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A Study on The Faster Adoption of Electric Vehicle Transportation Model in India-Intermediate Role of Motivation (Willingness)

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Abstract: The vision of NEMMP 2020 implemented in 2013 endeavours to control GHG emission as resolution passed in the UN climate change pact and to become an energy independent nation by converting India's transportation model in clean & green energy-based vehicles and E-vehicles represent the effective pathway for its success.
To evaluate e-mobility on Indian roads as an effective environment friendly medium, the present study analyses in-depth various techno-socio-economic-infrastructural-environmental-reward factors responsible to motivate people to switch to Electric vehicle. The study is based on primary data collected from the 300 residents approx. of Panvel region of Maharashtra through a structured questionnaire. The paper clearly presents a model using structural Equation Modelling using IBM SPSS AMOS 26 software. The significant influence of various factors is divided into five categories on the willingness of Indian people for fast adoption of E-Vehicle transportation model. The result of the analysis depicts high influence of social, economic, technological, environmental and Govt policy factors on the willingness to switch to EVs. The study also suggests meaningful points for the faster pace of EV adoption by Indian people to fulfil the mission of 30% electrification of vehicles on Indian roads by 2030.

Key Words: E-vehicle, fuel efficiency, energy, fossil fuel, sustainability, infrastructure

1. INTRODUCTION

Dependence on conventional source of energy resources is not a sustainable in terms of economic wellbeing and environment cleanliness. India is importing 80% of crude oil to fulfil the domestic requirement which not only creates additional financial burden on the economy but also increases environmental degradation. Govt of Indian is promoting e-vehicle mobility nearly in all auto segments as a wise solution for both the challenges. Niti Aayog has planned to achieve 70% of EV sales penetration nearly in all the segments of vehicles. The rapid pace of developing global electric vehicle market accounts for 8.3% of a global market share including all types of e-vehicles battery electric vehicles (BEVs) and Plug-in hybrid electric vehicles (PHEVs) at 6.75 million vehicles on road as compared to 4.2% in 2020. This is indeed an exponential increase of 108%. EVs are gaining importance worldwide as they are eco-friendly and ensure zero emission of CO_2. The Indian EV market is also evolving fast since 0.32 million e-vehicles were sold in 2021 upto 168% y-o-y. This e-vehicle adoption in India was launched after the Paris agreement to reduce carbon emissions to purify the air in urban area and to reduce oil imports. Govt of India is quite active in launching various programmes and policies for faster adoption of E-mobility transportation model on Indian roads. Faster Adoption of Manufacturing of (Hybrid) and Electric Vehicles (FAME), Production Linked Incentive for Advanced Chemistry Cell Battery Storage (PLI-ACC) to boost India's battery infrastructure for E-mobility, Battery Swapping Policy valid till March 31, 2025, Tax exemption up to 1,50,000 under 80EEB of Income tax on EV purchase on loan, reduced customs duty on nickel ore (key component of lithium-ion battery) and state wise reduction of road tax and other incentives etc are meaningful initiatives taken by Govt of India so far.

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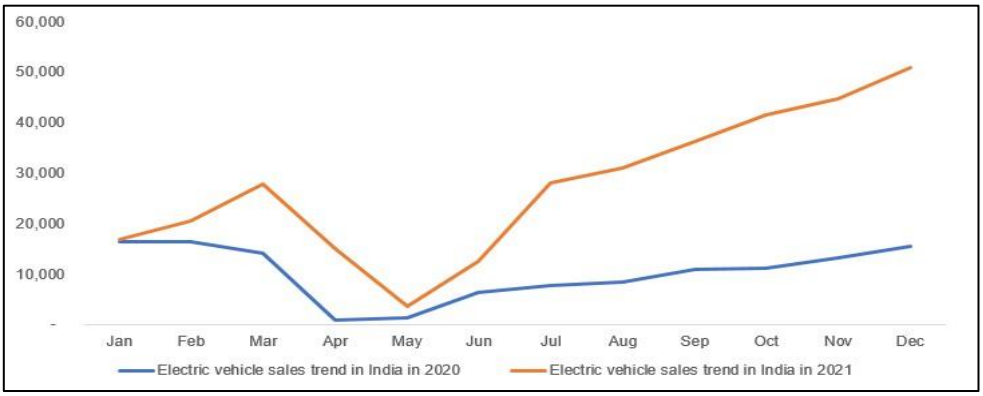
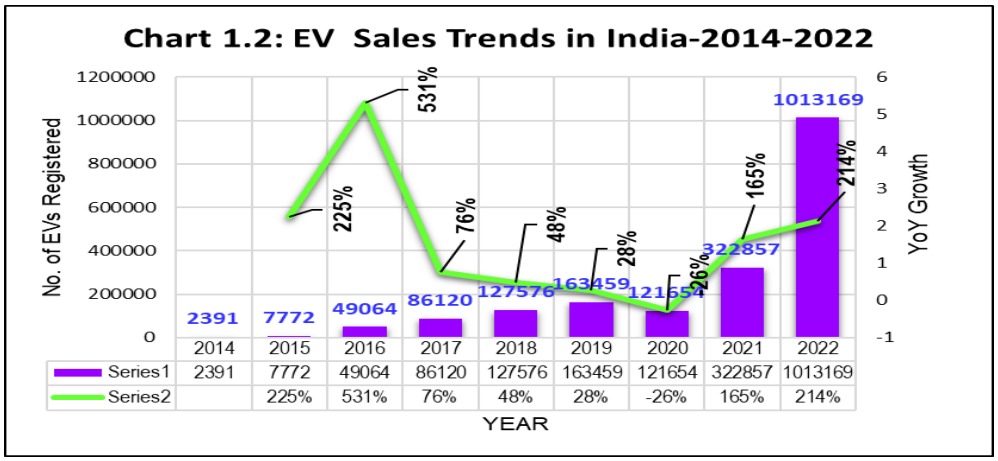
Chart 1.1 Electric vehicle Sales Trends in India



Source: India Brand Equity Foundation

The chart 1.1 depicts trends in electric vehicle sales in 2020 and 2021 in India. Govt of India aims to achieve 100% e-vehicles on Indian roads.



Source: Graph created by the researcher from Vahan Dashboard
Note: Data obtained from 1341 out of 1428 RTOs in 34 of 36 States and UTs.

Above chart 1.2 shows year on year growth in sales of E-vehicles including all the segments of Indian automobile Industry. It is clearly evident that right from year 2015 EV sales has been increasing but came down in 2017, 2018, 2019 and almost negative sales in COVID year 2020 but started increasing in 2021 and 2022 and continued to be increasing.

2. REVIEW OF LITERATURE

There are a considerate number of research which have focused on the identification of favourable and unfavourable factors playing important role in the EV adoption by the customers. These factors broadly fall into various categories like social effectiveness, infrastructural effectiveness, economic effectiveness, technological effectiveness, and environmental safety related effectiveness. A comprehensive literature review was done to arrive at significant gap areas to be incorporated in the proposed study Various research has already been done on the about parameters. The review of literature is divided factor wise for the current study.

Social effectiveness defines influence of neighbours, cultural trends, family and friends in decision and self-status etc. Axsen, Orelebar and Skippon (2013) [1] analysed influence of social attributes on the purchase decision and promotion of EVs. Axsen et al.[2] studied impact of social influence on customer perception of EVs in UK by dividing them into translation, reflexivity, and diffusion. Rasouli and Timmermans (2016) [3] also validate the social influence on EV adoption.

A greater extent the linkages of social-cognitive perceptions-attitude intention with the moderation of socio demographic variables and mediation of attitude towards BEV was found by Deepak J. et al. (2022).[4]

Anders F.J. et. al. (2017) [5] used real electric vehicle trip data to study the distribution of daily use and types of home-based journeys using e-vehicles instead of conventional vehicles. The result outcome indicates that EV alternative is mostly used for well-planned transport and EV use differs in households with two-wheeler their main means of transport.

Incentives by govt to buy EVs, pocket friendly policy for easier operation of EVs, affordable pricing of EVs, cost effective after sales services are some of the attributes which define the economic effectiveness of EVs. Benefits of Hybrid vehicle in USA were analysed by Beresteanu and Li (2011).[6] The inference drawn is that income tax incentives had caused an increase in the market share of HEV. A study on the comparative energy costs in small EVs was done by Wang and Gonzalez (2013).[7]

Looking at direst effects of GHG emission, increasing global warming and environmental degradation continuously due to fuel-based ICE in automobiles, there is a worldwide concern for safety of the environment for the sustainable development of the world. The road transport vehicles are main contributor in the above concern. Digalwar et al.[8] used interpretative structural modelling (ISM) approach for prioritizing factors which are barriers to deployment of EVs in India. The research outcome reveals lack of awareness and passivity of government in the success of EV transportation model in India and these must be resolved fast. The other hinderances found were slow industrial growth, lack of suppliers, poor customer management and battery technology have high dependence and will be eliminated if other hinderances are cleared.

Various studies on the demand side of EVs focused on the various forms of preference analysis of EVs. Beggs et al., (1981) and Calfee (1985) [9] studied preference for EVs based on driving and demographic features. The outcome indicated low market share and range anxiety due to lack of infrastructure as the main bottlenecks for the customers to choose EVs. The study also found out a greater preference heterogeneity in EV modal choices.

A pool of studies in early 1990s were done in response to California's zero emission vehicle mandate. Bunch et al. (1993)[10], Brownstone et al. (1996, 2000)[11] and Train (1999),[12] Tompkins et al. (1998),[13] Ewing and Sarigollu (2000),[14] and Dagvisiki et al. (2002)[15] etc tried to present prediction about the potential demand for EVs in California and outside California. These studies focused on entire population unlike only car users as shown in earlier studies. Secondly, they also included an attribute of emission level as standard vehicle attribute. Thirdly these studies included other vehicle technologies like concentrated natural gas, methanol and ethanol and hybrid electric etc as an alternative for conventional gasoline vehicles. These studies were done through customised survey to enhance the relevance of the research and arrived at an outcome that EVs have low market penetration due to limited driving range, longer time in charging, expensive models etc were main concerns for the customers. The studies also revealed about the willingness to pay a significant amount to reduce emission and save on gas.

The study by Deepak J., Arun D and Park Thaichon, (2022)[16] studied willingness of car users to adopt EVs. Here in this research motivation has been defined as willingness to adopt EVs. Three different sets of young consumer groups identified and labelled as conservatives, indifferents and enthusiasts are deemed to be buddying EV buyers.

Khurana K. et.al. (2019)[17] examined various factors affecting adoption of electric vehicles using structural equational modelling. The study has found role of attitude as strong mediator influencing people's willingness to adopt e-vehicle transportation model.

Liu R., Ding Z., Jiang X et al. (2020)[18] analysed the influencing factors of EVs. The adoption willingness is positively influenced by experience through direct and indirect paths which confirm the significant mediating effects of subjective norm, perceived behavioural control and attitude, cruising range, low poise and low emission.

Zhang Xingping et. al. (2017)[19] analysed China Govt policies on E-vehicles duly divided into three categories; finance policy, infrastructure promotion and research and development investment and also presented comparative study on the defects of EV policy mechanism in other countries.

The present survey-based research pursues its analysis directly on the attributes found in this research but on the respondents in different geographical location and by using a method that focuses on respondents' choice for EV attributes to show relationship and association among various EV effectiveness attributes and willingness to switch to EVs and finally make a rational purchase decision.

3. RESEARCH OBJECTIVES

The adoption of E-vehicle transportation model is need of the hour looking at environmental degradation in the world. Though state govt and central govt of India have taken meaningful measures to encourage people to accept EVs in their lifestyle but how far success is being achieved is really not known. So, the main (general) objective of this research study is to investigate the influence of various EV effectiveness factors on the willingness of people to decide to purchase E-vehicles. The objectives of the study are:

a. To study influence of social effectiveness factors on the willingness of the people to adopt E-vehicles
b. To study influence of infrastructural effectiveness factors on the willingness of the people to adopt E-vehicles
c. To study influence of EV specific technological effectiveness factors on the willingness of the people to adopt E-vehicles
d. To study influence of environmental protection effectiveness factors on the willingness of the people to adopt E-vehicles
e. To study influence of economic effectiveness factors on the willingness of the people to adopt E-vehicles
f. To analyse the interrelationship among all the five set of factors to enhance willingness for EV adoption.
g. To analyse impact of willingness to adopt EVs on the purchase decision of EV.

4. RESEARCH METHODOLOGY

Based on the literature review, this research paper tries to solve the following problems:

1. Characteristics of consumers of EVs in Panvel region of Maharashtra.
2. Factors influencing consumer's willingness (motivation) to switch to EVs.
3. Factors more likely influencing their EV purchase decision and to accept EV transportation model on Indian roads.

The research tries to find out valid outcomes through both the sources of information primary as well as secondary. Secondary sources of data like various Govt reports on policy and measures on E-vehicle, UN report on Environment protection and role play of all the member countries, past studies on E-vehicles, Automobile reports of various automobile companies, report by SIAM and ACMA especially of the progress and development of electric vehicles were referred to arrive at useful results and recommendations. The research has total 7 variables (one dependent variable, 5 independent variables and one mediating variable). Based on these variables, there were 7 constructs; five were independent, one mediating and one dependent. The questionnaire had 26 items measuring the input variables and 3+3=6 items measuring output variables. The item measured was purchase decision (PD) of EV by the people.

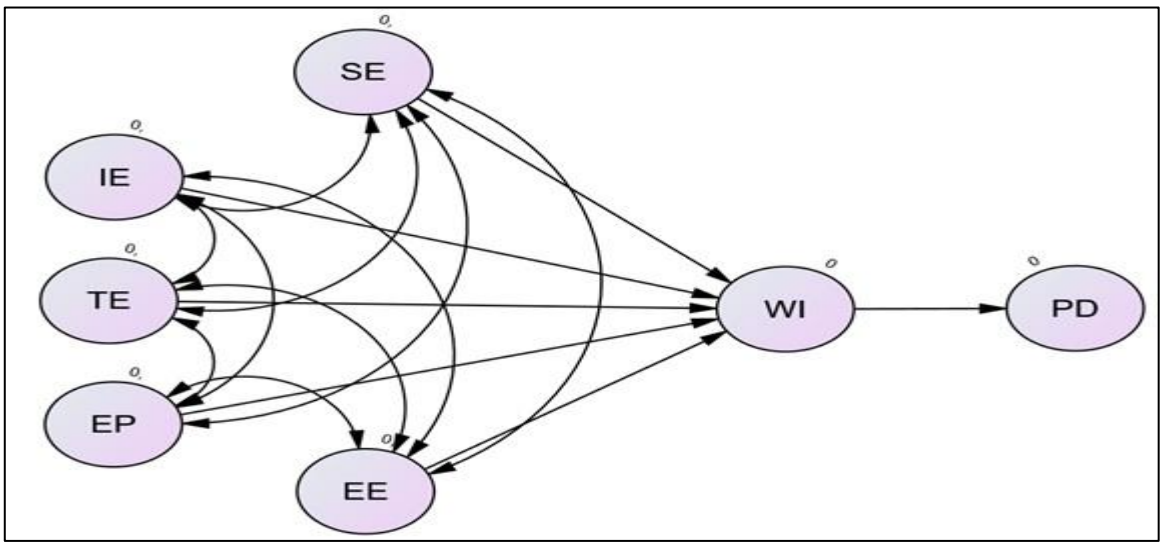
Formulation of Hypotheses

Maharashtra has been one of the first states in the country which designed and notify EV policy and this EV policy provided many financial and non-financial benefits to encourage manufacturing and adoption of EVs in various parts of Maharashtra, but penetration of Battery based electric vehicles is seen very low in different parts of the state despite the support provided to people by FAME India Scheme and State EV policy. The result is seen in the form of many bottlenecks like high purchase price of EVs, lack of variety of EV models comparable to ICE vehicles, non-availability of ample battery charging stations, lack of awareness about EVs or their benefits. For the above reasons, the present research was conducted in the Panvel region of Maharashtra. This research is empirical research based on primary data collected through a structured questionnaire. For a reliable analysis based on the review of literature, following seven alternate hypotheses are formulated to understand the effectiveness or feasibility of Electric vehicle transportation model in the sub-urban city of Panvel in Maharashtra:

H1: Social effectiveness (SE) significantly influences consumer's willingness (WI) to adopt Electric vehicle.
H2: Infrastructural effectiveness (IE) significantly influences consumer's willingness (WI) to adopt Electric vehicle.
H3: EV specific technological effectiveness (TP) significantly influences consumer's willingness (WI) to adopt Electric vehicle.

H4: Environmental protection effectiveness (EP) significantly influences consumer's willingness (WI) to adopt Electric vehicle.
H5: Economic effectiveness (EE) significantly influences consumer's willingness (WI) to adopt Electric vehicle.
H6: There is a significant interrelationship among all 5 - SE, IE, TE, EP and EE to boost willingness for EV adoption.
H7: Willingness (WI) to EV adoption mediates consumer's purchase decision (PD) of electric vehicle.
Based on the hypotheses formulated given above, the proposed model of the study is as follows:

Figure: 4.1 Proposed Model for Willingness to Adopt EVs and Purchase decision



Source: Created by the author from the results of data collection & tabulation
Note: Where- SE- Social effectiveness; IE- Infrastructural Effectiveness; TE- Technological Effectiveness; EP- Environmental Protection; EE- Economic Effectiveness; WI- Willingness; PD-Purchase Decision

The data collection instrument (questionnaire) had ample information about various constructs and their constituent indicators describing on the scenario and status of E-vehicle transportation model progress in Panvel region. The information in the questionnaire was divided into two parts: Part 1 contained information about study model variables specific to PD of E-vehicle and Part 2 focused on demographic information of the respondents.

Sampling method and Size

'Structural Equational modelling lacks a defined formula to determine appropriate sample size. Various sample sizes have been suggested by different researchers and authors like 100 or 200 (Boomsma, 1985), 5 or 10 observations per estimated parameter (Bentler and Chou, 1987; Bollen 1989) and 10 cases per variable (Nunnally, 1967) as different thumb rules.' (Khurana et.al). Glenn (1992) presented two tables for selection of samples size for precision from Population size 500 to 100,000 and recommended at least 222 responses precisely for 500 population size in management research at confidence level 95% and P=0.05. The present study analyses 222 valid responses collected through structured questionnaire-based survey using random sampling method after approaching 479 people especially existing four-wheeler and two-wheeler users from the age group 25 and above residing in Panvel region of Maharashtra for more than last four years. The survey was administered in the month of September 2022 and continued till first week of October 2022. A careful analysis of the responses shows that there was no missing data and all 222 were valid responses.

Measurement tools and techniques used

Various measurement tools and techniques have been used to analyse the data in valid manner to arrive at reliable research outcome. The descriptive statistics (a major component of almost all quantitative data analysis) has been calculated using Minitab to provide basic information about variables and to highlight potential relationships between variables used in this study. For the reliability and validity of various hypotheses; chi square test has been calculated. For the confirmatory factor analysis, Structural Equational Modelling has been done using IBM SPSS AMOS 26 graphics. SEM is a collection of statistical techniques that allow a set of relationship between one or more independent variables either continuous or discrete and more dependent variables either continuous or discrete to be examined. Both independent and dependent

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variables can be either factors or measured variables (Jodie B. Ullman PhD, Peter et.al (2012). Both the components of SEM-measurement model and structural model were constructed. Firstly, SEM validates the measurement model and secondly, it measures the extent of direction of the relationship among various variables. SEM is a structure of equations and can handle several relationships in a single analysis.

5. ANALYSIS AND INTERPRETATION OF DATA

The final part of the present research is analysis and interpretation of data collected from 222 respondents especially car users residing in Panvel region of Maharashtra for last four years. Both analysis and interpretation of data is the most important part of any research. Data analysis helps a researcher in categorising, manipulating and summarizing data using various statistical tools to answer critical questions of the research problem. Data interpretation stands for the process of reviewing data and arriving at the relevant conclusions using various analytical methods. In the present study, Data analysis and interpretation presents identification and explanation of data; comparison and contrast of data, identification of data outliers and future predictions about the research problem undertaken. The analysis of the data has been presented under 5 parts: Part A presents demographic analysis of the respondents; Part B presents descriptive statistics analysis of the respondents; Part C presents reliability and validity testing of 7 hypotheses formulated; Part D presents construct development and measurement or various E-vehicle influencing factor analysis using Structural Equation model and finally Part E presents results of Hypotheses testing whether accepted or rejected. Each part is given below in detail:

A. Demographic Analysis

Chart 5.1 & 5.2: Awareness about E-Vehicle

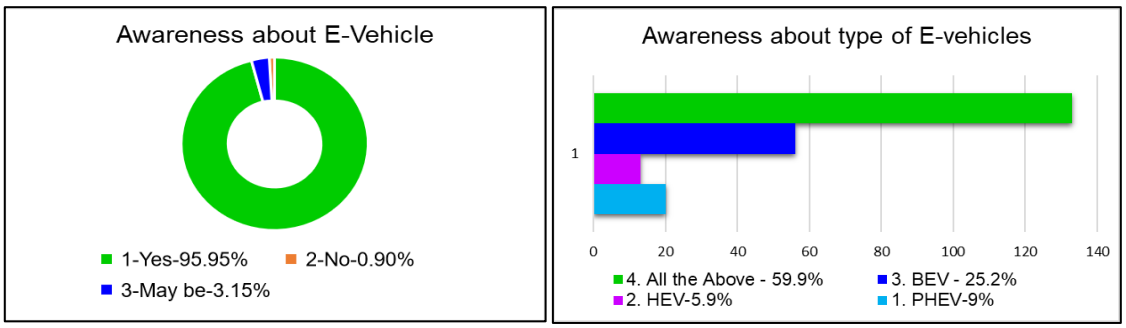

Chart 5.3 & 5.4: Awareness about E-Vehicle charging stations

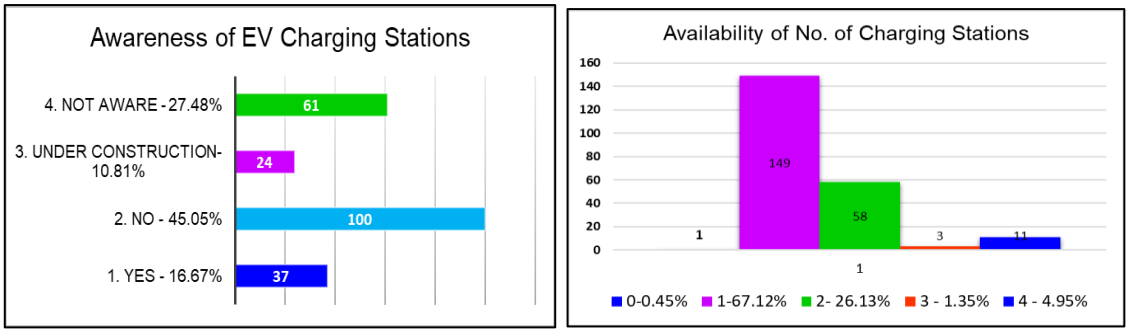

Chart 5.5 & 5.6: Awareness and need about E-Vehicle

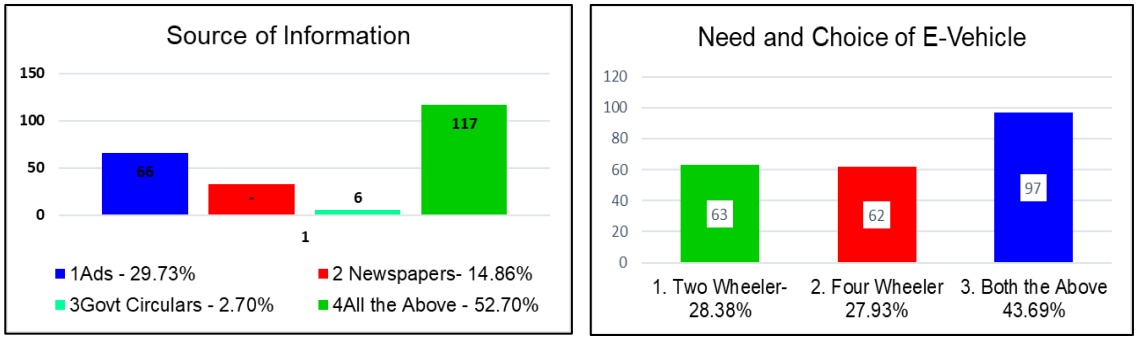

Chart 5.7 & 5.8: Willingness for E-Vehicle adoption

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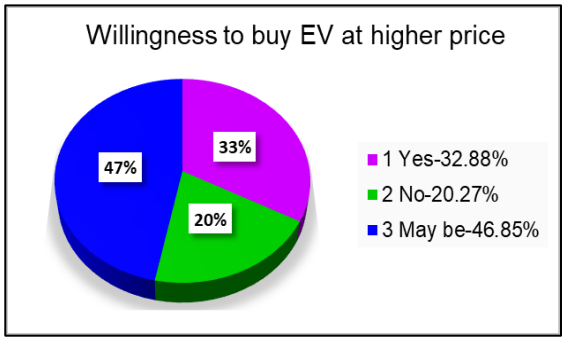


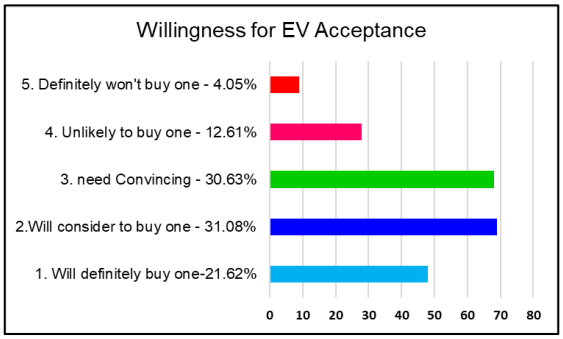
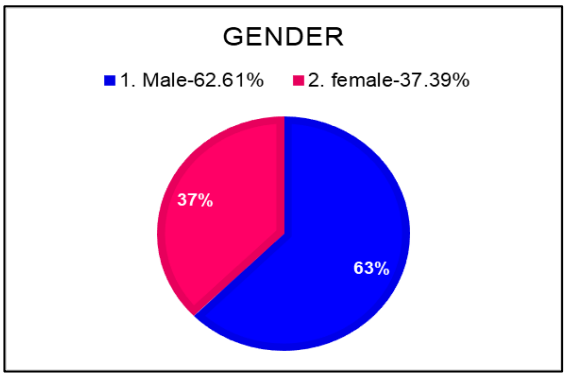


Chart 5.9 & 5.10: Choice of E-vehicles based on Demographic details (Gender & Age)



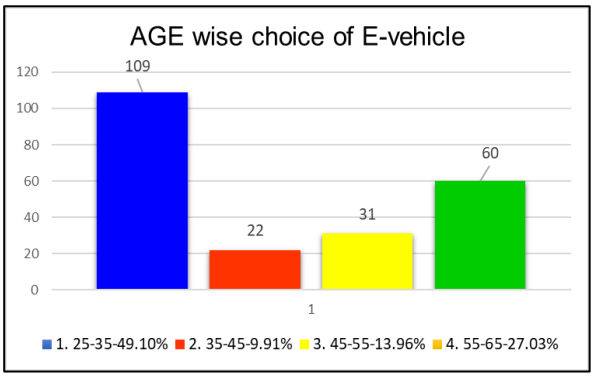
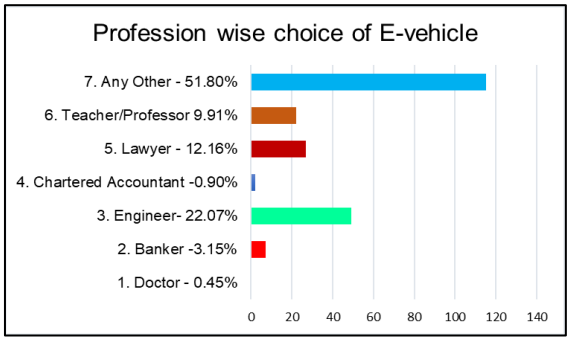


Chart 5.11 & 5.12: Choice of E-vehicles based on Demographic details of the consumers



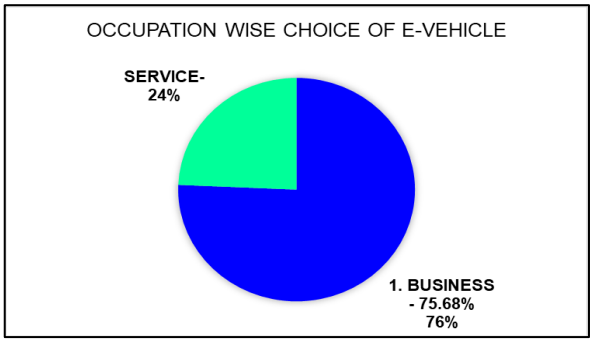


Chart 5.13: Choice of E-vehicles based on Annual Income

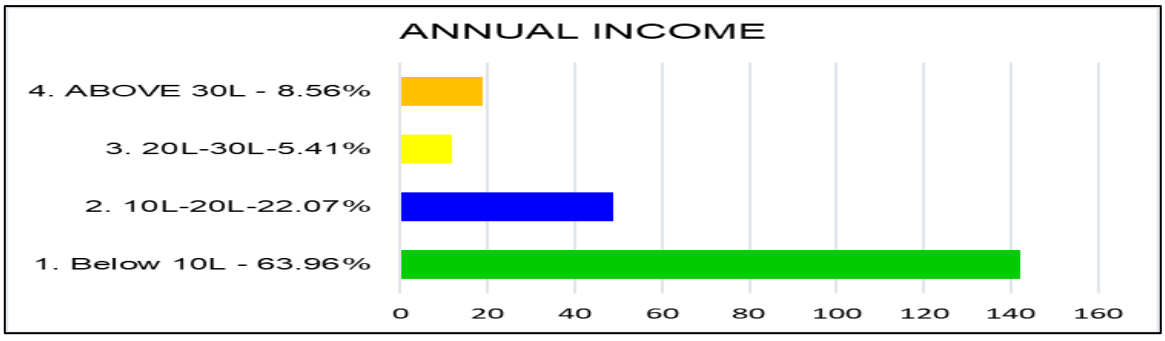


Chart 5.14 & 5.15: Choice of E-vehicles based on Annual Income

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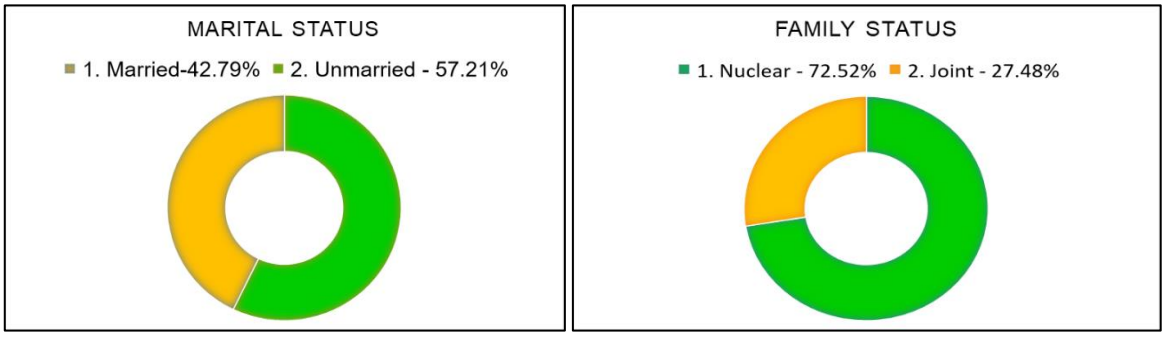

Source: Created by the author from the data collected and tabulated

Interpretation: Charts 5.1 & 5.2 depict awareness of respondents about E-vehicles and their different types available. Chart 5.1 clearly shows 95.95% consumers are quite aware about e-vehicle and 59.9% respondents as shown in chart 5.2 have knowledge about various categories of E-vehicles.

Charts 5.3 & 5.4 depict awareness level of people about the EV charging stations as EVs are non-fuel based and need electric energy for mobility. 40.05% respondents are not aware of EV charging stations and only 16.67% are aware of that e-vehicle need a charging point for mobility. This is inferred here that there is a serious need to spread awareness about EV charging points. As depicted in Chart, 67.12% respondents know that there is only one charging station in Panvel region; 26.13% people know availability of 2 charging stations; 1% people say availability of 3 and 5% people confirm availability of 4 charging stations. It is inferred from these charts that there is a great need of public charging points at reachable locations. These varied responses clearly show that in some areas, only one charging station is within the reach of public and others are available at home or in the area reachable by few people.

Chart 5.5 clearly depicts that 52.70% respondents use all the three sources of information about e-vehicles i.e. advertisement, newspapers and govt circulars. This also reveals that respondents are educated and alert and are quite curious to gather information about latest trends in the market using all these important portals of information. Chart 5.6 shows the need and choice of e-vehicle in different segments. 28.38% need e-two-wheeler, 27.93% need an e-car and 43.69% need both the vehicles. This indicates that the need for e-vehicle under all the segments will create a greater demand for EVs.

Charts 5.7 & 5.8 map the willingness of the people to purchase e-vehicle at higher price compared to ICE vehicles. Only 32.9% respondents are ready to buy at higher price but 20.3% are not willing to pay higher price. The critical information is that 46.85% are not clear about their willingness to buy high priced e-vehicles. This is inferred that Govt must introduce variety of e-vehicle modals supporting affordability of the people in developing countries. The main reason of this unwillingness is the low per capita income in India as compared to developing countries. Chart 5.8 records responses about willingness to accept EVs in next two years by purchasing. 21.62% are definite in their decision to purchase; 31.08% will consider buying but 30.63% need to be motivated by more points to convince their minds. Respondents who are unwilling are 12.8% and 4%. The reason may be their income not supporting purchase of higher priced vehicle.

Gender wise 62.61% male and 37.39% females are the respondents in Chart 5.9. Age wise analysis in chart 5.10 says maximum respondents-49.10% are in the age group between 25-35 years and 27% are in the age group of 55 to 65 years old.

In chart 5.11, Profession wise we see that 51.80% respondents are from other than teachers, lawyers, CAs, Engineers, Bankers, and doctors. It is inferred from the chart that 76% respondents are from business world and 24% are from service class.

The chart 5.13 shows that 63.96% respondents are from the income group less than 10 lakhs. 22% respondents are earning above 10 lakhs; 5% are earning above 20 lakh and 9% respondents are earning more than 30 lakhs. Annual income has a great influence on the willingness to purchase EVs as the cost of EVs currently is high as compared to ICE vehicle. The solution is that there is a need for variety of e-vehicle models affordable for the various income groups.

Chart 5.14 depicts results based on marital status, 42.79% respondents are married and 57.21% are working unmarried people. The Chart 5.15 depicts that 72.5% respondents are living in nuclear family and 27% hail from joint family. Vehicle size and space need differ for the consumers living in joint and nuclear family system and thus become a good indicator for the auto manufacturers to design the various e-vehicles as the requirement of the family size.

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B. Descriptive Statistics

Table 5.1: Descriptive Statistics of the Study

Variable	Mean	SE Mean	StDev	Variance	CoefVar	Sum of Squares	Minimum	Maximum	Skewness	Kurtosis
SE1	2.455	0.0621	0.9249	0.8554	37.67	1527	1	5	0.32	-0.32
SE2	2.1937	0.0668	0.9947	0.9895	45.34	1287	1	5	0.66	0.13
SE3	2.2658	0.0681	1.0142	1.0286	44.76	1367	1	5	0.65	0.06
SE4	3.2523	0.082	1.2217	1.4926	37.57	2678	1	5	-0.16	-0.95
SE5	2.4144	0.0599	0.8921	0.7958	36.95	1470	1	5	0.4	0.1
IE1	2.6351	0.0814	1.2135	1.4726	46.05	1867	1	5	0.33	-0.79
IE2	2.3468	0.0652	0.9708	0.9425	41.37	1431	1	5	0.78	0.7
IE3	2.473	0.0684	1.0187	1.0377	41.19	1587	1	5	0.58	0.09
IE4	2.5135	0.0817	1.2173	1.4817	48.43	1730	1	5	0.53	-0.68
IE5	2.4279	0.0667	0.994	0.988	40.94	1527	1	5	0.56	0.14
TE1	2.6036	0.0741	1.1035	1.2177	42.38	1774	1	5	0.18	-0.75
TE2	2.7883	0.068	1.0136	1.0274	36.35	1953	1	5	0.07	-0.41
TE3	2.5315	0.0662	0.987	0.9741	38.99	1638	1	5	0.51	0.09
TE4	2.5225	0.0678	1.0099	1.0199	40.03	1638	1	5	0.51	0.16
TE5	2.2748	0.0616	0.918	0.8427	40.36	1335	1	5	0.56	0.34
TE6	2.2534	0.0644	0.9578	0.9173	42.5	1324	1	5	0.57	0.11
EP1	2.0495	0.0557	0.8306	0.6898	40.52	1085	1	5	0.62	0.74
EP2	1.8559	0.0517	0.771	0.5945	41.55	896	1	5	0.73	0.98
EP3	1.8063	0.0539	0.8035	0.6456	44.48	867	1	5	1.1	2.04
EP4	1.8964	0.0572	0.8525	0.7268	44.95	959	1	5	0.95	1.2
EP5	2.1081	0.0625	0.9306	0.8661	44.15	1178	1	5	0.6	0.03
EE1	2.6126	0.0754	1.1229	1.261	42.98	1794	1	5	0.31	-0.69
EE2	2.6306	0.0725	1.0799	1.1661	41.05	1794	1	5	0.41	-0.29
EE3	2.3153	0.0616	0.9172	0.8413	39.62	1376	1	5	0.68	0.88
EE4	2.3919	0.0692	1.031	1.0629	43.1	1505	1	5	0.53	-0.06
EE5	2.2117	0.065	0.9679	0.9369	43.76	1293	1	5	0.74	0.65
WI1	2.5991	0.0741	1.1039	1.2186	42.47	1769	1	5	0.34	-0.5
WI2	3.0135	0.0727	1.0825	1.1718	35.92	2275	1	5	-0.01	-0.58
WI3	2.4099	0.0595	0.8865	0.786	36.79	1463	1	5	0.43	0.34
PD1	2.455	0.0729	1.0868	1.1812	44.27	1599	1	5	0.38	-0.5
PD2	2.4189	0.0745	1.1095	1.231	45.87	1571	1	5	0.42	-0.57
PD3	2.2973	0.0661	0.9849	0.97	42.87	1386	1	4	0.15	-1.04

Source: Created by the author based on results of data collection and tabulation

C. Reliability & Validity Analysis-Testing of Hypotheses and its Result

Table 5.2: Reliability and Validity of the constructs

Constructs/Factor	Number of Items	Cronbach's Alpha (CB)	Factor Loading	AVE
SE	5	0.67	0.847	0.811
IE	5	0.81	0.744	0.673
TE	6	0.85	0.883	0.835
EP	5	0.88	0.89	0.84
EE	5	0.84	0.88	0.832
WI	3	0.77	0.821	0.738
PD	3	0.53	0.591	0.516
Overall	**32**	**0.92**	**---**	**0.663**

Source: Created by the authors based on results of data collection and tabulation

Note: SE- Social Effectiveness; IE- Infrastructural Effectiveness; TE-Technological Effectiveness; EP- Environment Protection Effectiveness; EE- Economic Effectiveness; WI-Willingness; PD- Purchase Decision; AVE- Average Variance extracted.

Interpretation: The qualitative assessment of the hypotheses is done through reliability and validity analysis using various statistical tests. Reliability is defined as the scale to produce consistent results and validity is defined as an ability of the scale to produce accurate results. The present research employs Cronbach's alpha to test the internal consistency among items of the construct and Average Variance extracted (AVE) confirms the validity of the scales measuring the constructs of the hypothesised model. Value above 0.6 is the good fit limit of Cronbach alpha test and Table above shows CB value above 0.6 except purchase decision (PD). It confirms the reliability of SE, IE, TE, EP, EE and WI. Overall CB is 0.92 and

this is an excellent value to prove the reliability of all the constructs. AVE greater than 0.5 is recommended for the good fit of validity (Fornell and Larcker, 1981). In the above table All AVE values of all 7 constructs are greater than 0.5 and overall AVE also 0.663 thus confirm the validity. Finally factor loading is an essential indicator of construct validity. It is significant above 0.5 for confirming validity of the constructs. In the above table, column 4 shows factor loading values of all the 7 constructs above 0.5 and thus confirms validity of the constructs.

Table 5.3: Chi Square Analysis for reliability and validity

Variables	Factors	Measured Indicators	Chi Square	P Value
Set 1 Social Effectiveness for willingness to adopt EV	SE1	Knowledge of EVs	114.126	0.0000
	SE2	convinience of charging stations	100.207	0.0000
	SE3	Education	96.1982	0.0000
	SE4	Affordable Purchase Price of EVs	23.1802	0.0000
	SE5	Variety of E-vehicle modals	133	0.0000
			466.7114	**0.0000**
Set 2 Infrastructural Effectivenss for willingness to adopt EV	IE1	Increase in EV charging points	29.982	0.0000
	IE2	Convinience to recharge at home	130.117	0.0000
	IE3	convinience to recharge at workplace	98.0901	0.0000
	IE4	Convinience to recharge at highways	46.1081	0.0000
	IE5	better range of Evs due to improved technology	103.586	0.0000
			407.8832	**0.0000**
Set 3 EV Specific Infrastructural Effectiveness for willingness to adopt EV	TE1	No diriving distance coverage anxiety	50.1171	0.0000
	TE2	less time for recharging	82.6396	0.0000
	TE3	better modals with sufficient space	106.288	0.0000
	TE4	Good Battery Life	103.45	0.0000
	TE5	enhanced safety due to imporoved technology	126.784	0.0000
	TE6	increasing sensitivity for pollution free	108.45	0.0000
			577.7287	**0.0000**
Set 4 Environment Protection Effectiveness for willingness to adopt EV	EP1	No GHG emission	343.802	0.0000
	EP2	No Noise Pollution	191.883	0.0000
	EP3	No Air Pollution	304.599	0.0000
	EP4	Assurance for Safety of Environement	263.121	0.0000
	EP5	Control on wastage of Natural resources	224.585	0.0000
			265.598	**0.0000**
Set 5 Economic Effectiveness for willingness to adopt EVs	EE1	User friendly Purchase cost	136.345	0.0000
	EE2	Cost effective battery life	186.497	0.0000
	EE3	Reduced recharging cost	347.109	0.0000
	EE4	Affordable vehicle maintenance	195.205	0.0000
	EE5	Incentives by Govt to switch to Evs	256.668	0.0000
			224.365	**0.0000**
WILLINNESS FOR E-VEHICLE ACCEPTANCE	WI1	Willingness due to increased affordability	58.7658	0.0000
	WI2	Willingness due to Strong urge for Environment Protection	56.6937	0.0000
	WI3	Willingness to promote EVs	139.982	0.0000
			255.4415	**0.0000**
PURCHASE DECISION OF E-VEHICLE	PD1	decide to purchase within six months	154.459	0.0000
	PD2	decide to purchase within a year	127.609	0.0000
	PD3	decide to purcahse within 2 years	92.4	0.0000
			124.823	**0.0000**

Source: Created by the author from Data collection and tabulation table

Interpretation: The chi-square test value as displayed in the Table is represented by P-value. P-value less than 0.05 and CI 95% and above affirm the reliability and validity of alternate hypotheses. The P-value of all the constructs is less than 0.05 and total Chi-square value is observed 1219.18 so all alternate hypotheses are reliable and valid for the analysis.

D. Construct Development and Measurement through SEM

The current research study has employed SEM to analyse the interrelationship among five exogenous variables, one endogenous variable and one intermediate variable. The five exogenous variables are SE (Social Effectiveness), IE (Infrastructural Effectiveness), TE (EV specific technological effectiveness), EP (Environmental protection effectiveness) and EE (Economic effectiveness). These four independent variables (SE, EP, TE and EE) are measured by 5 items each and one independent variable (TE) is measured by 6 items. Three items measure endogenous variable (PD) purchase Decision of EV and intermediate variable is (WI) willingness of EV adoption as a key to arrive at purchase decision of EVs and measured by three items. SEM is a twostep validation process. Both measurement and validation has been done for confirmatory factor analysis and validation of the inferences using SEM.

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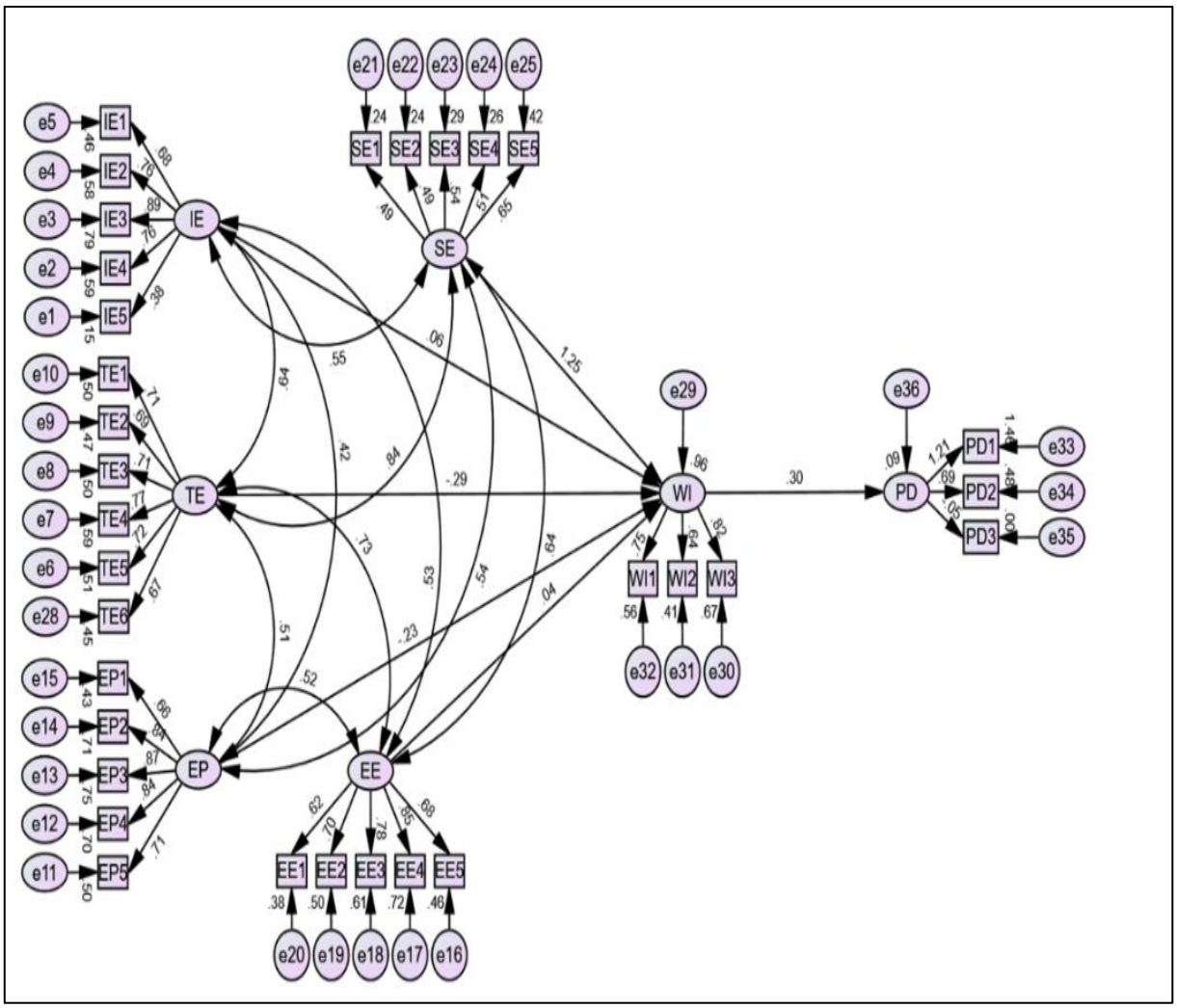
Figure 5.1: Structural Equation Model for Confirmatory Factor Analysis and Results of Association among various factors



Source: Created by the author based on results of data collection and tabulation

Note: SE- Social Effectiveness; IE- Infrastructural Effectiveness; TE-Technological Effectiveness; EP- Environment Protection Effectiveness; EE- Economic Effectiveness; PC- Positively Correlated.

Table 5.4: Fitness Indices- Confirmatory Factor Analysis

FIT INDICES	RECOMMENDED	OBSERVED	RESULT
P-VALUE	Less than 0.05	***	Significant
CMIN/DF (Minimus discrepancy as indexed Chi-square	Less than 5	2.721	Acceptable Fit
CFI (Comparative Fit Index)	More than 0.9 good fit. 0.8-0.9 borderline fit	0.799	Borderline Fit
GFI (Goodness Fit Index)	0.9 and above is the best		Missed
PNFI (Parsimonius Normal FIT)	More than 0.5	0.612	Acceptable FIT
RMSEA (Root Mean Square Error of Approximation	Less than 0.08 for adequate Fit. 0.08-0.1 for acceptable FIT	0.088	Acceptable FIT

Source: Created by the author based on results of data collection and tabulation

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E. Result of Hypotheses Testing

Table 5.5: Result of Hypotheses Testing

Hypotheses Number	CONSTRUCT	SRW	P-VALUE	Result
1	WI<---SE	1.255	***	Significant
2	WI<---IE	0.064	0.534	NS
3	WI<---TE	-0.288	0.299	NS
4	WI<---EP	-0.228	0.026	Significant
5	WI<---EE	0.04	0.75	NS
7	PD<---WI	0.302	***	Significant

Source: Created by the author based on results of data collection and tabulation
Note: SRW- Standardised Regression Weights; NS- Not Significant

Interpretation: The results of various hypotheses indicate that H2, H3 and H5 show non-significance of impact of IE, TE and EE on the willingness to adopt EVs. Three hypotheses H1, H4 and H7 show significant relationship between independent and dependent variables. H7 is very important here as it shows that willingness of car users for EV adoption is crucial to convert it into a purchase decision of E-vehicle.

Table 5.6: (Result of Hypothesis 6) Correlation among all the variable

FACTORS			Covariance (Estimate)	S.E.	C.R.	P	Correlation (Estimate)	Result
SE	<-->	IE	0.094	0.025	3.709	***	0.545	PC
SE	<-->	TE	0.248	0.045	5.472	***	0.836	PC
SE	<-->	EP	0.162	0.035	4.586	***	0.544	PC
SE	<-->	EE	0.19	0.039	4.868	***	0.642	PC
IE	<-->	TE	0.158	0.036	4.361	***	0.635	PC
IE	<-->	EP	0.105	0.028	3.776	***	0.421	PC
IE	<-->	EE	0.131	0.032	4.069	***	0.527	PC
TE	<-->	EP	0.219	0.041	5.29	***	0.508	PC
TE	<-->	EE	0.313	0.05	6.26	***	0.728	PC
EP	<-->	EE	0.222	0.042	5.259	***	0.516	PC

Source: Created by the author's based on results of data collection and tabulation
Note: SE- Social Effectiveness; IE- Infrastructural Effectiveness; TE-Technological Effectiveness; EP- Environment Protection Effectiveness; EE- Economic Effectiveness; PC- Positively Correlated.

Interpretation: Table 5.6 shows the covariance values, p-values and correlation among various independent variables. The P-value is less than 0.05 confirms strong interrelated of 5 independent variables. It is further inferred from correlation values that all SE, IE, TE, EP and EE are positively correlated as all influence one another to boost/dampen the willingness of Panvel residents to adopt EVs and then significantly impacts the purchase decision of EVs among respondents.

6. RECOMMENDATION, IMPLICATIONS LIMITATION OF THE STUDY & FURTHER SCOPE FOR RESEARCH

Willingness to accept EV transportation model is not a guarantee to be converted into purchase decision of E-vehicle as there are constraints of other factors. Panvel Car users can afford a reasonably priced model of the car like variety available in ICE vehicles. So key automobile companies must develop e-vehicle models suitable to the affordability of the car users in Panvel. There is further need for the development of electric vehicle charging stations road side at frequent distance so that distance anxiety and charging anxiety be reduced. Govt must invest in the technology supporting better charging with reduced time. Pricing of EVs must be affordable by the Indian customers. All these recommendations will surely provide clear path of purchase decision of EVs to the consumers.

The research findings emphasize the substantial impact of social, economic, technological, environmental, and government policy factors on the willingness of residents in the Panvel region to adopt electric vehicles (EVs). These results highlight the critical role of comprehensive support systems and incentives to enhance EV adoption rates among the Indian populace. The significant implications suggest that by addressing the identified barriers and leveraging the motivators, India could accelerate its transition towards a sustainable transportation model. This could significantly contribute to the nation's goals of reducing carbon emissions and dependence on imported fossil fuels, aligning with global environmental objectives.

The limitations of the study are as follows: The study could have a greater number of responses to analyse the perception of people towards E-vehicle transportation if a greater number of people filled the questionnaire. The sample size should be greater to arrive at better feasible decisions about EVs as E-mobility revolution is need of the hour due to Environmental safety concern. The study is limited to residents of Panvel region only. "Willingness' does not lead to confirmed purchase decision by the consumers as shown in this study. People are motivated to adopt and accept e-vehicle transportation model but don't ascertain if they would definitely switch to EV.

The study has lot of scope for future research. Future study can focus on other attributes which show positive influence on the purchase decision of e-vehicle. This research has studied 5 covariates (SE, IE, TE, EP & EE). Further studies can examine risk with EVs, experience, income, safety, and scepticism etc. Similar study can be done region wise, zone wise, city wise or state wise (subject to cost of research) under different conditions. This model must be tested with actual EV owners since pollution free environment is very crucial currently and India's mission is to convert at least 50% fuel-based transport mobility into e- mobility. Such studies will be indeed useful for the E-vehicle consumers, automobile manufacturers and E-vehicle planners and policy makers in a country.

7. CONCLUSION

Thus, the study is concluded that Indian EV industry and EV adoption is expanding very slowly with the support by the government initiatives and continuous increase in crude oil prices. Due to these two reasons, people are continuously looking for viable source to control their monthly fuel bills. The EV penetration is too slow as compared to developed countries like US, China, UK etc. A giant leap from ICE vehicles to EVs is in need to have mass expansion of EV supporting infrastructure facilities with higher range vehicles like a greater number of charging stations at various locations in Panvel region. Several initiatives by the central govt and statement govt supporting EV manufacturing and adoption of EVs in the country should help in achieving the target of a 100% EV adoption by 2030.

DECLARATION

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REFERENCES

1. Arie Beresteanu & Shanjun Li, (2011). 'Gasoline Prices, Government Support, And The Demand For Hybrid Vehicles In The United States,' *International Economic Review*, 52(1), 161-182.
2. Axsen, J., Bailey, J., & Castro, M. A. (2015). 'Preference and lifestyle heterogeneity among potential plug-in electric vehicle buyers.' *Energy Economics*, 50, 190–201.
3. Axsen, J., Orlebar, C., & Skippon, S. (2013). 'Social influence and consumer preference formation for pro-environmental technology: The case of a U.K. workplace electric-vehicle study.' *Ecological Economics*, 95, 96–107.
4. Bunch, D.S., Bradley, M., Golob, T.F., Kitamura, R., Occhiuzzo, G.P., (1993). Demand for clean-fuel vehicles in California: a discrete choice stated preference pilot project. *Transportation Research Part A* 27(3), 237–253.
5. Calfee, J.E., (1985). Estimating the demand for electric automobiles using disaggregated probabilistic choice analysis. *Transportation Research B: Methodological* 19 (4), 287–301.

6. David Brownstone, David S. Bunch, Thomas F. Golob, Weiping Ren (1996), A transactions choice model for forecasting demand for alternative-fuel vehicles, Research in Transportation Economics. 4, 87-129. ISSN 0739-8859, https://doi.org/10.1016/S0739-8859(96)80007-2.
7. Deepak J., Arun D., Park T (2022) 'Who will adopt vehicles? Segmenting and exemplifying potential buyer heterogeneity and forthcoming research.' *Journal of Retailing and Consumer Services.* 67, 102969.
8. Deepak J., Vikrant K., Arun D., Rishi K., Padeep K., (2022) 'What drives electric vehicle in emerging markets?' *Journal of Marketing Intelligence and Planning*.
9. Deepak Jaiswal, Vikrant Kaushal, Rishi Kant, Pankaj Kumar Singh, (2021). 'Consumer adoption intention for electric vehicles: Insights and evidence from Indian sustainable transportation.' *Technological Forecasting and Social Change, 123.* 121089, ISSN 0040-1625, https://doi.org/10.1016/j.techfore.2021.121089.
10. Digalwar, Abhijeet & Giridhar, Ganneri. (2015). Interpretive Structural Modeling Approach for Development of Electric Vehicle Market in India. Procedia CIRP. 26. 10.1016/j.procir.2014.07.125.
11. https://www.grandviewresearch.com/industry-analysis/india-electric-vehicle-market-report
12. https://www.ibef.org/blogs/electric-vehicles-market-in-india
13. https://www.iea.org/reports/electric-vehicles
14. IEA, *Electric car registrations and sales share in selected countries, 2016-2021*, IEA, Paris https://www.iea.org/data-and-statistics/charts/electric-car-registrations-and-sales-share-in-selected-countries-2016-2021, IEA. License: CC BY 4.0.
15. International Energy Agency (IEA-2016). Retrieved from https://www.iea.org/reports/electric-vehicles
16. Jensen, A. F., Cherchi, E., & Mabit, S. L. (2013). 'The stability of preferences and attitudes before and after experiencing an electric vehicle.' *Transportation Research Part D: Transport and Environment*, 25, 24–32.
17. Jensen, Anders & Mabit, Stefan. (2017). 'The use of electric vehicles: A case study on adding an electric car to a household.' *Transportation Research Part A: Policy and Practice.* 106. 89-99. 10.1016/j.tra.2017.09.004.
18. Jodie B., Peter M. Structural Equation Modelling. Research Methods in Psychology Vol. 2., 2012.
19. Kenneth Train (1980). 'The potential market for non-gasoline-powered automobiles. Transportation Research Part A: General, 14(5–6), 405-414, ISSN 0191-2607, https://doi.org/10.1016/0191-2607(80)90058-8.
20. 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. https://doi.org/10.1177/0972262919875548
21. Liu, R., Ding, Z., Jiang, X. *et al.* How does experience impact the adoption willingness of battery electric vehicles? The role of psychological factors. *Environ Sci Pollut Res* 27, 25230–25247 (2020). https://doi.org/10.1007/s11356-020-08834-w
22. Rasouli, Soora & Timmermans, Harry. (2013). Influence of Social Networks on Latent Choice of Electric Cars: A Mixed Logit Specification Using Experimental Design Data. Networks and Spatial Economics. 16. 10.1007/s11067-013-9194-6.
23. S Beggs, S Cardell, J Hausman, (1981), Assessing the potential demand for electric cars. Journal of Econometrics, 17(1). 1-19, ISSN 0304-4076, https://doi.org/10.1016/0304-4076(81)90056-7.
24. Wang X., & González J. A. (2013). Assessing feasibility of electric buses in small and medium-sized communities. *International Journal of Sustainable Transportation*, 7(6), 431–448.
25. Zhang, Xingping & Liang, Yanni & Yu, Enhai & Rao, Rao & Xie, Jian, 2017. "Review of electric vehicle policies in China: Content summary and effect analysis," *Renewable and Sustainable Energy Reviews, Elsevier*, vol. 70(C), pages 698-714.