facilities), personal characteristics, government policies, demographics, environmental concern and market are some of these factors.

1.1. Need for study

As the EV technology is picking up pace across the globe, India is yet to set its mark in this sector. The Indian Government has set out a roadmap that is ambitious and desirable for pure electric vehicles. It provides a transformative solution of shared-connected-electric mobility, wherein, 40% of private vehicles and 100% public transport vehicles can become all electric by 2030 (SIAM, 2017). An expansion of this vision is necessary to have a future of complete electric mobility by maximising the usage of electric vehicles. The aim of the study to find the possible factors that can influence the adoption of EVs and provide the Government to come out with the policies and to help the automakers to understand the needs and wants of the customer. In order to achieve this goal, sufficient market study needs to be conducted, and this is one drawback that the country currently faces at present.

1.2. Objective of the work

This study would give an insight to the Indian market’s perception of EV adoption, thus giving us a deeper understanding of why consumers resist buying Electric Vehicles. The aim of this study is to provide a comprehensive market assessment in identifying the potential factors that influence the Electric Vehicle Adoption.

1.3. Target specifications

The findings of this research may be useful for manufacturers and suppliers of the automobile industry, the private and public institutions dealing with e-mobility, sustainability or green business solutions as well as the governments. This could further help them to develop and provide strategies with the goal to overcome the adoption barriers currently existing. Overcoming these barriers would then attract larger number of consumers to Electric Vehicles.
2. Background theory
The automotive industry across the globe is at the brink of an extensive transformation given, the
heightening concerns for our energy and environmental conservation. The expeditious advancements
in technologies for power-plant electrification, the digitalization and innovative business models
clubbed with the ever-increasing consumer expectations are driving the transformation of the automo-
tive sector. An important facet of this change is the swift development in the area of electric
mobility that could lead to a transformation of the automotive business like never before. The Indian
automobile industry is considering innovative and pragmatic approaches to soar during this phase of
transformation so that by 2026, it can emerge among the top 3 in automobile manufacturing.
E-mobility is considered to provide a great scope for the Indian industry to engage and emerge
amongst the top in the automotive business, given the availability of skilled and semi-skilled tech-
nological base, a larger market and relatively cheaper production and labor cost. Various Indian
automotive players like Mahindra and Mahindra, Tata Motors, Bajaj Auto and TVS Motors are trying to
transform at a faster pace during this period of growth of electric vehicles while maintaining
competitive advantages in the market. This has further led to various strategic alliances: Mahindra
and Mahindra with Renault and Ford, Tata Motors with Fiat, TVS with Suzuki, Bajaj Auto with Kawasaki,
Jaguar Land Rover by Tata Motors and KTM by Bajaj Auto (Bhalla et al., 2018).

Various countries across the globe have developed and adopted long-term policies that are
aligned with that particular nation’s ecological aspects and goals in attaining decarbonisation of
industrial activities. Every country has its own approach that is based on its per capita income,
market environment, strategic needs and goals and purchasing power.

2.1. Product and market overview
Electric vehicles are classified into three main types: Battery Electric Vehicles (BEVs), Plug-in Hybrid
Electric Vehicles (PHEVs), Hybrid Electric Vehicles and Autonomous Vehicle (Run on electricity)

2.1.1. Battery electric vehicles
These are termed to be all-electric or pure electric vehicles since they are solely powered by an
electric motor and not the internal combustion engine (ICE). The battery draws its power, which is
electricity, from the grid. Usually, these EVs are equipped with powerful Lithium-ion batteries since
the battery is the only source of power. These batteries possess a capacity of 20kWh or more than
50kWh to deliver higher vehicle performance (Perujo et al., 2011).

2.1.2. Plug-in hybrid electric vehicles
These vehicles have a combination of an ICE and a battery with up to 40kWh capacity (usually
lithium-based). The vehicle can be powered by either the ICE or can draw power directly from
the grid. The vehicles can alone run on electric power at fast speeds, for shorter distances (Lytton,
2010). The ICE kicks in and provides power once the battery power reaches its range limit. The
range issues experienced in BEVs are addressed by the PHEVs.

2.1.3. Hybrid electric vehicles
These are also referred to as “Conventional Hybrid” vehicles. These vehicles have a provision to charge
its battery by the ICE using regenerative braking and not from an external source of electricity.

2.1.4. Autonomous Vehicle (AV)
In the recent years, a new type of vehicle technology, Autonomous Vehicle's (AV) have been on the
rise. The Investment in the autonomous vehicle have been increasing by the researchers and the
developers. A study by Othman (2022) on autonomous vehicles have a significant impact on fleet
size, utilisation, and cost. It also discusses the benefits and drawbacks of AV in developing countries.
While AVs have many benefits, they also introduce new threats. Regulatory actions can influence how
the technology is adopted, which influences how much impact AVs have on our mother nature.
This research will, however, solely focus on Battery Electric Vehicles (BEVs). Few electric vehicles (BEVs) available in India are listed below -

(1) **Hyundai Kona Electric**: provides a range of 452 km/charge

(2) **Tata Tigor EV**: provides a range of 140 km/charge

(3) **Mahindra e20Plus**: provides a range of 110 km/charge

(4) **Mahindra E Verito**: provides a range of 140 km/charge.

(5) **Tata Nexon**: Provides a range of 300 km/charge

### 2.2. Literature review

A study conducted had revealed that in developing countries like India, Electric Vehicles would be a more natural alternative, than in developed countries. Given the lack of oil reserves and the driving habits of the people in India, EV technology appears to be appropriate and economically viable (Biswas & Biswas, 1999). However, the development of the market of electric vehicles is intrinsically bound to general awareness, prospective consumers' choice, and understanding of potential benefits of using electric vehicles. Although the electric vehicle market growth continues, its widespread uptake is prevented by various barriers. Rezvani et al. (2015) have successfully carried out research in the past and have identified some factors that affect a consumer's choice on purchasing an EV. When it comes to Vehicle Restraint Systems (VRS), researchers have found that including elements like guardrails, terminals, transitions, and crash cushions in the planning stages of road and highway construction can boost VRS's overall performance (Tahmasseby et al., 2021).

Some of the critical factors/barriers have been discussed below.

#### 2.2.1. Technological factors (vehicle performance)

While electricity as a vehicle fuel has many benefits, it has two disadvantages: it is bulkier to store and costlier, and slower to refill. The former means that the current electric vehicles would have a smaller range than diesel, and the latter means that they cannot be refuelled easily on the road (Pearre et al., 2011). This brings us to the major technological factors.

These include driving range anxiety, recharging time and EV model variety.

- **Range Anxiety**: According to studies conducted, range anxiety is found to be a predominant barrier in a customer’s decision to buy an EV (Jensen et al., 2013). Research suggests that consumers prefer an ideal driving range, which is expected to be between 300 km to 450 km (Zhu, 2016). However, this at times is not practically possible thereby giving rise to range anxiety. This is mainly observed during battery charge depletion while driving for long hours when the driver fails to predict the approximate distance that could be covered with the remaining battery power. The limited and uncertain vehicle range aroused anxiety among drivers to use EVs for long journeys (Noel et al., 2020). This would decrease the reliability of these vehicles.

- **Recharging time**: Here, the time it would take to recharge the battery would depend on the driver's battery range choice. The more the battery is charged; greater range would be offered (Diaziano & Chiew, 2012). But this leads to excess charging time since the refuelling capacity is slow (Egbue & Long, 2012). Although this factor is viewed as the least problematic, it still contributes to increasing the rejection factor for EV purchase (Carley et al., 2013). Most of the drivers consider charging an EV to be inconvenient as compared to refuelling an Internal Combustion Engine (ICE) vehicle (Brückmann et al., 2021). They believe that EV charging time may pose to be a constrain in their everyday routines as the inability to quickly refill fuel and go on-the-run causes inconvenience especially for on-road drivers (Graham-Rowe et al., 2012). Also, if a charging station is available at home, sudden unexpected trips cannot be made by the driver when the EV is being charged. This reduces flexibility.

In case of taxi drivers, unintelligently controlled charging of electric vehicles, may lead drivers to return back home and plug-in their vehicles for charging when the demand is at its peak (Christensen et al., 2012).
2.2.2. Economical factors (financial barrier)
These include purchase price of the EV, fuel price and price of battery.

The high purchase price of an EV is found to be a large constraint in many consumer survey studies (Carley et al., 2013; She et al., 2017). The technology used in manufacturing EVs is expensive and this in turn raises the price value of the vehicle (Noel et al., 2020). As constant efforts are made and newer technologies are introduced to increase range of EVs, the complexity of battery material (Lithium-ion batteries) used increases (Biresselioğlu et al., 2018). This causes a rise in the battery price (Noel et al., 2020). Thus, replacement of such batteries in the future would be expensive. Poor understanding of the costs of vehicle fuel and maintenance also add to this barrier. Basically, the poor economy of scale causes upcoming technologies to compare unsatisfactorily to existing dominant price designs.

This has also to do with the customer’s perception about the money value of the EV. The service and maintenance costs of these are less when compared to ICE vehicles. But the initial high purchase price becomes a hindrance to consumers to buy EVs. This shows that the consumers aren’t fully aware that an advantage of having lower operating costs of EVs is that it leads to potential savings (Krause et al., 2013).

2.2.3. Lack of infrastructure- charging networks
Another relevant risk is the lack of a charging station when travelling (Krupa et al., 2014). As a result, to consider the need of long-distance drives, consumers would often demand that public charging stations be made available at more locations (Habla et al., 2020). The cost of setting these networks is again very high (Brückmann et al., 2021). This has led to uncertainty regarding the future expansion of the infrastructure for charging stations. Investing in infrastructural facilities by the Government and manufacturers for EVs could facilitate the consumers’ EV adoption rate (Bhalla et al., 2018).

The lack of a consistent charging system often discourages some drivers from depending on it. Still, there continues to be some debate as to how far public charging facilities may be needed to raise the willingness of consumers to adopt EVs. It is likely that setting up more charging points thus making them accessible would offer reassurance to consumers to accept EVs as a viable transportation alternative (Noel et al., 2020). It will be important to monitor how public perceptions of EVs change in cities where charging points are introduced and thus the salience of EVs increased (Bunce et al., 2014).

2.2.4. Personal characteristics
According to the Theory of Planned Behavior humans make decisions bases on logical evaluations of stimuli and the plausible outcomes of decisions (Ajzen, 1991). Customer knowledge and experience have an effect on attitude (Ajzen & Fishbein, 1980). Other factors that influence EV adoption are gender, age, income, educational level, tastes and environmental awareness.

Consumers who readily adopt EVs are usually highly educated and environmentally sensitive. Individuals respond to social expectations and social pressure reflected in statements, such as socially acceptable behaviour, being considerate of others, expressing shared values and social responsibility.

Kahn (2007) further goes on to state that a consumer who strongly believes in environmental conservation purchases an EV for two incentives. First, driving a more fuel-efficient car would reduce one’s carbon footprint for any given number of miles driven per year. The second incentive is that, everybody in the community sees the type of vehicle that a person drives. In an environmentalist community, driving a fuel inefficient vehicle may trigger some embarrassment and ostracism. This would lead to a person’s purchase of an EV due to peer pressure.
In some cases, EVs’ performance, style, size and safety were reported as barriers.

Lack of awareness regarding EVs and its benefits can also be a barrier in its adoption (Wang et al., 2017). A lack of knowledge about future market opportunities inhibits innovation in EVs with many manufacturers (Lieven et al., 2011). It is also important for product designers and marketers to develop and align electric vehicles to elicit positive emotional reactions (Moons & Pelsmacker, 2012).

Providing effective information would increase environmental knowledge. This will raise more doubt, decrease fatalism and increase consumer desire to change behaviour (as suggested by the Theory of Planned Behaviour), but it is often a necessary precursor (Lane & Potter, 2007).

In general, education and environmental consciousness are found to be mildly associated. Higher education could foster understanding of the climate-mitigation potential of a purchase of a single vehicle. Nevertheless, as higher education positively correlates with employment, higher-educated customers prefer to drive more costly vehicles with usually higher CO₂ emissions (Peters et al., 2015).

2.2.5. Environmental concern as a factor
Temperature increase in cities have been linked to increasing population, urban surface materials, forest removal, man-made heat, noise and air pollution, concrete buildings and building congested roads (Sampson et al., 2021). This further reinstates the thought that few people are heavily influenced by the depletion of natural resources and are thus concerned about environmental conservation (Heffner et al., 2007; Mohamed el al. 2018). It was found in a focus group analysis that most participants did not find any correlation between their choice of vehicle ownership and their environmental attitudes until the subject was addressed in structured conversations (Flamm & Agrawal, 2012). According to Asadi et al. (2021), Electric vehicles are considered to be the future alternatives which will address most of the environmental concerns. People/consumers accept the idea that by adopting EVs, a lot of pollution would be reduced (Skippon & Garwood, 2011). This motivates them to buy the EV to reduce the ecological footprint and “living lighter”, i.e. consuming fewer natural resources (Ozaki & Sevastyanova, 2011; Mohamed et al. 2018). An Environmental Index was employed to conduct this study in order to measure respondent environmental awareness. Currently, electric vehicles are mostly used by particular social groups, such as environmentalists, early adopters, people with above average income, young urban citizens and technology enthusiasts (Axsen et al., 2015; Talantsev, 2017).

Skerlos and Winebrake (2010), in their study discuss the social benefits of using EVs which include reduction in GHGs emissions and other air pollutants. EVs have shown substantially lower emissions than traditional ICE vehicles, while considering the emissions from power plants used in charging such vehicles. The magnitude of this difference depends strongly on the source of generation of power for these EVs: natural gas, coal or renewable fuels.

2.2.6. Policies
The Non-acceptance of policies and consumers’ perception towards them could also be a barrier in EV adoption (Brückmann et al., 2021). Regulations and incentives put forth by the government regarding fuel prices, fuel infrastructure development which are environment related would influence the adoption (David Diamond, 2009). Sometimes these policies aren’t well understood by the consumers. This may be caused due to frequent changes in policies, thus creating uncertainties for consumers. This in turn may make them reluctant in adopting EVs (Kester el al., 2018).

In order to facilitate EV diffusion in the market, policymakers are suggested to allow companies to experiment with automobiles to promote the spread of EV on the market. This can also be done by providing EVs for monitoring or removing other possible obstacles, which do not result in consumers purchasing EVs (Sierachula, 2014).
2.3. Research gap
From the literature (Brückmann et al., 2021; Noel et al., 2020), given a particular geographical distribution of a region and its demographics, the factors influencing EV adoption could vary. Most of the studies conducted in developed countries had infrastructure, Technological factors of the EV, and the financial factors available to them. In this case, India being geographically a large country, it should be seen if these factors can change the perceptions of people to buy an Electric Vehicle (EV). This causes a knowledge gap in the study of the influence of barriers on consumers’ intention to purchase an EV. This gap gives rise to the attitude-action lag between consumer purchase intention and actual behaviour.

3. Methodology
This research study seeks to identify the factors that could be potentially influencing Electric Vehicle adoption by consumers' in India. The study was conducted from December 2019 to April 2020 on a small population in the city of Bengaluru in the state of Karnataka, India. Quantitative methodology was followed for this research through using a survey instrument. The analytical method used was Exploratory Factor Analysis. Since the study uses a small scale, the data was examined to find out if the research met the required sampling adequacy that allowed a good fit of a structure using factor analysis. To accomplish this, Bartlett’s test for correlation adequacy and the KMO sampling adequacy test was used.

3.1. Sampling
There isn't a fixed consensus on the required sample size for conducting an Exploratory Factor Analysis (Costello & Osborne, 2005). Nevertheless, some researchers generally recommend having a minimum of 100 samples, in order to go ahead and conduct a factor analysis (Coakes & Ong, 2011 Gorsuch, 1988; MacCallum et al., 1999). In this research study, a sample size ratio of 1:5 is considered (Bujang et al., 2012). Initially, a pilot study was conducted with 52 responses, the results of which implied collecting large number of samples. For the main study, snowballing method was used to collect the responses and a total of 172 responses were collected from the respondents. The data was collected from the metropolitan city of Bengaluru of the state of Karnataka, India. The required sample size of this study was 130 samples. The questionnaire was circulated through offline and online (Google Forms) modes to around 230 respondents and 172 responses were collected. This was done to make up for the error at the time of data collection. The targeted population mainly consisted of businessmen, corporate workers and self-employed workers. Socio-demographic factors like age, gender, occupation, annual income and number of cars owned were considered for the survey.

3.2. Questionnaire design
To conduct this study, the research instrument used is a questionnaire. The questionnaire is designed based on past literature. The factors influencing consumers’ adoption of Electric Vehicles are measured. The questionnaire has been divided into two parts. In the first part, basic information of the respondents like age, gender, occupation, annual income and number of cars; was taken. The second part included questions pertaining to the assumed factors such as price, vehicle performance, market awareness, recharging facilities, etc. For the prepared questionnaire, a 7- point Likert scale is used.

1 = “Strongly disagree”

2 = “Disagree”

3 = “Moderately disagree”

4 = “Neutral”

5 = “Moderately agree”
6 = “Agree”

7 = “Strongly agree”

3.3. Factor analysis
Factor Analysis is a significant instrument for analyzing data which could be used in the development, refinement and evaluation of tests, scales and measures (Williams et al., 2010). It is a multivariate statistical procedure and is commonly used in the fields of information system, psychology, commerce and education. It is also considered as the approach of choice for the interpretation of self-reporting survey (Bryant et al., 1999).

Factor analysis reduces a large number of variables (factors) into smaller sets. It also provides the validity of the constructs. It is used to convert a large data set into a smaller one and is known as a data reduction technique. It is used to find the number of factors that affect the variables and to check if the variables have any relationship between them (Yong & Pearce, 2013). It is divided into two main types, namely, Exploratory Factor Analysis and Confirmatory Factor Analysis. If the researcher has no expectations of the number or nature of factors, Exploratory Factor Analysis is used. It helps the researcher to explore the main variables to create a theory or model from a set of items. It is employed when there is no theory regarding possible connections between variables (Hurley et al., 1997). Confirmatory Factor Analysis, on the other hand, is a form of structural equation modelling and is used to test a proposed theory or model by a researcher. This study considers the approach of Exploratory Factor Analysis.

Kaiser-Meyer-Olkin (KMO) Test and Bartlett’s sphericity test are used to check sample adequacy. When the variable to participants’ ratio is about 1:5, the KMO test for adequacy of samples is recommended (Williams et al., 2012). According to the KMO measure of sampling adequacy, a 0.5 KMO value for sample study should be the minimum considerable value for proceeding with factor analysis (Kaiser, 1974). The value of significance for Bartlett’s sphericity test should be less than 0.05, after which the sample can be considered adequate. Therefore, in this research a KMO test and Bartlett’s sphericity test were carried out to measure the sample adequacy to conduct the factor analysis.

To assess the internal consistency of variables determined by the factor analysis, conducting a reliability test is necessary. The reliability of a scale is defined to be the amount of variation in a scale’s score (DeVellis, 2003). Cronbach’s alpha is used to check the internal consistency reliability.

4. Result analysis

4.1. Reliability test
The Cronbach alpha is used for calculating the study ‘s reliability. It’s used to test the reliability of the scale used when there are many Likert questions in a questionnaire (Table 1).

A Cronbach alpha of the value 0.720 is obtained from the study result which suggests a good consistency level for the selected Likert scale of 7 with 26 items and a sample size of 172. A value greater than 0.7 is considered to be good for internal consistency. However, values above 0.51 are also considered to be up to the mark (Straub et al., 2004). A Cronbach alpha value of 0.720 suggests a strong consistency level for the instrument (Gliem & Gliem, 2003).

| Table 1. Reliability test result |
|----------------------------------|
| **Reliability Statistics**       |
| Cronbach’s Alpha | Cronbach’s Alpha Based on Standardized Items | N of Items |
| 0.720                | 0.718                        | 26          |
4.2. Demographic distribution of consumers

4.2.1. On Gender basis
The data collected shows that out of the sample of 172, 56.4% are males (97 respondents) and 43.6% are females (75 respondents). Since a majority of this study were males, it can be interpreted that the EV automobile industry should focus on the male counterpart of the society while designing the features of the product and the marketing strategies (Table 2).

| Sr. No. | Demographic Factor | Percentage of responses |
|---------|--------------------|-------------------------|
| 1       | Gender             |                         |
|         | Male               | 56.4%                   |
|         | Female             | 43.6%                   |
| 2       | Age group          |                         |
|         | 25–34 years        | 62.8%                   |
|         | 35–44 years        | 33.1%                   |
|         | 45 years and above | 4.1%                    |
| 3       | Occupation         |                         |
|         | Salaried employee  | 98.3%                   |
|         | Owner of a firm    | 1.7%                    |
| 4       | Annual Income      |                         |
|         | At most 6 Lac      | 29.7%                   |
|         | Above 6 Lac – less than 10 Lac | 34.9% |
|         | 10 Lac – 20 Lac    | 21.5%                   |
|         | Above 20 Lac       | 13.9%                   |
| 5       | Number of cars owned |                      |
|         | None               | 16.9%                   |
|         | One                | 58.1%                   |
|         | Two                | 22.7%                   |
|         | Three or more      | 2.3%                    |

4.2.2. On age basis
In the data analysis, it was observed that a maximum percentage of respondents, that is 62.8% (108 respondents) belonged to the age group of 25–34 years followed by 33.1% (57 respondents) belonging to the age group 35–44 years and 4.1% (7 respondents) in the age group of 45 and above.

4.2.3. On occupation basis
98.3% of the sample (169 respondents) were salaried employees and 1.7% (3 respondents) had their own business.

4.2.4. On annual income basis
A majority of the sample which is 34.9% (60 respondents) have their annual income above 6 Lac and less than 10 Lac. This is followed by those having an annual income of at most 6 Lac, which formed 29.7% (51 respondents) of the sample. Next to that, were those having an annual income of 10 Lac to 20 Lac, 21.5% (37 respondents) and lowest belonged to those whose income was above 20 Lac, which formed 13.9% of the sample size (24 respondents).

4.2.5. On number of cars owned basis
16.9% of the sample size (29 respondents) did not own a car of their own. However, these respondents could be potential buyers of electric vehicles. The majority of the sample strength, 58.1% (100 respondents) owned one car. This was followed by 22.7% (39 respondents) who owned two cars. A minimum percentage of the sample size, 2.3% (4 respondents) owned three or more cars.
4.2.6. KMO and Bartlett’s test

The KMO-Bartlett’s test is conducted to measure the sampling adequacy to check the suitability of the data used in the questionnaire. The sampling adequacy provides the researcher with information related to classifying or grouping of the survey items. Grouping of the items helps the researcher to categorize the set into interpretable factors that can better explain the constructs that are being investigated. The sampling adequacy explains how strongly an item is correlated with other items in EFA correlation matrix (Burton & Mazerolle, 2011).

The results of this study obtained here indicate a KMO value of 0.764 which is greater than the acceptable index of 0.5. Hence, the number of samples used is sufficient and is accepted (Williams et al., 2010). This indicates that some pattern of correlations exists in the data.

The level of significance obtained is 0.000 which is significant ($p < 0.05$), indicating that the correlation matrix is not an identity matrix, thus suggesting that clusters of items are correlated. This indicates that we can now proceed with the EFA.

Communalities were measured to find the proportion of the variance of variable that each factor can explain. The initial values show the variance estimates for all factors. It is always 1 for the Principal Component Extraction. The extraction value is the estimation of all components of the variable’s variance. A high value for extraction indicates that all variables have been well represented. The respective results are shown in the Table 3 and 4 below:

| Table 3. KMO and Bartlett’s test result |
|-----------------------------------------|
| **KMO and Bartlett’s Test**             |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy | .764 |
| Bartlett’s Test of Sphericity           |     |
| Approx. Chi Square                     | 2564.232 |
| df                                      | 325  |
| Sig.                                    | .000 |

| Table 4. Communalities                  |
|-----------------------------------------|
| Initial | Extraction |
| Q1      | 1.000 | .646 |
| Q2      | 1.000 | .718 |
| Q3      | 1.000 | .718 |
| Q4      | 1.000 | .697 |
| Q5      | 1.000 | .500 |
| Q6      | 1.000 | .631 |
| Q7      | 1.000 | .705 |
| Q8      | 1.000 | .810 |
| Q9      | 1.000 | .761 |
| Q10     | 1.000 | .324 |
| Q11     | 1.000 | .750 |
| Q12     | 1.000 | .587 |
| Q13     | 1.000 | .787 |

(Continued)
The Extraction Method used is Principal Component Analysis. From the table above, it is observed that the communalities extracted are above 0.3 which is the minimum acceptable level (Costello & Osborne, 2005). The value of Total Variance Explained obtained is 65.764% which is acceptable.

4.2.7. Scree plot

The scree plot is a graph that shows the eigenvalue versus the number of factors in the study. The factors that cause the line to become flat show that the magnitude of variance is decreasing. As a result, the first six variables explain the greatest amount of variance, as shown in Figure 1.

Figure 1. Scree plot.
The rotation is performed in the Rotated Component Matrix to reduce the number of factors on which the variables have high loadings (Table 5). The study shows different values of variance above 0.5 from the variables that have been extracted by Principal Component Analysis. The Principal Component Analysis extracts maximum variance from the data, thereby reducing a large number of variables into smaller groups of components.

Using Principal component analysis extraction method with eigen values greater than 1 along with Varimax with Kaiser Normalization rotation method, the rotation was found to converge in six iterations. It has formed six factors out of 26 items. One of the items (Q10) had factor loadings less than 0.5 and was hence suppressed. Hence, we can consider deleting Q10 (Table 6).

Below is the rotated component matrix after deleting Q10:

| Table 5. Rotated component matrix |
|-----------------------------------|
| **1** | **2** | **3** | **4** | **5** | **6** |
| Q8    | .876  |      |      |      |      |
| Q13   | .857  |      |      |      |      |
| Q9    | .855  |      |      |      |      |
| Q11   | .836  |      |      |      |      |
| Q14   | .821  |      |      |      |      |
| Q7    | .816  |      |      |      |      |
| Q15   | .729  |      |      |      |      |
| Q12   | .721  |      |      |      |      |
| Q6    | .769  |      |      |      |      |
| Q2    | .751  |      |      |      |      |
| Q4    | .740  |      |      |      |      |
| Q1    | .725  |      |      |      |      |
| Q3    | .718  |      |      |      |      |
| Q5    | .669  |      |      |      |      |
| Q18   |      | .830 |      |      |      |
| Q17   |      | .801 |      |      |      |
| Q16   |      |      | .599 |      |      |
| Q19   |      |      |      | .858 |      |
| Q20   |      |      |      | .824 |      |
| Q21   |      |      |      | .608 |      |
| Q24   |      |      |      |      | .777 |
| Q26   |      |      |      |      | .753 |
| Q25   |      |      |      |      | .723 |
| Q23   |      |      |      |      | .882 |
| Q22   |      |      |      |      | .792 |

It is observed that all items have loadings above 0.5 and the factor loadings have not cross-loaded and 6 components have been identified. Eight items were loaded onto the first factor, followed by six items on the second factor, three items on the third, fourth and fifth factor each. Only two questions were loaded onto the last factor.
| Sl. No. | BARRIERS/ FACTORS          | ITEMS                                                                 |
|--------|---------------------------|----------------------------------------------------------------------|
| 1.     | Financial barriers/ Factors | Q8 I am confident that it is easy to maintain an EV.                 |
|        |                           | Q13 I would buy an EV if an excellent battery warranty is provided.   |
|        |                           | Q9 I would want to buy an EV for the same price that I would buy a conventional ICE vehicle for. |
|        |                           | Q11 I do not consider buying an EV now because purchase prices may drop in the next few years. |
|        |                           | Q14 I think that the cost of replacing an EV battery is very high.   |
|        |                           | Q7 I think owning an EV is more cost effective than owning a conventional vehicle (ICE), in the long-run. |
|        |                           | Q15 Driving an EV helps me to spend less on fuel.                    |
|        |                           | Q12 The unknown cost of maintenance along with its repair is a major reason to stop me from adopting an EV. |

2. Vehicle Performance barriers /Factors

| Sl. No. | BARRIERS/ FACTORS          | ITEMS                                                                 |
|--------|---------------------------|----------------------------------------------------------------------|
|        |                           | Q6 EV charging is difficult due to lengthy charge times.             |
|        |                           | Q2 I would always be worried about running out of charge when driving an EV. |
|        |                           | Q4 I would only prefer to use the Electric Vehicle for short-distance journeys. |
|        |                           | Q1 While using an Electric Vehicle, I would have to plan my trips carefully. |
|        |                           | Q3 I would reduce the use of air conditioning in EVs in order to reduce the battery power consumption. |
|        |                           | Q5 The need for charging makes EVs very unpractical for everyday use. |

(Continued)
5. Findings and discussions of the study

India has started off late on the path to electrification and thus a strong policy is required to catch-up and move rapidly towards the stated goal of hundred percent pure electric technology regime. Currently, the penetration of Electric vehicles in the market remains quite low in India, ~0.1% in Private Vehicles, ~0.2% in two-wheelers and practically nil for commercial vehicles. This could be due to several reasons including significant affordability gap and low level of consumers’ acceptance (i.e. lack of demand), low level of electric vehicle manufacturing activities (i.e. lack of supply), non-existent public charging infrastructure, etc. However, it may be expected that with a concerted policy and an enough time for such a policy to bear fruits, all these aspects could be well taken care of.

Most of the personal vehicle buyers consider upfront purchase price, fuel efficiency, maintenance and service cost, comfort features as the key buying criteria. The single major factor for EVs’ market penetration to be slow is its high price which is around 2 to 2.5 times more than the comparable

| Sl. No. | BARRIERS/ FACTORS | ITEMS |
|---------|-------------------|-------|
| 3.      | Lack of Charging Infrastructure | Q18 | Charging an EV isn’t possible with an ordinary electric socket. |
|         |                   | Q17 | Lack of recharging facilities at home for overnight charging causes inconvenience when using an EV. |
|         |                   | Q16 | It is difficult to use EVs for longer distances due to the lack of charging stations along the roadway. |
| 4.      | Environmental Concern | Q19 | I believe that Electric Vehicles can reduce climate change. |
|         |                   | Q20 | Driving an EV would express my environmental awareness. |
|         |                   | Q21 | Driving EVs would reduce the consumption of natural resources. |
| 5.      | Societal Influence | Q24 | The people around me think that I should purchase an EV. |
|         |                   | Q26 | Driving the EV would make me feel socially responsible. |
|         |                   | Q25 | The people close to me think that it is important to consider the environment when purchasing an EV. |
| 6.      | Awareness of EV’s | Q23 | I am aware of the technology used in EVs. |
|         |                   | Q22 | I am aware that the battery warranty of an EV. |
conventional vehicles. Besides this, the other concern that consumers usually face with regard to electric vehicles is the range per charge offered. A higher battery capacity would be required to offer a higher range amount in the electric vehicle. An improved battery capacity would mean an increase in the price of the EV, which then increases the price gap. However, EVs would offer a significant advantage on operating costs as compared to the conventional ICE vehicles. In India, the affordability index is lower than developed economies due to lower per capita income. Manufacturers will hence have to offer medium range electric vehicles so that the cost of the vehicles remain affordable for the masses. Studies from the past literature have also suggested that awareness of electric vehicles is low among the society. This included familiarity with technology, lack of knowledge concerning government schemes and economic benefits. Studies have also indicated that there is a direct correlation between knowledge of electric vehicles and its adoption.

From the data analysis, six unique components/factors were identified which were grouped and named, based on the items loaded in each of the following factors. Conceptually, these factors make sense within the context of what the literature review stated. The factors identified were similar to the factors considered in other studies and these factors will play a major role for setting the road map for EVs in the country. The study is conducted in Bengaluru which boasts of Major IT hub, Education, Textile, Automobile and other manufacturing companies. The identified factors were labelled as: Financial barriers, vehicle performance barriers, lack of charging infrastructure, environmental concern, societal influence and awareness of electric vehicles and the details of the factors are listed below.

5.1. Financial barriers/ factors
The financial factors mainly include pricing concerns. This includes the overall EV cost due to its superior design, the maintenance cost as compared to ICE vehicles and the cost of the EV battery (Sierzhula, 2014). Some consumers consider buying an Electric Vehicle for the same price as that of the ICE vehicles. They do not consider purchasing EVs as of now, assuming that its price would drop down in the future. Considering electricity as a fuel would help them spend less on exhaustible fossil fuels like petroleum, diesel and CNG (Krause et al., 2013). The cost of battery replacement of EVs is also high and this concerns the consumers (She et al., 2017). The unknown cost of service and maintenance adds to this list as well. The price of the electric vehicle and battery was also found to be a key factor and overall, in line with that of Noel et al. (2020).

5.2. Vehicle Performance barriers/ factors
Under vehicle performance factors, consumers are mainly concerned with the maximum range offered by electric vehicles in a single charge and the lengthy charging times. They consider being worried about running out of charge when driving an EV and would hence have to plan their trips carefully. This makes them to consider using EVs only for short-distance journeys (Noel et al., 2020; Zhu, 2016). Repeated recharging of Electric Vehicles makes it unpractical for everyday use due to its lengthy charging time (Rowe et al., 2012).

5.3. Lack of charging infrastructure
The unavailability of recharging facilities at home as well as along highways was also found to be a factor for not purchasing an Electric vehicle. Lack of recharging facilities at home for overnight charging and along the highways causes inconvenience while using Electric Vehicles (Lane & Potter, 2007). This factor was noted in the previous studies and supports the results by Kester et al. (2018) and Noel et al. (2020).

5.4. Environmental concern
Consumers believe that driving an electric vehicle would express their awareness towards environmental conservation. They believe that it would reduce the consumption of natural resources, thus reducing climate change (Heffner et al., 2007).
5.5. Societal influence
Due to the increasing awareness on environmental conservation around the consumers they feel influenced by their peers, family or society to consider the environment while purchasing an electric vehicle. They feel socially responsible while driving electric vehicles (Kahn, 2007).

5.6. Awareness of electric vehicles
Market awareness also plays a role in adopting electric vehicles (Wang et al., 2017). The people are aware of the technology used in electric vehicles and are aware of what makes EVs different from the ICE vehicles. This is majorly to do with how electric vehicles have been marketed to the consumers.

6. Conclusion, limitations and future scope of work
With India’s aim to transform its automobile industry by focussing on e-mobility, it is mandatory to address the knowledge gap as lack of awareness of potential barriers in EV adoption. As a limited study has been conducted in this field in India, identifying and classifying these barriers into various groups is necessary. The aim of this project is to determine the factors influencing consumers’ intention of electric vehicle adoption in India. Based on the components grouped, six factors were identified and named as financial factors, vehicle performance factors, lack of charging infrastructure, environmental concern, societal influence and awareness of electric vehicles. Based on the results the factors found in this study are similar to some of the factors found by Noel et al. (2020). Financial barriers, vehicle performance barriers and lack of charging infrastructure facilities are found to be the major factor in adoption of EV’s in Indian context.

The findings of this research can be used by manufacturers and suppliers of the automobile industry, the private and public institutions dealing with e-mobility, sustainability or green business solutions as well as the governments. This could further help them to develop and provide strategies with the goal to overcome the adoption barriers currently existing. Overcoming these barriers would then attract larger number of consumers to Electric Vehicles.

The study was restricted to one metropolitan city in India, which is an IT hub. The sample size was limited to only 172 respondents and mostly in the age group of 25–34 with salaried people. There is a need to replicate the study in other cities to understand the influencing factors. Further studies can focus on the influence of the factors identified in this study and also on acceptance of new technology when buying electric vehicles (Table 6).

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### ANNEXURES

#### Annexure A: Questionnaire

| SR. NO. | QUESTIONS                                                                 | LEVEL OF AGREEMENT |
|---------|---------------------------------------------------------------------------|--------------------|
| 1       | While using an Electric Vehicle, I would have to plan my trips carefully. |                     |
| 2       | I would always be worried about running out of charge when driving an EV.  |                     |
| 3       | I would reduce the use of air conditioning in EVs in order to reduce the battery power consumption. |                     |
| 4       | I would only prefer to use the Electric Vehicle for short-distance journeys. |                     |
| 5       | The need for charging makes EVs very unpractical for everyday use.         |                     |
| 6       | EV charging is difficult due to lengthy charge times.                      |                     |
| 7       | I think owning an EV is more cost effective than owning a conventional vehicle (ICE), in the long-run. |                     |
| 8       | I am confident that it is easy to maintain an EV.                         |                     |
| 9       | I would want to buy an EV for the same price that I would buy a conventional ICE vehicle for. |                     |
| 10      | I think that the superior EV design is the reason for its high price.      |                     |
| 11      | I do not consider buying an EV now because purchase prices may drop in the next few years. |                     |
| 12      | The unknown cost of maintenance along with its repair is a major reason to stop me from adopting an EV. |                     |
| 13      | I would buy an EV if an excellent battery warranty is provided.            |                     |
| 14      | I think that the cost of replacing an EV battery is very high.             |                     |
| 15      | Driving an EV helps me to spend less on fuel.                              |                     |
| 16      | It is difficult to use EVs for longer distances due to the lack of charging stations along the roadway. |                     |
| 17      | Lack of recharging facilities at home for overnight charging causes inconvenience when using an EV. |                     |
| 18      | Charging an EV isn't possible with an ordinary electric socket.            |                     |
| 19      | I believe that Electric Vehicles can reduce climate change.               |                     |
| 20      | Driving an EV would express my environmental awareness.                    |                     |
| 21      | Driving EVs would reduce the consumption of natural resources.             |                     |
| 22      | I am aware that the battery warranty of an EV.                             |                     |
| 23      | I am aware of the technology used in EVs.                                 |                     |
| 24      | The people around me think that I should purchase an EV.                   |                     |
| 25      | The people close to me think that it is important to consider the environment when purchasing an EV. |                     |
| 26      | Driving the EV would make me feel socially responsible.                   |                     |
