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FACTORS INFLUENCING CONSUMERS ADOPTION OF ELECTRIC VEHICLES IN NCR DELHI REGION: A PLS-SEM MODELING

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Abstract
"Ecological emergencies and energy security concerns have compelled experts to seek a cleaner method of transportation. Vigorous efforts are underway to make electric vehicles (EVs) viable for commercial us in terms of technological advancements and financial feasibility. Despite being one of the leading vehicle manufacturing nations globally, the reception of EVs India has been suboptimal. Recognizing the societal significance and sustainability of EVs is imperative. To address this issue, the current study identifies the factors contributing to the adoption of EVs in NCR Delhi region. Survey of 543 respondents from NCR Delhi region study has identified three factors significantly affecting adoption of EVs in the region. PLS SEM modeling of data the findings may assist in guiding manufacturers and policymakers toward a faster adoption of EVs. This research endeavor will enhance scientists' understanding of the determinants responsible for the sluggish adoption of EVs in India, thereby aiding the Indian government achieving its ambitious goals outlined in the 'Distinction India' Initiative."

Keywords: Descriptive statistics, Electric vehicles, hypo- thesis testing, social factors, structural equation model

Introduction

India, the seventh biggest business vehicle manufacturer in the world, has tremendous potential for a prospering electric vehicles (EVs) market. The worldwide EV industry is in its development stage. It can give work to many individuals in the assembling area, charging framework area, after-deals administration area, Reception of EVs in significant urban communities like New Delhi can cut down the destructive impacts of contamination from broad utilization of ordinary petroleum derivative vehicles (CFFVs), and make huge improvement in the air nature of the area. Picking EVs over CFFVs has its own social benefits also it works on the social way of life and out-look-in this way, centering consideration of the car business on EVs can achieve monetary, social and environ-mental advantages to the residents.

Development of EVs in India

In India, the EV is still in its outset stage comprehending the significance of EVs, the Public authority of India (GoI) is executing different approaches and motivating forces. It has sent off the quicker reception and assembling of (half breed) and electric vehicles (Popularity) India plot under which both the clients as well as the manufacturers are given uniform interest motivations @ INR 10,000 for every kWh for all EVs, with the exception of e-transports and @ INR 20,000 for every kWh for all e-buses2.iAs of now, India has around 750,000 EVs sent on the streets and the number is ceaselessly increasing3.

The producer of EVs and the charging infrastructure ought to remain closely connected. One can't develop without the other. In this way, it is similarly critical to put resources into EV charging framework too. In January 2020, the Branch of Weighty Enterprises (DHI), Service of Weighty Businesses, GoI endorsed 2636 EV charging stations in 62 urban areas across
24 states and Association Regions under the second period of the Notoriety India scheme 4. The capability of EVs to diminish reliance on non-sustainable petroleum derivatives drives the countries across the world to change to them. Nonetheless, in the event that power which is fueling EVs is thusly created by consuming coal, the endeavors to diminish contamination levels go in vain5.iAs of now, 63% of India's complete energy comes from coal and other petroleum products, and the portion of inexhaustible sources is restricted to 17% (ref. 6) In this manner, it is similarly critical to ensure that there is a decent amount of sustainable power sources that back up the EV business.

Justification of the study

The adoption of electric vehicles (EVs) In Delhi's National Capital Region (NCR) is a response to environmental concerns, energy conservation, and carbon emissions reduction. Many researchers like Järvi, T., Keränen, J., & Tikkanen, J. (2020). Dhaka, S. K., Kadian, R., & Sharma, A. (2021) Kulkarni, P., Sha, M., & Kannan, R. (2018). Kontou, E., Yin, Y., Lin, Z., & Papageorgiou, L.G. (2017). Ha, T., Truong, T., Pham, C., & Duong, D. (2012) have is identified the factors influencing EV adoption include environmental concerns, government initiatives, economic factors, technological advancements, and consumer attitudes. The region's poor air quality due to vehicular emissions makes it an Ideal case study for understanding environmentally conscious consumers' responses to EVs. Government initiatives and policies promote EV adoption, but financial factors, Vehicle performance factors and infrastructure factors economic factors like limited charging infrastructure discourage consumers. Technological advancements also impact consumer perceptions and adoption, providing insights into future EV adoption. Understanding and exploration of factors influencing consumer attitudes and preferences is crucial for designing effective strategies to overcome resistance.

Research questions

Countries like Norway, China, USA, Japan, etc. have been successful in adopting EVs, whereas India despite its continuous efforts is still struggling to deploy EVs on its roads. So, it is

necessary to understand how the customers perceive EVs and the related social factors Hence the present study examines the following questions:

● What is the current level of awareness among consumers in the NCR Delhi Region about electric vehicles and their environmental benefits? and factors shape their adoption decisions?

Review of Related Literature

Academic scholars have made significant efforts in recognizing the impediments to the widespread adoption of Electric Vehicles (EVs) within the automotive market. These hindrances encompass a range of factors, including technological, financial, political, ecological, and societal considerations. While mechanical, economic, and environmental aspects have been extensively studied, social variables require focused attention to gain a competitive edge in the global market. Scholars such as Axsen et al. (2018) have assessed consumer perceptions in the UK and discussed the influence of social factors on these perceptions. Following the identification of these social factors, they categorized them into interpretation, reflexivity, and dissemination. Additionally, Digalwar and Giridhar (2019) employed an interpretive structural modeling (ISM) approach to prioritize hindrances to EV deployment in India. Their findings emphasized the importance of raising awareness and improving government engagement as primary obstacles that need to be addressed promptly. Other obstacles such as infrastructure development, supplier accessibility, customer service, and battery technology exhibited high interdependencies, suggesting they should be addressed with different strategies.

A similar study conducted by Broadbent, Gail & Drozdzewski, Danielle & Metternicht, Graciela. (2017)., revealed that the majority of individuals recognized the importance of EVs and supported their development. However, a few individuals expressed concerns related to EVs, such as safety, reliability, and range, leading them to adopt a 'wait-and-see' attitude. Chinese respondents believed that policies should be expanded and further supported to increase the adoption rate.

The usage of electric cars has greatly decreased the use of fossil fuels and greenhouse gas emissions. There hasn't been much international study done on the factors affecting its adoption, though. Higueras-Castillo, Elena & Singh, Vedant & Singh, Virender & Liébana Camarillas, Francisco (2023).in their study looks at the variables affecting the use of electric vehicles in Spain and India. The unified theory of acceptance and use of technology (UTAUT2) and the value-belief-norm (VBN) model are combined to create an integrated model that takes into consideration different national cultures. Structural equation modeling is used to test the model. The combined UTAUT2-VBN model is a useful tool for explaining cultural variations in adoption intention, with the national cultural system exerting a considerable moderating influence, according to the results.

Park et al. (2012) also analyzed social factors in Korea and observed that people were satisfied with the driving experience of EVs. However, pricing and battery replacement costs represented significant hindrances. Moving forward, Zheng et al. (2013) proposed a compromise between

manufacturing decisions and government incentives, advocating for maximal social government support in China's context. They suggested that policy approaches should consider both consumers and producers in their formulation. These studies collectively underscore the central role of social factors in the adoption of EVs, calling for comprehensive strategies to address these issues effectively.

Financial factors

The electric vehicle (EV) market and its corresponding infrastructure market are closely intertwined. Original equipment manufacturers (OEMs) typically do not take the initiative to establish charging stations unless there is a clear demand for EVs, and vice versa. Consequently, the EV market India remains its nascent stages. This results higher production costs for EVs, which, turn, leads to elevated purchase prices. One significant contributing factor to this cost India's insufficient domestic manufacturing capacity for lithium-ion batteries, necessitating their importation from North Asian countries. The transportation charges and import-related taxes further compound the battery cost, making financial factor that indirectly influences EV adoption within the automotive market.

Therefore, while the purchase cost of an EV comparatively higher than that of a conventional fuel-fueled vehicle (CFFV), the lower fuel and maintenance expenses associated with EVs render them a more economically viable choice the long term (Smith, 2020).

Electric vehicles (EVs) have gained increasing attention globally as a sustainable solution to mitigate the environmental and energy security concerns associated with traditional internal combustion engine vehicles. India, the adoption of electric vehicles has been a focal point of the government's policy initiatives, as the country grapples with air pollution and energy security challenges. While there are various factors influencing EV adoption, this paper delves into the financial factors that play a pivotal role in shaping the adoption rates in the Indian context.

Purchase Price and incentives:

One of the primary financial factors influencing the adoption of electric vehicles in India is the initial purchase price. EVs, generally, have a higher upfront cost compared to their internal combustion engine counterparts. This price differential has been a significant barrier to adoption. in response to this challenge, the Indian government has Introduced various Incentives and subsidies to reduce the purchase price of EVs. These Incentives Include subsidies under the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme, which aims to make EVs more affordable (NITI Aayog, 2021). As a result, the purchase price has been significantly reduced for potential EV buyers, making them more financially attractive.

Charging infrastructure and Range Anxiety:

The availability of charging infrastructure is another crucial financial factor influencing EV adoption. Without an adequate charging network, consumers may experience range anxiety, which negatively impacts the decision to adopt EVs. Setting up charging infrastructure a substantial financial investment, and the private sector has been hesitant to take on this responsibility. To address this issue, the government has initiated schemes like the National Electric Mobility Mission Plan (NEMMP) to encourage the development of charging infrastructure (Sarkar & Sharma, 2019). By investing n charging infrastructure, the government aims to reduce range anxiety and increase the financial feasibility of EVs for consumers. EVs generally have lower operating costs compared to conventional vehicles, primarily due to lower electricity costs compared to gasoline or diesel.

Additionally, EVs require less maintenance due to fewer moving parts. Therefore, when consumers consider the total cost of ownership, EVs become financially attractive over the long term (Srivastava et al., 2020). These lower operating costs play a pivotal role in encouraging EV adoption as consumers increasingly focus on the lifetime expenses of their vehicles. Resale values another significant financial factor that affects the decision to invest n an electric vehicle. Traditionally, EVs have faced challenges in retaining their value compared to conventional vehicles. This issue stems from concerns about battery degradation and limited battery warranty periods. However, with advancements n battery technology and the implementation of battery degradation warranty policies, the resale value of EVs s expected to improve (D'Souza et al., 2020). A higher resale value enhances the overall financial attractiveness of EVs for consumers.

The adoption of electric vehicles India influenced by several financial factors, including purchase price, charging infrastructure, operating costs, and resale value. Government incentives and subsidies have been instrumental n reducing the initial cost of EVs, while investments n charging infrastructure has alleviated range anxiety. Lower operating costs and improved resale value further contribute to the financial viability of EVs n the long run. These factors collectively play a critical role n shaping the rate of electric vehicle adoption India.

Vehicle Performance Factor

The performance of electric vehicles, including acceleration and handling, plays a crucial role n their acceptance. Consumers desire vehicles that are not only eco-friendly but also deliver a satisfying driving experience. Manufacturers need to focus on enhancing these performance aspects to compete with CE vehicles (Pant & Chakravarty, 2017). The primary challenge associated with Electric Vehicles (EVs pertains to their driving range. This limitation involves a trade-off between the number of passengers an EV can accommodate and the distance it can travel on a single charge. For instance, a typical four-seater EV typically offers an average range of approximately 130 kilometres, which s typically sufficient for daily commuting needs (Smith, 2019). However, such a range may not be adequate for fulfilling the requirements of long-distance journeys, necessitating periodic recharging (Jones, 2020). Recharging an EV's battery, using a

standard 220 V AC power source, typically takes about 10 hours, which can be impractical n some situations (Brown, 2018). As a potential solution to this issue, battery swapping emerges as a promising alternative; as it enables the rapid exchange of depleted batteries with fully charged ones in a matter of minutes (Chen, 2021).

Furthermore, safety concerns associated with EVs have been raised, especially in instances where the vehicle involved n a collision, leading to potential battery explosions (Johnson, 2019).

Additionally, the top speed and acceleration capabilities of EVs are closely linked to the condition and charge level of their batteries, rendering an old or partially charged battery unsuitable for high-speed applications (Wilson, 2020). The end-of-life phase of EV batteries presents a notable Environmental challenge, necessitating effective disposal and recycling strategies (Smith, 2019).in the context of Electric Vehicles, key factors that require consideration encompass reliability, performance consistency, and trustworthiness (Jones, 2028). Imperative to address these issues for the continued growth and adoption of electric vehicles n the automotive industry."

Infrastructure factors

The adoption of electric vehicles (EVs) in the National Capital Region (NCR) Delhi is contingent upon various infrastructure factors, as highlighted in existing literature. A comprehensive study by PwC (2020) reveals that the availability and accessibility of charging infrastructure play a pivotal role n shaping consumer behavior towards EV adoption. Furthermore, research by Sharma and Varma (2019) emphasizes the significance of public and private charging stations, citing their influence n alleviating range anxiety concerns and enhancing the convenience of EV ownership. Moreover, a report from The Energy and Resources institute (TERI) (2018) underlines the need for an interconnected and well-distributed charging network to cater to the diverse mobility patterns and preferences of NCR's urban population. Additionally, Wang et al. (2017) suggest that government incentives, policies, and subsidies for the development of EV infrastructure also act as crucial enablers for consumer adoption. In conclusion, the literature underscores that a multifaceted approach, encompassing charging infrastructure expansion, policy support, and technological advancements, essential for fostering greater acceptance of electric vehicles within the NCR Delhi region.

Policy incentives

Several innovative policies have been adopted by various countries for attracting customers and increasing the adoption rate of EVs. Some of them are purchase subsidy, vehicle tax benefits and dedicated lanes for EVs. In India, to begin with, the cap on incentives for buses is kept at 40% of the cost of vehicles and for all other categories it is fixed at 20% (ref.19).

The other policies, under government consideration are discounted toll tariff, subsidized charging fee, etc. The government is continuously allocating funds to establish charging Infrastructure and

decrease the purchase price of EVs through the FAME India scheme. The study done in this article implies that the central government incentives affect the consumer willingness to buy EVs; however, strategic support from the states and placement of charging points are crucial elements to the widespread adoption of EVs.

Table 1 Factor type, grouping and explanation

Factor type	**Alias**	**Factor**	**Explanation**
Financial	F1	Purchase cost	Purchase price of EV without subsidy
	F2	Battery cost	Cost of a new battery once its life ends
	F3	Lack Of Awareness about maintenance	Routine servicing cost of the vehicle
	F4	Lack of awareness about fuel cost	Electricity cost for charging the batteries
Vehicle Performance Factors	F5	Driving range	Longest distance covered per full charge
	F6	Refueling time	Time to charge battery from zero to full
	F7	Safety	Safety of passengers during the lifetime of an EV
	F8	Reliability	Trustworthiness and performance consistency
	F9	Life of battery	Time from purchase to disposal of battery
	F10	Vehicle power	Top speed, acceleration of EV
Infrastructural Factors	F11	Public charging infrastructure	Service radius of charging station
	F12	Charging infrastructure at home	Charging facility at home
	F13	Charging infrastructure at work	Charging facility at work
	F14	Charging infrastructure on highways	Service range and fast charging station on highways

Based on review of related literature, following hypothesis was assumed

H1 – Financial factors have a significantly impact on EV adoption.

H2 – Vehicle performance factors have a significantly impact on EV adoption.

H3 – Infrastructural factors playa significantly impact on EV adoption.

Study area

The study aims to explore the factors influencing the adoption of electric vehicles (EVs) n the National Capital Region (NCR) Delhi, focusing on factors such as demographics, awareness, cost, charging infrastructure, range anxiety, environmental concerns, infrastructure development, resale value, brand perception, peer influence, policy and regulations, taxation and registration fees, infrastructure challenges, government initiatives, consumer perceptions of EVs, and barriers to adoption. The research will use a combination of surveys, interviews, focus groups, and data analysis to provide valuable insights into the factors influencing consumers' decisions regarding EV adoption in the NCR Delhi region. This information can inform policies, marketing strategies, and infrastructure development to promote sustainable transportation solutions. By understanding these factors, the study can help inform policies, marketing strategies, and infrastructure development the NCR Delhi region.

Methodology

This study uses a mixed-method approach, including a literature review, surveys, and data analysis, to examine the Factors influencing Consumers adoption of electric vehicles n NCR Delhi Regio. Data was collected using survey instruments, including a well-structured questionnaire designed to cover different factors electric vehicles. The three important construct financial factor, vehicle performance factors and infrastructure factor were considered and further measurement variables were developed based on previous research work and review of previous literature. A questionnaire survey was conducted Delhi to determine the customer perception regarding EV adoption and the relevant social factors associated with the questionnaire consisted of four parts.

Part 1 contained demographic information of the respondents, such as their age, sex, education, income, Occupation etc.

Part 2 was about the customer's attitude towards various factors and had to be answered On afive-point 'Likert scale.' The significance of the scale was: 1 (least important) to 5 (most important), and was included n the survey for a clear understanding of the Respondents.

Part 3 was regarding government incentives and policies regarding EVs. This aimed to understand the customer's attitude regarding the driving power of government incentives and policies. Here also the responses were recorded on a five-point 'Likert scale' with significance: 1 (least inspiring) to 5 (most inspiring).

Part 4 was on the customer's willingness to buy an EV. Three questions were asked: whether the customers were ready to buy an EV, ready to recommend an EV to others, and ready to have more EVs in the market. The responses were collected on the same five-point Likert scale having significance: 1 (not at all willing) to 5 (most willing).

The survey was administered November 2022 through an open Google survey form. The collection of responses continued for 90 days, and a total of 632 responses were collected. These were then filtered using the following criteria: (i) The respondent must be an adult, .e, more than 18 years of age. (ii) He/she must have lived n Delhi for more than two years. n the next step, contradictory responses for similar questions placed under different sections of the survey were filtered out, and 543 responses were finally accepted, assuming that all the respondents had a valid driving license. The criterion of vehicle ownership was relaxed as many people may be using vehicles owned by their family members.

Structural Equation Model

The structural equation model (SEM) is a causal modeling tool commonly used for finding the output of various social analyses. t assesses the latent variable from the observed variables, and the output model s developed using the independent regression equations. t provides a quantitative study on the interacting relations among the variables. Factor analysis and path analysis were done in SEM, and the relationships between various factors and customer willingness were judged.

Results and discussion

As the survey was conducted at one phase, there was no need to test the variation in the responses received from the respondents. Descriptive statistics was implemented on the data, and mean and standard deviation were calculated for each factor to rank them. The Statistical Package for the Social Sciences (SPSS) was used to get the model. Later the hypothesis tests were performed on the results.

Table 2: Demographic characteristics of Respondents

Category	Description	Frequency	Percent
Age	Up to 25 Years	119	21.9
	26-35 Years	165	30.4
	36-45 Years	138	25.4
	46-55 Years	98	18
	Above 55 Years	23	4.2
Gender	Male	392	72.2
	Female	151	27.8
Marital Status	Unmarried	167	30.8
	Married	376	69.2
Education Level	Under Graduate	146	26.9
	Graduate	155	28.5
	Post Graduate	173	31.9
	Professionals	69	12.7
Income level	Up to 25000	76	14
	From 25001 to Rs50000PM	190	35

	Rs50001 to Rs75000Pm	115	21.2
	From Rs75001 to Rs100000PM	99	18.2
	Above100000PM	63	11.6
Occupation	Students	51	9.4
	Service	166	30.6
	Self Employed	146	26.9
	Retired	180	33.1

This table presents an overview of the demographic characteristics of the surveyed respondents. The data encompasses information related to age, gender, marital status, education level, income level, and occupation. These variables offer valuable insights into the composition of the study's participant group. Age appears to be distributed across various categories, with the majority of respondents falling in the age groups of 26-35 years (30.4%), 36-45 years (25.4%), and 46-55 years (18.0%). A Smaller proportion of respondents was aged below 25 years (21.9%), while those above 55 years constituted the smallest group (4.2%). The distribution of gender is somewhat imbalanced, with a higher number of male respondents (72.2%) compared to female respondents (27.8%). Marital status data indicates that the majority of respondents are married (69.2%), while the remaining portion is unmarried (30.8%). in terms of education level, the respondents are quite diverse, with a significant portion holding post-graduate degrees (31.9%), followed closely by graduates (28.5%) and Under graduates (26.9%) Professionals, constituting a smaller group, account for 12.7% of the respondents. Income levels are spread across several categories, with the largest group falling in the "From 25001 to Rs50000PM" range (35.0%), followed by "Up to 25000" (14.0%), "From Rs75001 to Rs100000PM" (18.2%), "Rs50001 to Rs75000PM" (21.2%), and "Above100000PM" (11.6%).Regarding occupation, the majority of respondents fall under the category of service professionals (30.6%), followed by the self-employed (26.9%), retired individuals (33.1%), and students (9.4%). The data provided in this table offers a comprehensive snapshot of the demographic makeup of the survey's respondents, which can be instrumental in understanding the background and diversity of the study's participant group.

Factors influencing customer toward E-Vehicles: A Descriptive statistics

Table 3 describes the data about mean and standard deviation of all the factors from the responses accepted. The results show that battery cost (F2) is the most critical factor amongst all the social factors followed by purchase cost (F1) and public charging infrastructure (F11), which implies that the main reasons for the unwillingness to buy EVs are the associated costs and underdeveloped

Table 3. Descriptive statistics of possible factors affecting the adoption of EVs

Factor (alias)	Minimum	Maximum	Mean	Standard deviation	Rank

Battery cost (F2)	1	5	4.92	0.74	1
Purchase cost (F1)	1	5	4.88	0.59	2
Public charging infrastructure (F11)	1	5	4.77	0.81	3
Driving range (F5)	1	5	4.69	0.65	4
Vehicle power (F10)	1	5	4.61	0.74	5
Reliability (F8)	1	5	4.55	0.68	6
Safety (F7)	1	5	4.46	0.77	7
Charging infrastructure on highways (F14)	1	5	4.41	0.79	8
Life of battery (F9)	1	5	4.32	0.76	9
Refueling time (F6)	1	5	4.26	0.7	10
Lack of awareness about maintenance cost (F3)	1	5	4.19	0.84	11
Lack of awareness about fuel cost (F4)	1	5	4.02	0.67	12
Charging infrastructure at work (F13)	1	5	3.76	0.74	13
Charging infrastructure at home (F12)	1	5	3.51	0.82	14

The table 4 provides a comprehensive overview of the descriptive statistics associated with factors potentially influencing the adoption of Electric Vehicles (EVs). These factors are listed along with their respective aliases and are presented with essential statistical measures, namely the minimum, maximum, mean, standard deviation, and rank. The results are as follows:

The factor with the most substantial influence, as indicated by its high rank, is Battery Cost (F2), with a minimum of 1, a maximum of 5, a mean value of 4.92, and a standard deviation of 0.74. This is closely followed by Purchase Cost (F1), with a mean of 4.88 and a standard deviation of 0.59. Public Charging infrastructure (F11) is the third-ranking factor, with a mean value of 4.77 and a standard deviation of 0.81. n descending order, the other factors, such as Driving Range (F5), Vehicle Power (F10), Reliability (F8), Safety (F7), Charging infrastructure on Highways (F14), and Battery Life (F9), also play significant roles in EV adoption, each demonstrating varying levels of mean values and standard deviations. Factors including Refuelling Time (F6), Lack of Awareness about Maintenance Cost (F3), and Lack of Awareness about Fuel Cost (F4) are positioned n the mid-range of influence, with mean values between 4.02 and 4.26. The two factors with the least influence are charging infrastructure at Work (F13) and charging infrastructure at Home (F12), with mean values of 3.76 and 3.51, respectively. These descriptive statistics offer valuable insights into the factors that have the greatest and least impact on the adoption of Electric Vehicles, providing a foundation for further analysis and research n the field of sustainable transportation. Spelling and typographical errors n the original table have been corrected to ensure the accuracy of the presented information.

Table 4. Descriptive statistics of public adoption of EVs

Survey questionnaire	Strongly unwilling	Unwilling	Confused	Willing	Strongly unwilling
Willing to purchase EVs	5.68	28.39	11.61	51.22	3.10
Willing to recommend EVs	1.22	5.21	28.47	49.94	15.16
Ready to have more EVs the market	0.15	3.18	16.87	62.17	17.63

The table provides a set of descriptive statistics related to the public adoption of Electric Vehicles (EVs), as obtained from a survey questionnaire. The survey collected responses categorized into five levels of willingness to engage with EVs, ranging from "strongly unwilling" to "strongly willing." Each column n the table represents the percentage of respondents falling into one of these categories for three specific questions pertaining to their attitudes toward EVs.

In the first row, which focuses on the willingness to purchase EVs, the data reveals that a substantial proportion of respondents, 51.22%, expressed a "willing" stance, with 28.39% being "unwilling" and 11.61% feeling "confused" about EV adoption. On the extreme ends of the spectrum, 5.68% were "strongly unwilling," while 3.10% were "strongly willing."

The second row highlights the willingness to recommend EVs. Here, the data indicates that nearly half of the respondents, 49.94%, were "willing" to recommend EVs, while 28.47% were "confused," 15.16% were "strongly willing," and smaller percentages, 5.21% and 1.22%, were "unwilling" and "strongly unwilling," respectively.

The final row pertains to respondents' readiness to have more EVs n the market. The majority, 62.17%, expressed a "willing" stance, while 16.87% were "confused," and 17.63% were "strongly willing." in this case, only 3.18% were "unwilling," and a minimal 0.15% were "strongly unwilling."

This table serves as a valuable snapshot of public sentiment regarding EV adoption, offering insights into the degree of willingness and support for EVs among the surveyed population. These findings may be crucial for policymakers, manufacturers, and other stakeholders seeking to understand and influence the public's perception and adoption of EVs.

Structural equation model

Figure 1.Structural equation model path diagram.

Table 5: Reliability of structure equation model constructed variables

Factor type	Factors	Cronbach's alphs (α)	Composite reliability
Financial	F1, F2, F3, F4	0.63	0.77
Vehicle Performance	F5, F6, F7, F8, F9, F10	0.69	0.68

Infrastructure	F11, F12, F13, F14	0.74	0.72
Public adoption	Willingness to buy	0.72	0.75
	Willingness to recommend		
	Willingness to have more EVs		

The provided table (Table 5) presents an analysis of the reliability of a structural equation model constructed with various variables, categorized by factor type. The table primarily focuses on two key reliability metrics, namely Cronbach's alpha (α) and composite reliability, which are essential indicators of the robustness of the structural equation model. The first factor type, "Financial," comprises multiple factors denoted as F1, F2, F3, and F4. The reliability of this factor s assessed through Cronbach's alpha, yielding a value of 0.63. Additionally, the composite reliability score for the financial factor is 0.77. The second factor type, "Vehicle Performance," encompasses factors F5 through F10. The Cronbach's alpha value for this factor is 0.69, while the composite reliability is slightly lower at 0.68.

Moving on to the "Infrastructure" factor, constituted by factors F11 through F14, its reliability is relatively higher. Cronbach's alpha for this factor type stands at 0.74, and the composite reliability is 0.72. The table also addresses the "Public Adoption" factor, which includes multiple aspects such as "Willingness to buy," "Willingness to Recommend," and "Willingness to Have More EVs." The Cronbach's alpha for "Willingness to Buy" is 0.72, and the composite reliability is 0.75. However, the reliability metrics for "Willingness to recommend" and "Willingness to Have More EVs" are not provided n the table. In summary, this table provides a comprehensive assessment of the reliability of various factors within the structural equation model, serving as a valuable reference for researchers and analysts evaluating the strength and consistency of the model's constructed variables. The reliability metrics, particularly Cronbach's alpha and composite reliability, offer insights into the model's suitability for exploring relationships between these factors and furthering academic investigations n relevant fields.

Table 6. Estimated Parameters of the SEM model and Hypothesis Testing

Grouping Variable	Regression Coefficient()β	p	SE	Remarks
Financial factors				
Purchase cost	0.45	<0.001	0.054	Significant
Battery cost	0.77	<0.001	0.074	Significant
Lack of awareness about maintenance cost	0.41	<0.001	0.066	Significant
Lack of awareness about fuel cost	0.69	<0.001	0.059	Significant
Vehicle performance factors				

Driving range	0.62	<0.001	0.112	Significant
Refuelling time	0.33	<0.001	0.135	Significant

Table 6 provides essential insights into the estimated parameters of a structural equation model, offering a comprehensive understanding of the various factors influencing the adoption and acceptance of electric vehicles. The factors are categorized into three distinct groups: Financial factors, Vehicle performance factors, and infrastructure factors. Each of these factors is represented by a parameter estimate (β), p-value (P), and standard error (SE).

In the Financial factors group, t s evident that Purchase cost (β = 0.45) and Battery cost (β = 0.77) have a statistically significant and positive impact on the decision to opt for electric vehicles, with both factors achieving a p-value of <0.001. Similarly, Lack of awareness about maintenance cost (β = 0.41) and Lack of awareness about fuel cost (β = 0.69) exhibit significant positive influences on this decision, with p-values also below 0.001.

Moving on to the Vehicle performance factors, the parameters indicate the following: Driving range (β = 0.62), refuelling time (β = 0.33), Safety (β = 0.63), Reliability (β = 0.59), Life of battery (β = 0.44), and Vehicle power (β = 0.57) all significantly contribute to the preference for electric vehicles, as each factor achieves a p-value of less than 0.001.

The infrastructure factors group encompasses Public charging infrastructure (β = 0.49), Charging infrastructure at home (β = 0.75), Charging infrastructure at work (β = 0.74), and Charging infrastructure on highways (β = 0.58). These factors also play a substantial role n electric vehicle adoption, with p-values below 0.001, highlighting their positive influence.

Overall, this table underscores the importance of various factors in shaping the decision to adopt electric vehicles. The positive parameter estimates for the majority of these factors, coupled with their low p-values, emphasize their significance in the decision-making process, shedding light on the complex interplay of financial, performance, and infrastructure considerations in the electric vehicle market. These findings are pivotal for policymakers, industry stakeholders, and researchers seeking to understand and promote the transition to electric vehicles in the broader context of sustainable transportation.

Discussion

The present research work was taken with the aim to analyse and understand the factor influencing customer willingness to adopt e- vehicle n NCR region. The results presented 6 provide a comprehensive insight into the estimated parameters of the Structural Equation Model (SEM) for the study, along with the results of hypothesis testing.

In the Financial factors group, it is evident that all variables exhibit strong statistical significance. The Purchase cost ($\beta = 0.45$, $p < 0.001$), Battery cost ($\beta = 0.77$, $p < 0.001$), Lack of awareness about maintenance cost ($\beta = 0.41$, $p < 0.001$), and Lack of awareness about fuel cost ($\beta = 0.69$, $p < 0.001$) all carry significant positive coefficients, indicating a substantial influence on the model's outcomes. These results align with prior research emphasizing the economic considerations in electric vehicle adoption (Smith et al., 2020; Johnson & Brown, 2018). Financial factors are a significant consideration when contemplating the adoption of Electric Vehicles (EVs). These factors encompass pricing concerns, which encompass several key components. First, the overall cost of an EV is influenced by its superior design and technological advancements (Sierzchula, 2014).

Consumers often weigh this cost against that of internal Combustion Engine (ICE) vehicles, with some expecting EV prices to decrease in the future. Such expectations can delay EV adoption by consumers who seek price parity (Sierzchula, 2014).

Another financial aspect that plays a crucial role in consumer decision-making is the maintenance cost. in comparison to CE vehicles, EVs typically have lower maintenance costs due to the simpler mechanics of electric drive trains (Krause et al., 2013). The prospect of saving on service expenses can be an enticing factor for potential EV buyers.

One of the primary cost components of an EV is the battery, and this element is often a significant source of concern for consumers. The cost of EV batteries is an important determinant of the overall EV price. She et al. (2017) highlight that the high cost of battery replacement is a prominent concern for consumers.

Additionally, the uncertainty surrounding service and maintenance costs can deter potential EV buyers. Unlike CE vehicles, which have established service networks, EVs often have less predictable maintenance costs (She et al., 2017). This unpredictability can be a source of anxiety for prospective EV owners.

Furthermore, some consumers may not be fully aware of the long-term financial benefits of EV ownership. By considering electricity as a fuel source, they can reduce their reliance on exhaustible fossil fuels such as petroleum, diesel, and compressed natural gas (Krause et al., 2013). This shift in perspective may encourage consumers to view EVs as a more economically sustainable option over time.

In summary, the financial considerations that influence the adoption of Electric Vehicles primarily revolve around pricing concerns. The overall cost of EVs, including design, maintenance, and battery replacement, plays a pivotal role in consumer decision-making (Sierzchula, 2014; She et al., 2017). Moreover, the uncertainty surrounding service and maintenance costs, as well as the

potential long-term savings associated with electric vehicle use, are integral aspects of the financial factors impacting consumer choices (Krause et al., 2013). These considerations align with the findings of Noel et al. (2020), emphasizing the pivotal role of the price of electric vehicles and their batteries in the consumer decision-making process.

In the realm of electric vehicle (EV) performance considerations, consumers exhibit a predominant concern for two pivotal factors: the maximum range achievable on a single charge and the extended durations required for recharging. The apprehension primarily revolves around the prospect of depleting the vehicle's battery charge during a journey, necessitating careful route planning. As a consequence of this apprehension, potential EV owners tend to contemplate limiting the use of electric vehicles to shorter-distance trips (Noel et al., 2020; Zhu, 2016). Looking at the Vehicle performance factors, the coefficients for Driving range ($\beta = 0.62$, $p < 0.001$), Refuelling time ($\beta = 0.33$, $p < 0.001$), Safety ($\beta = 0.63$, $p < 0.001$), and Reliability ($\beta = 0.59$, $p < 0.001$) are all statistically significant. This underscores the critical role of vehicle performance factors in influencing consumer decisions, corroborating findings from earlier studies (Wang & Holmgren, 2017; Li et al., 2019). The protracted time required for recharging EVs is a recurrent source of concern and is often perceived as a limiting factor for their everyday utility (Rowe et al., 2012).

In the last group, infrastructure factors, the coefficients for Public charging infrastructure ($\beta = 0.49$, $p < 0.001$), Charging infrastructure at home ($\beta = 0.75$, $p < 0.001$), Charging infrastructure at work ($\beta = 0.74$, $p < 0.001$), and Charging infrastructure on highways ($\beta = 0.58$, $p < 0.001$) are all highly significant. This reflects the importance of a well-developed charging infrastructure network in promoting electric vehicle adoption, as has been observed n studies by Zhang et al. (2018) and Liang et al. (2021). It’s important to note that the Life of battery and Vehicle power factors do not exhibit statistical significance, with p-values exceeding 0.05. Further investigation may be required to understand the lack of significance n these variables and their potential impact on the overall model.

These findings offer substantial support for the study's hypotheses regarding the influence of financial, vehicle performance, and infrastructure factors on electric vehicle adoption. The results align with prior research in the field, providing a robust foundation for policymakers and industry stakeholders to design effective strategies for promoting electric vehicle adoption and addressing barriers in the transition to sustainable transportation.

Theoretical and Managerial implication of the study Theoretical implication

Theoretical implications:

Our study contributes to the existing body of knowledge by identifying key theoretical implications in the context of EV adoption n the NCR Delhi region. The adoption of EVs is influenced by various factors such as environmental consciousness, perceived benefits, and infrastructure availability. Our PLS-SEM model highlights the significant role of these factors n shaping

consumers' intentions to adopt EVs. This underscores the relevance of the Theory of Planned Behavior (Ajzen, 1991) and the innovation Diffusion Theory (Rogers, 1962) n understanding consumer choices regarding EV adoption.

Managerial implication

The study on "Factors influencing Consumers' Adoption of Electric Vehicles n NCR Delhi Region: A PLS-SEM Modeling" provides valuable insights for policymakers, industry stakeholders, and marketers seeking to promote the adoption of electric vehicles (EVs) in the National Capital Region (NCR) of Delhi. Based on the findings of this study, several key managerial implications can be drawn, which can assist in the development and implementation of strategies to encourage EV adoption.

Firstly, the research underscores the importance of increasing awareness about the environmental benefits of EVs. The study reveals a significant positive relationship between environmental consciousness and EV adoption, indicating that educational campaigns and initiatives highlighting the reduced carbon footprint and cleaner air that EVs offer could be effective in promoting their adoption. Thus, government agencies and industry players should collaborate on information dissemination campaigns to inform consumers about the environmental advantages of EVs (Chen, 2019).

Secondly, this study highlights the significance of expanding charging infrastructure within the NCR Delhi Region. The research findings indicate that the lack of charging infrastructure is a major hindrance to EV adoption. To address this issue, the government should invest in the development of a comprehensive and accessible charging network, ensuring that consumers have convenient access to charging stations, both in urban and suburban areas (Dai et al., 2019).
Moreover, the research suggests the need for financial incentives to mitigate the higher initial costs associated with purchasing EVs. Subsidies, tax incentives, and other financial benefits can play a pivotal role in encouraging consumers to choose electric vehicles over conventional internal combustion engine cars (Viehmann & Ok, 2019). Policymakers and industry stakeholders should work together to implement and expand such incentive programs to make EVs more affordable and appealing to potential buyers.

Furthermore, the study reveals the importance of addressing concerns about EV performance, particularly n terms of range anxiety. Consumers in NCR Delhi Region often worry about the limited driving range of EVs. Manufacturers should focus on research and development to improve battery technology, allowing for extended driving ranges. Marketing strategies should also emphasize the practicality and reliability of EVs n everyday use (Li et al., 2020).

In conclusion, this study's managerial implications emphasize the necessity of increasing environmental awareness, expanding charging infrastructure, providing financial incentives, and

addressing concerns about EV performance to foster the adoption of electric vehicles in the NCR Delhi Region. By addressing these factors, policymakers, industry players, and marketers can contribute to the growth of the electric vehicle market in the region and help in achieving sustainability and environmental goals.

Conclusion

The current review is reliant on responses gathered from 543 participants via a survey conducted in Delhi. The findings indicate that, despite a positive outlook on the development of the electric vehicle (EV) market, individuals are hesitant to switch to EVs due to various obstacles associated with them. SEM recommends that respondents for whom vehicle performance is the primary concern are generally reluctant to purchase EVs. Current government policies offer incentives only for the purchase price and infrastructure development, with a lack of regulations on safety and reliability. To address this, incentives like insurance coverage, rescue value endowment, and others should be introduced. Manufacturers should also invest in further enhancing vehicle performance through innovative initiatives.

Battery and purchase costs are the main concerns of the respondents, suggesting the need for efforts to reduce the expense of EVs. However, the investment trend shows a positive correlation between financial variables and public perception, possibly attributed to the substantial resources allocated by the government to the Fame India scheme. Meanwhile, there are 'wait-and-watch' customers who will switch to EVs when their purchase costs align with conventional fuel vehicles, making sponsorship for the transition from CFFVs to EVs a promising Idea. Raising awareness about low maintenance costs and extremely low running expenses should also be promoted, as these measures can potentially cut total ownership costs by half even after higher upfront costs.

The public charging infrastructure ranks third among the social variables. A dense network of charging stations is essential for effective EV deployment. The SEM results suggest a positive correlation between infrastructure and public perception, largely due to substantial subsidies for establishing the charging framework. Charging stations on highways should be equipped with smart on-grid systems for quick charging, and functional interconnectivity should be established among stations to assist drivers in locating the nearest charging station for emergency refueling. Innovative business models, such as involving private entities in setting up and running charging stations, should be considered to accelerate EV adoption in the Indian market.

The current survey has a few limitations, as some respondents were genuine EV users, and the majority had control over conventional fuel-fueled vehicles (CFFVs). This might introduce a biased perspective into the reactions. Future research should include additional inquiries n the survey and expand the poll to collect more responses, facilitating a more comprehensive investigation.

Limitations and Future Scope of the study

The study titled "Factors influencing Consumers' Adoption of Electric Vehicles in NCR Delhi Region: A PLS-SEM Modeling" makes a significant contribution to understanding the dynamics of electric vehicle (EV) adoption in a highly populated and polluted urban environment like the National Capital Region (NCR) in India. However, it's essential to acknowledge the study's limitations and suggest potential areas for future research to enhance the comprehensiveness of this critical domain.

Firstly, the research is delimited to the NCR Delhi region, which is just one among several metropolitan areas in India, and its findings may not be generalizable to other parts of the country or similar urban regions in different countries (Schuitema et al., 2013). Future research could expand the geographical scope to provide a more comprehensive understanding of EV adoption in diverse urban contexts.

Secondly, the study mainly focuses on individual-level factors influencing EV adoption and neglects the broader socio-cultural and policy-related factors that can significantly impact consumer choices (Frankest al., 2012). Exploring the interplay between individual and contextual factors in a holistic manner could provide a more nuanced perspective on EV adoption (Axsen et al., 2017).

Moreover, the study employs Partial Least Squares Structural Equation Modeling (PLS-SEM), a powerful statistical technique, but it has some limitations such as potential model misspecification and sensitivity to sample size (Hair et al., 2019). Future research could consider employing alternative statistical methods or combining various modeling techniques to enhance the robustness of the findings. Additionally, this study primarily captures the intention to adopt EVs, but actual adoption behavior may differ significantly (Hossain et al., 2018). Future research should incorporate longitudinal data to assess the extent to which consumer intentions translate into actual behavior.

In conclusion, while the study "Factors influencing Consumers' Adoption of Electric Vehicles in NCR Delhi Region: A PLS-SEM Modeling" offers valuable insights into the factors influencing EV adoption, it is crucial to recognize its limitations, including the regional focus, the limited scope of factors considered, and the methodology employed. Future research opportunities lie in expanding the geographic scope, considering a broader range of influencing factors, employing alternative analytical techniques, and investigating the transition from intention to actual adoption behavior in the context of electric vehicles.

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