



Review On Factors Influencing Adoption of Electric Vehicles

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Abstract: Growing environmental concerns about fossil fuel depletion and greenhouse gas (GHG) emissions have led consumers to consider electric vehicles (EVs) as a rapidly emerging alternative to fossil fuel-powered vehicles such as gasoline, diesel, and CNG. . This paper aims to identify the factors that can influence consumers' intention to adopt electric vehicles. Quantitative approach was adopted and data was collected from 172 respondents from Bengaluru city through online survey method using snowball sampling method. Strong statistical methods such as exploratory factor analysis were used to identify factors using IBM SPSS 23. The study identified factors such as Financial Barriers, Vehicle Performance Barriers, Lack of Charging Infrastructure, Environmental Protection, Social Impact, and Social Awareness of Electric Vehicles as influencing the adoption of electric vehicles electricity. The results of the study help policy makers to change the current policy towards electric vehicles in developing countries.

Keywords: Electric vehicles, adoption, consumers intention, financial barriers, vehicle performance

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., Citation2016). 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, Citation2017).

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, Citation2011; Hawkins et al., Citation2013). Being cognizant of these benefits, countries around the world are setting EV adoption targets (Coffman et al., Citation2016).

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., Citation2009; Larson et al., Citation2014). 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 improvising the technology used in EVs, less consideration was shown towards the factors affecting the acceptance of this technology by customers (Yeh & Liu, Citation2007). 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., Citation2011). 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.

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.

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, Citation1999). 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. (Citation2015) 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., Citation2021).

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.

Sampling

There isn't a fixed consensus on the required sample size for conducting an Exploratory Factor Analysis (Costello & Osborne, Citation2005). Nevertheless, some researchers generally recommend having a minimum of 100 samples, in order to go ahead and conduct a factor analysis (Coakes & Ong, Citation2011 Gorsuch, Citation1988; MacCallum et al., Citation1999). In this research study, a sample size ratio of 1:5 is considered (Bujang et al., Citation2012). Initially, a pilot study was conducted with 52 responses, the results of which implied collecting large number of samples. For the main study, snow balling 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.

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"

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., Citation2010). 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., Citation1999).

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, Citation2013). 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., Citation1997). 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., Citation2012). 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, Citation1974). 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, Citation2003). Cronbach's alpha is used to check the internal consistency reliability.

Result analysis

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)

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, Citation2011).

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., Citation2010). 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.

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%

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., Citation2004). A Cronbach alpha value of 0.720 suggests a strong consistency level for the instrument (Gliem & Gliem, Citation2003).

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.

On occupation basis

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

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).

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.

Conclusion, limitations and future scope of work

With India's aim to transform its automobile industry by focusing 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. (Citation2020). 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.

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