Vol. XVII & Issue No. 05 May - 2024
INDUSTRIAL ENGINEERING JOURNAL

A STUDY ON THE ADOPTION OF ELECTRIC VEHICLE – A STEP TOWARDS SUSTAINABILITY IN PUNJAB

Harmanpreet Kaur
Department of Commerce,
Punjabi University Patiala
Harmanmoney07@gmail.com

Sarabjit Singh
Department of mechanical engineering
Chandigarh Engineering College Jhanjeri
sarabjit.j251@cgc.ac.in

Abstract:

Environmental pollution has become a global concern as a major share of toxic emissions is contributed by vehicles running on the road. Electric vehicles (EVs) have emerged as the optimal solution for controlling pollution. The popularity of EVs has grown due to environmentally friendly, comfortable, good public transit experience and cost-effectiveness. A call for ''only electric vehicles" by 2030 has also been given by the government of India. Various financial and non-financial Incentives are also given by various governments to encourage people to switch to EVs. The current study aims to examine the various parameters such as social, Economic and environmental aspects that affect the perception and acceptance of EVs. The study has been conducted in five major cities of Punjab i.e. Ludhiana, Patiala, Jalandhar, Bathinda and Amritsar with 300 respondents. The data has been analyzed by using Factor analysis and Structural Model Analysis. The study found PEB as a non-significant variable, EC and Soc. In as partially significant, IM and ATT are significant variables. The findings of the study are expected to add value to the existing literature regarding EV adoption.

Keywords: Electric Vehicles, Sustainability, Adoption, Factors towards adoption.

1. INTRODUCTION

An efficient infrastructure of transportation plays a crucial role in economic and social development. But no economic development is said to be a sustainable economy if we fail to protect the environment and dilute the living standard. To control pollution the need of alternative sustainable fuels and a booming population forced us to think about the usage of environment-friendly substitutes such as electronic automobiles. The government has also provided various financial and non-financial incentives to promote EVs such as rebates, tax reductions, free parking facilities, reductions in tolls, etc. Recently, Punjab gave a nod to draft EV policy. The first one lakh buyers of EV will get a financial incentive of up to Rs 10,000, whereas the first 10,000 buyers of electric auto rickshaws and E - rickshaws will get a concession of up to Rs 30,000. Apart from that, it will also waive the registration fee and road tax. The main aim of the policy is to reduce carbon emissions through EVs. With the new policy, EVs will be promoted in major cities such as Ludhiana, Patiala, Amritsar and Jalandhar. Out of 1.24 crore total registered vehicles, 14804 are electric vehicles (As per data submitted by the union minister of state for heavy industries in Lok Sabha). Across the country, there are a total of 1536 retail outlets out of which 41 are in Punjab.

Table1: Number of Eclectic and Non-Electric Vehicles

State	Electric	Non-Electric	Total
Haryana	37,035	1,07,78,270	1,08,15,305
Punjab	14,804	1,24,63,019	1,24,77,823
Himachal Pradesh	1,175	19,64,754	19,65,929
Chandigarh	2,812	7,46,881	7,49,693
India	13,34,385	27,81,69,631	27,95,04016

During the Conference of the Parties (COP)-21 summit held at Paris , the Government of India made commitments to reduce the intensity of emissions by 2030 by 33- 35 % from 2005 levels. The charging Infrastructure for electric vehicles - Guidelines and standards have been issued by the Ministry of power Bureau of energy efficiency (BEE) as a central nodal agency (CNA) has also been designated by the ministry of power for the National level rollout of charging Infrastructure. The EV charging stations have also been expanded by 2.5 times across 9 mega cities i.e. Delhi, Surat, Ahmedabad, Pune, Bengluru, Chennai, Hyderabad, Mumbai and Kolkata. A total of 678 public EV charging stations were installed between Oct 2021 to January 2022 in these nine cities. To enhance

public charging infrastructure, the government is making 360 - degree efforts by involving public and private agencies. (BEE, EESL, PGCIL ,NTPC etc.) A web portal called" E - Amrit" was also launched in November 2021 at the COP26 summit in Glasgow, UK. In addition to programs of governments and policy push, the adoption and promotion of EVs are dependent on various environmental and socio-technical factors ranging from psychological factors, social behavior, financial, and technical infrastructure, among others (Tarei et al. 2021, Mukherjee & Ryan, 2020, Haider et al., 2019;) So in present study focus has been made to study the various factors affecting behavioral intention of customers in five major cities of Punjab i.e. Ludhiana, Patiala, Jalandhar, Bathinda and Amritsar.

Electric Vehicles (EVs): EVs are run by electric motors and these motors are powered by energy stored in batteries. Instead of an internal combustion Engine (ICE), EVs have an electric motor. These vehicles do not emit exhaust from the tailpipe. It doesn't contain a fuel line, fuel pump or fuel tank. There are four types of electric vehicles available.

- Battery electric vehicle (BEV): BEVs are fully powered by electricity. As compared to hybrid and plug-in hybrids these are more efficient.
- Hybrid electric vehicle (HEV): HEV uses both battery-powered motor power trains and the internal combustion engine. PHEVs are chargeable from an external socket (having a plug).
- Fuel cell electric vehicle (FCEV): FCEV chemical energy produces electric energy. Hydrogen FCEV is one example.

2. LITERATURE REVIEW

The literature review aims to give an overview of the previous studies on a given topic. Available literature guides the right path and also provides directions for new research. Various research papers published in journals, doctoral theses, books, and magazines were referred and explained to study EV adoption. Some of these are listed below-

Kumar et al. (2015) proposed strategies to enhance EV penetration in India. The study has tested a vehicle-to-home scheme for a specific route in the state of Kerala. The findings of the study suggested during parking time EVs be used as an energy storage medium which will reduce the payback period of EVs and increase consumers' willingness to pay.

Jansson et al. (2017) studied opinion leadership and norms' effect on EV adoption in Sweden. The study found that both attitudinal factors and interpersonal factors affect the adoption of eco-innovation products like EVs.

Bhalla et al. (2018) studied various factors affecting customer perception regarding EVs and which may also lead to commercial success. The study found technological advancement and environmental issues as critical factors affecting perception and infrastructure, and social acceptance and cost as major factors affecting the adoption of EVs.

Kumar et al. (2018) conducted research on the commercial viability of EVs in India. For this purpose, 100 E-vehicles of a fleet operator and associated infrastructure were considered as a sample. The study found large waiting time, permission from authorities and high initial investment affected EVs adoption. The author suggested that there should be proper infrastructure, subsidies and incentives to enhance EV adoption.

Motwani & Patil (2019) suggested factors affecting the features of an electric car to know the intention of the customer to buy it. A survey has been conducted on 345 respondents in Pune had been done. The study found recharging features and mobility as crucial factors whereas regional transport office (RTO) norms were found to be the least significant factor that affects customers' decisions.

Shankar and Kumari (2019) explored the resistors and inhibitors of EVs and the intent of adoption from the seller's perspective. The study is based on a survey analysis of 292 respondents based in the metro cities of Mumbai, Kolkata, Delhi, Chennai and Bangalore was done. The study found environmental concerns, PBC, SN, AT and CSR had positive impacts on adoption and found perceived value, expected threat, regret avoidance, and inertia as resistors to EV adoption.

Khurana et al. (2020) studied various factors affecting EV adoption. For this purpose, a sample of 450 respondents from the cities of Delhi, Pune and Mumbai had been considered. The study found Attitude as a critical factor for EVs adoption. Apart from this environmental concerns and proper incentives also played a major role while determining the adoption intentions of individuals.

Kumar et al. (2020) tried to explore the various challenges regarding EV adoption in India. The secondary literature review with expert group discussion had been done. The author found low purchasing power of individuals, lack of infrastructure and high cost affected the adoption of EVs.

Navalagund et al. (2020) tried to explore the various factors affecting the intention to purchase Evs of Indian consumers. A survey of 384 respondents across 10 cities in the state of Karnataka was conducted. The study found EV eco-system and pro-environmental behavior as crucial factors and cost and financial advantage as insignificant factors.

Shetty et al. (2020) made an effort to study barriers to EV adoption in urban centers. A survey of 1230 respondents from India and Sri Lanka was done. The study found familiarity with EVs , awareness, cost benefits and functional knowledge of EVs had a significant impact on the purchase intentions of the consumers.

Jena et al. (2020) made efforts to analyze the sentiments of consumers regarding EVs. For this purpose, data had been collected from various platforms of social media from 2016-2018. The study found no effect of incentives on sizable customers and positive effect of battery technology of battery**,** its life and charging point infrastructure on consumer sentiments.

Tarei et al. (2021) reviewed work regarding the Indian EV context had classified the barriers in EV adoption into five main categories: infrastructural barriers (low maintenance

availability, charging point shortage, reliable electricity availability, lack of manufacturer, etc.), behavioral (perceived benefits, skepticism on safety, reliability, etc.), financial barriers (total cost of ownership, resale value, high upfront cost, etc.), technical barriers (reliability of suppliers, range, performance, technology, etc.), and external (raw material use and recycling).

Bansal et al. (2021) studied the attitude, preferences and willingness of Indian consumers to pay for EVs. A survey of 2176 respondents across India was done and the study found consumers were willing to pay extra to reduce the timings of charging, low maintenance costs and improve driving range.

GIZ (2021) Study found EV adoption is affected by various factors such as dominance by two-wheelers and three-wheelers, high traffic density, dependence on public transport, price-sensitive customers and low vehicle ownership. The study anticipated the growth in EVs in two-wheeler over four-wheelers by early adopters.

Shalendra & Sharma (2021) tried to predict EV adoption intention in India. The study covered five automobile companies – Toyota Bhraat, Honda Car, Tata Motors, Hyundai Motors and Maruti Suzuki. A Sample of 326 customers from 57 dealerships of these five companies was considered. A study found moral aspects, environmental concerns, PBC,SN and AT had positive impact on customer EV adoption intention.

Neupane and Sharma (2023) tried to compare and analyze the behavioral and psychological factors affecting first time EV purchase. Study found environmental concern, charging infrastructure and affordability as the major factors .Study also found a developing trend of EVs and bright future for automobile industry.

3. RESEARCH METHODOLOGY

The main objective of the study is to know the various factors affecting EVs adoption among consumers. The primary data has been collected through a structured questionnaire from 300 respondents. The questionnaire contained two parts where first part covered the demographic features of the respondents such as age, gender, education and scooters in the household and the second part covered the model variables. There is one dependent variable i.e. EVs adoption and five independent variables i.e. EC, PEB, SI, IM and ATT. Data has been collected from existing scooter owners from Five major cities of Punjab i.e. Ludhiana, Patiala, Jalandhar, Bathinda and Amritsar. Collected Data was complete and responses were valid.

Measurement: The first part of the questionnaire contained demographic features that were measured by using a 5-points Likert scale. AMOS and SPSS were used to analyze the data.

Hypothesis

$H1_0$: Environmental concern (EC) is a significant predictor of the adoption of EVs.

$H2_0$: Perceived Economic benefit (PEB) is a significant predictor of adoption of EVs.

$H3_0$: Social Influence (SI) is a significant predictor of the adoption of EVs.

$H4_0$: Self-image (IM) is a significant predictor of the adoption of EVs.

$H5_0$: Attitude (ATT) is a significant predictor of the adoption of EVs.

4. DATA ANALYSIS AND INTERPRETATION

Demographic profile reveals that out of 300 respondents 75% were men and the rest 25% were women as far as educational qualification is concerned the majority of respondents are well educated as shown data in Fig1. Fig2 showsage wise distribution of the respondents.

Fig 1. Distribution based on Educational

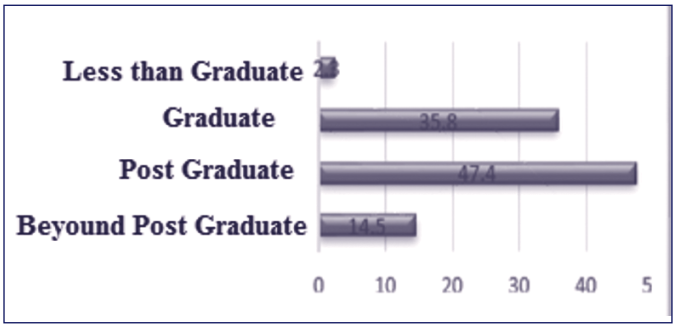
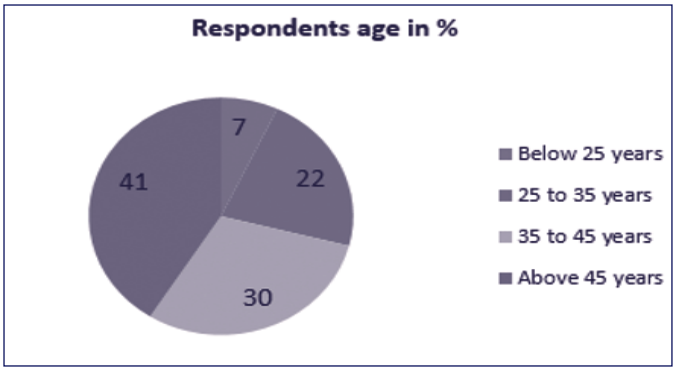


Fig 2. Distribution based on age



Source: Primary Data analysis

Out of the variables involved in the hypothesized model, four (PEB, EC, SI, IM) were measured by using four items for each variable and three items for ATT (Table 2). A 5-point Likert scale has been used with 5 as strongly agree to 1 as strongly disagree. Reliability and validity are quality assessment tools. Reliability is the ability of the scale to produce consistent results. To check the consistency among the items, Cronbach's alpha has been used. To check the validity of the scale average variance (AVE) extracted has been used. Cronbach's alpha value of the variables is above the threshold limit of 0.6 as seen in table 1 and supporting reliability. On the other hand, AVE of the three constructs is below the threshold of 0.5 so validity is reaffirmed by the factor loading.

Table 2: Reliability and Validity

Sr. No.	Construct	No. of Items	Cronbach's Alpha	AVE *
1	PEB	4	0.713	0.387
2	EC	4	0.833	0.547
3	SI	4	0.652	0.334
4	IM	4	0.725	0.445
5	ATT	3	0.884	0.74

*Constructs validity results

In Table2 measured Indicators, factor loading, and construction have been contained. Results show that all the indicators have a value of more than 0.5 and are significant at 0.1 % level of significance.

Table3: Factor Loading

Measured Indicator	Construct	Factor Loading
PEB 1: I am fully aware ofthe economic benefits of EVs.	←PEB	0.711***
PEB 2: Due to government incentives overall owning cost of EVs will be lowered	←PEB	0.6***
PEB 3: The Maintenance cost of EVs will be less.	←PEB	0.566***
PEB 4: Fuel expenses will be saved and running costs should be lower.	←PEB	0.608***
EC 1: By using EVs I want to conserve the environment.	←EC	0.765***
EC 2: I am aware of the environmental benefits of EVs.	←EC	0.61***
EC 3: EVs can help in saving future generations by contributing to the environment	←EC	0.804***
EC 4: Due to increased air pollution I want to adopt EVs.	←EC	0.706***
SI 1: It would be a status symbol for me.	←SI	0.613***
SI 2: Opinions of my Knowns regarding EVs are good	←SI	0.631***
SI 3: If my friends adopt EVs, I would also be more likely to adopt EVs.	← SI	0.465***
SI 4: Reaction of people will be positive if they see EVs on road.	← SI	0.611***
IM 1: My image will be improved with the knowledge of EVs.	← IM	0.647***
IM 2: Evs will be opted by Eco- Friendly people.	← IM	0.45***
IM 3: My personality will be reflected by driving EVs.	←IM	0.741***
IM 4: Driving EVs to suit my style	← IM	0.732***
ATT 1: The use of EVs makes sense.	← ATT	0.877***
ATT 2: The choiceof driving EVs will be a wise decision.	← ATT	0.912***
ATT 3: I want to switch to EVs.	← ATT	0.782***

Structural Model Analysis: All the proposed hypothesis is tested through the structural model's analysis. The results accept H*(IV)* and H*(V)*at P < .05 significance level. Hypotheses H*(II)* and H*(III)*are supported partially as P- values are .07 and .077. Results found PEB as insignificant and P value is above P < .05 rejected H *(I)*.

Table4: Hypothesis Results

Hypothesis	Construct	SRW	Significance	Result
$H1_0$	BI ← PEB	042.-	0.512	NS
$H2_0$	BI ← EC	0161.	0.070	PS
$H3_0$	BI ← SI	0.133	0.077	PS
$H4_0$	BI ← IM	0.252	***	Significant
$H5_0$	BI ← ATT	0.626	***	Significant

Source: Primary Data analysis, where NS (Not significant), PS (Significant), p < .05

CONCLUSION

Electric vehicles are getting popular due to the matured technology, declined cost, more awareness and increased charging opportunities, etc. Various rebates and incentives are also given by central and state governments. Apart from that fuel price is also at its spike. The present study has been conducted to examine the various parameters affecting customer perception regarding EV adoption. The study found no relation between PEB and BI to adopt EVs. EC and SI are significant but partial predictors of BI. At the same time, IM is stable and ATT is a significant predictor of BI. The study suggested that ATT is the major factor affecting customer perception regarding EVs so marketers and manufacturers must consider this factor and try to move it in a positive direction to promote EVs.

REFERENCES

1. *Adhikari, M., Ghimire, L.P., Kim, Y., Aryal, P., Khadka, S. B.(2020). Identification and Analysis of Barriers against Electric Vehicle Use. Sustainability 12(12), 4850.*
2. *Avalagund, N., Mahantshetti, S., Nulkar, G. (2020). Factors influencing purchase intention towards Evehicles among the Potential Indian consumers-A study on Karnataka region. Journal of the Social Sciences 48(3), 1598-1616.*
3. *Bansal, P., Kumar, R.R., Raj, A., Dubey, S., Graham, D.J. (2021). Willingness to Pay and Attitudinal Preferences of Indian Consumers for Electric Vehicles.*
4. *Bhalla, P., Ali, I.S., Nazneen, (2018).A study of consumer perception and purchase intention of electric vehicles. European Journal of Scientific Research 149(4), 362-368.*
5. *Alanazi F.(2023) Electric Vehicles: Benefits, Challenges, and Potential Solutions for Widespread Adaptation. Applied Sciences, 13(10)*
6. *GIZ (2021). Status quo Analysis of Various Segments of Electric Mobility and Low Carbon Passenger Road Transport in India.*

7. *Haider, S.W., Zhuang, G., Ali, S. (2019). Identifying and bridging the attitude-behavior gap in sustainable transportation adoption. Journal of Ambient Intelligence and Humanized Computing 10(9), 3723-3738.*
8. *Jena, R. (2020). An empirical case study on Indian consumers' sentiment towards electric vehicles: A big data analytics approach. Industrial Marketing Management 90, 605-616.*
9. *Johan Jansson, Annika Nordlund, Kerstin Westin (2017). Examining drivers of sustainable consumption: The influence of norms and opinion leadership on electric vehicle adoption in Sweden,Journal of Cleaner Production,Volume 154,176-187.*
10. *Khurana, A., Kumar, V. V. R., & Sidhpuria, M. (2020). A Study on the Adoption of Electric Vehicles in India: The Mediating Role of Attitude. Vision, 24(1), 23–34.*
11. *Khurana, A., Kumar, V.R., Sidhpuria, M. (2020).A Study on the Adoption of Electric Vehicles in India: The Mediating Role of Attitude. Vision 24(1), 23-34.*
12. *Kumar, A., Choudhary, S.K., Chethan, K.N. (2018). Commercial viability of electric vehicles in India. International Journal of Mechanical Engineering and Technology 9(6), 730-745.*
13. *Kumar, A.G., Anmol, M., Akhil, V.S (2015), A strategy to Enhance electric vehicle penetration level in India. Procedia Technology 21, 552-559*
14. *Kumar, R., Jha, A., Damodaran, A., Bangwal, D., Dwivedi, A(2020): Addressing the challenges to electric vehicle adoption via sharing economy: an Indian perspective. Management of Environmental Quality,32(1), 82- 99.*
15. *Mishra,S., Rout,P., Kumar,S. (2022). International Research Journal of Modernization in Engineering Technology and Science, Analyzing the Sustainability Of E-Rickshaws in Indian Cities.*
16. *Motwani, D.B., Patil, A. (2019).Customer Buying Intention towards Electric Vehicle in India. International Journal of Mechanical Engineering and Technology 10(5), 391-398.*
17. *Mukherjee, S.C., Ryan, L. (2020). Factors influencing early battery electric vehicle adoption in Ireland. Renewable and Sustainable Energy Reviews 118, 109504*
18. *P,Neupane., B.K.Sharma (2023). Study on factors affecting electric vehicle (EV) purchase in India, Symbiosis Institute of Business Management, International conference on research innovations: Trends in science and technology , Volume: 2954*
19. *Shalender, K., Sharma, N. (2021). Using the extended theory of planned behaviour (TPB) to predict adoption intention of electric vehicles in India. Environment, Development and Sustainability 23(1), 665-681.*
20. *Shankar, A., Kumari, P. (2019).Exploring the enablers and inhibitors of electric vehicle adoption intention from sellers' perspective in India: A view of the dual-factor model. International Journal of Nonprofit and Voluntary Sector Marketing 24(4), e1662*
21. *Shetty, D.K., Shetty, S., Rodrigues, L.R., Naik, N., Maddodi, C.B., Malarout, N., Sooriyaperakasam, N. (2020). Barriers to widespread adoption of plug-in electric vehicles in emerging Asian markets: An analysis of consumer behavioral attitudes and perceptions. Cogent Engineering 7(1).*
22. *Tarei, P.K., Chand, P., Gupta, H. (2021). Barriers to the adoption of electric vehicles: Evidence from India. Journal of Cleaner Production.*

DISCLAIMER

(Forgery of Documents)

It has come to my notice that some agencies or individuals are publishing papers online under the title of "Industrial Engineering Journal" in a Clandestine way and are also issuing certificates of publication of papers with the forged signatures and stamp of the undersigned. This is to bring to the notice of all concerned that the Indian Institution of Industrial Engineering is the sole proprietor of IE Journal and does not issue/offer any certificate to authors for publishing his/her paper in the Industrial Engineering Journal. Also, Industrial Engineering Journal does not publish online papers. All are advised to be cautious of this unscrupulous practice. The IIIE National Headquarters or the undersigned do not take any responsibility for the fake publication and issue of the certificate.

Sd/-
Editor-in-chief
Industrial Engineering Journal
IIIE National Headquarters
Navi Mumbai