Electrifying for Sustainability'- Exploring Electric Car Adoption in the Indian Landscape

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Abstract: Considering the disruptive potential of electric cars in the automotive industry, this study aims to analyze the factors influencing electric car adoption behavior among Indian car users Methodology: The research adopts both exploratory and descriptive approaches, conducted in two phases. Phase one involves engaging with 200 prospective electric car buyers to identify critical adoption factors. Phase two employs conjoint analysis, involving 300 consumers and assessing nine attribute combinations (price, recharge time, and driving range) derived from literature review and interactions with potential buyers. Findings: The study reveals the three most valued attribute combinations for Indian consumers when selecting electric cars. Practical Implications: Decision-makers and electric vehicle manufacturers can leverage these results to introduce advanced technology into the Indian market. The conjoint analysis findings assist manufacturers in understanding the relative importance of features influencing consumer utility. Originality: This study contributes to the existing literature by focusing on consumer behavior in developing markets, particularly India, which has been less explored compared to the asymmetry in research on electric car adoption behavior in developed markets

Keywords: Climate change, Carbon emission, Electric cars, Sustainability, Sustainable development goals, SDG13

1. Introduction

With the growing importance of the threat of global warming detrimental to the environment, reducing and subsequently eradicating environmental hazards has become a worldwide issue. Regulatory bodies have created and implemented rules to encourage the production and adoption of electric vehicles in addition to several other initiatives to address this issue (Chandel, 2023; Sierzchula; 2014). Continuously increasing fuel costs and the problem of environmental destruction have indeed been of significant worry to government agencies and automakers, but also to a substantial proportion of global customers (Haghani et al; 2023; Desreveaux et al; 2023; Chandel et al., 2023). The topic of vehicles that run on renewable fuels has been gathering steam recently, but the notion that these automobiles are still regarded as highly specialized products warrants interrogation. Consequently, it is essential to identify the variables and attributes that may encourage an average Indian consumer to consider a vehicle powered by renewable fuel. As multiple sorts of cars operate on various fuels, the present study focuses solely on electric vehicles (particularly electric cars) fuelled solely by battery systems.

2. Overview of the Indian Automotive Sector

India's automobile sector, a pivotal contributor to the nation's economy, has witnessed remarkable growth, becoming the world's fifth-largest automaker post-liberalization in 1991 (The Economic Times, 2016). In the fiscal year 2021, India produced 22.65 million vehicles, with two-wheelers dominating the market due to the expanding middle class and youthful population. The industry's upward trajectory is also fuelled by corporations venturing into rural areas, and significant efforts by the government and manufacturers aim to position India among the top global two- and four-wheeler markets by 2022.In the calendar year 2021, all segments experienced growth, with overall sales increasing by 5.8% to 18.49 million vehicles compared to the previous year. Passenger car sales surged by 26.6%, reaching 3.08 million vehicles. Commercial vehicle sales saw a notable increase of 34%, totaling 677,119 units in FY21. Two-wheelers and passenger cars command the domestic market, holding a combined market share of 81.21% and 14.56%, respectively, with over 17.8 million vehicles sold (ibef.org, 2022).

3. Automotive Emissions in India

The escalating number of vehicles in India has resulted in alarming pollution levels, positioning the country as one of the most contaminated globally (Times of India, 2016). Thirteen Indian cities rank among the top 20 most polluted globally, and the nation exhibits one of the highest levels of particulate matter, with Delhi having the world's highest concentration of dangerous particulate matter (PM2.5), exceeding the World Health Organization's safety limit by six times (CBC News, 2016).Surveys by organizations including the World Health Organization, University of California at Berkeley, and IIT Delhi, Kanpur, and Mumbai confirm Delhi as the most polluted city globally, with an average PM2.5 exposure 15 times higher than the WHO's recommended level, posing severe health risks (indiatoday.in, 2022). The surge in automobile numbers not only exacerbates air pollution but also strains India's fuel import costs, leading to an increase in the nation's gross oil imports and a subsequent rise in the current account deficit (Energy World, 2017).As the fifth-largest global automaker, India faces a significant increase in car sales, projecting a threefold increment by 2030, escalating the risk of harmful emissions (ibef.org, 2022). Efforts are underway to curb pollution, with India aiming for an all-electric fleet by 2030, a move expected to reduce the oil import bill by $60 billion and cut pollutant discharges by 37% (Times of India, 2017; Quartz India, Sep 2017)

4. Mitigating Environmental Harm through the Adoption of Electric Vehicles

India, aspiring to be a global economic powerhouse, is aggressively pursuing electric vehicle (EV) adoption to ensure sustainable energy reliability (The Economic Times, 2017). Currently the 5th major automotive market globally, India's economic ascent is poised to elevate it to the 3rd position by the next decade (ibef.org, 2022). By 2030, an estimated 40 billion Indian consumers will demand mobility services, creating the potential for an EV revolution aligned with sustainability goals (ibef.org, 2022).Amidst high fuel prices and escalating pollution, particularly in cities like Delhi, EVs are viewed as a remedy for achieving growth without compromising urban environments (The Economic Times, 2017). The Indian government aims to transform 30% of new automobile sales to EVs by 2030, reducing emissions by one billion tons and achieving net-zero emissions by 2070 (The Economic Times, 2017).This aggressive EV push aims to contribute significantly to India's energy independence by reducing reliance on oil imports, currently exceeding 80%, enhancing power system stability, and facilitating greater renewable energy production (The Economic Times, 2017). While EVs presently represent less than 1% of total vehicular sales in India, the industry is growing rapidly, with the demand for EV batteries expected to reach 900-1100 GWh by 2030 (The Economic Times, 2017).Despite the current negligible EV penetration, India's reliance on imported lithium-ion batteries is projected to cost over $1 billion in 2021, signaling a substantial demand surge with the future prevalence of EVs (The Economic Times, 2017). To address this, the Indian government is undertaking initiatives like establishing EV preferential zones, developing charging and battery replacing facilities, and implementing incentive schemes to boost the EV ecosystem (The Economic Times, 2017). The schemes, requiring an investment of approximately INR 1,00,000 crore, aim to foster domestic EV production, battery infrastructure, and a robust distribution network, with anticipated benefits such as reduced oil import bills (The Economic Times, 2017). This forward-looking approach positions EVs as a means of transportation that will contribute to a greener and more sustainable environment for future generations.

5. Electric Vehicle Scenario in India

In India, a surge in fuel prices has prompted a rapid shift from gasoline-powered cars to electric vehicles (EVs), leading to a substantial increase in EV sales. In 2021, EV sales in India more than tripled, reaching 14,800 units, and the trend continues to grow. A study by the Federation of Automobile Dealers Associations (FADA) reported a remarkable 296 percent increase in sales of electric passenger cars in February 2022, totaling 2,352 units. Government incentives and heightened public awareness in urban areas have played pivotal roles in driving this growth, albeit challenges posed by high gasoline prices. Government statistics from the Union Ministry of Road Transport & Highways highlight that electric vehicle registrations across all segments hit 3.13 lakh units in 2021, with February marking the highest monthly total. Tata Motors dominated the sector by selling 2,264 units in the preceding month, marking a substantial 551 percent increase from January 2022, where they sold 1,360 units. Conversely, MG Motors witnessed a 70 percent year-on-year decrease, selling only 38 units, while Mahindra experienced a 50 percent year-on-year increase, selling 12 units. Battery-powered two-wheelers saw a remarkable 433 percent surge, reaching 32,443 units in February 2022, as reported by the National Electric Vehicle Sales Association. Producers like Hero Electric, Ather Energy, and Ola recorded record-breaking monthly sales in the past few months. The first two months of 2022 witnessed electric vehicle sales surpassing the one lakh mark for the first time, rebounding from a decline in January 2022 attributed to the aftermath of the Omicron-induced third wave. As the pandemic's third wave subsides and businesses reopen nationwide, monthly registered EV volumes have once again exceeded the 50,000 marks (zeenews.india.com, 2022).In 2020, Hyundai Motors, Tata Motors, Mahindra & Mahindra,

Audi, BMW, MG Motors, and Olectra Greentech stood out as key players in the electric vehicle industry, offering diverse options across passenger vehicles, light vehicles, and electric buses. Their emphasis on introducing advanced and technically sophisticated products demonstrates a commitment to shaping the future of the electric vehicle market. Through strategic initiatives such as mergers, acquisitions, alliances, and collaborations, these industry leaders actively enhance their market position, solidifying their influence in the evolving electric vehicle landscape.

5.1Electric Vehicles

Acceleration and driving are accomplished with the help of one or more electric motors, which are fueled by a pack of batteries in the case of an electric car. Electric motors (or batteries) can either aide a traditional internal combustion engine (ICE) or completely power a vehicle, based upon the kind of electrified vehicle (mynrma.com, 2022). Below is a section on brief description of these electric vehicle categories

5.2Hybrid electric vehicles (HEV)

Hybrid electric vehicles (HEVs) optimize fuel efficiency by combining a traditional internal combustion engine (ICE) with an electric motor and battery pack, utilizing the electric motor in scenarios where the ICE is less efficient, such as acceleration (Ehsani et al., 2007). HEVs, similar to conventional vehicles, use traditional fuel, typically petrol, but stand out in their ability to automatically recharge the battery through regenerative braking, eliminating the need for manual monitoring or prolonged charging (Hannan et al., 2014; Sciarretta & Guzzella, 2007)

5.3Plug-in Hybrid Electric Vehicles (PHEV)

A plug-in hybrid electric vehicle (PHEV), akin to a hybrid car, integrates an internal combustion engine, electric motor, and a more potent battery pack designed to handle substantial workload during motion. Notably, PHEVs can operate solely on electricity even with the internal combustion engine completely off (Ehsani, Gao & Miller, 2007; Galus & Andersson, 2008).

5.4Battery electric vehicles (BEV)

A battery electric vehicle (BEV), often termed "all-electric," relies solely on electricity, drawing power from built-in battery packs, setting it apart from hybrid counterparts (Lin & Greene, 2011). Characterized by larger battery capacities and kWh outputs, BEVs tend to be pricier due to advanced battery technology (Frieske et al., 2013). Charging is essential for BEVs, achievable through home chargers, fast charging stations, and regenerative braking to recover energy (Patwari et al., 2024; Chau et al., 2024; Ehsani et al., 2007; Ecer, 2021; Ziegler et al., 2019).

5.5. Mild-hybrid electric vehicles (MHEVs) and fuel cell electric vehicles (FCEVs)

Mild-hybrid electric vehicles (MHEVs) and fuel cell electric vehicles (FCEVs) are alternative options in Australia. MHEVs employ a 48-volt integrated starter generator (ISG) to complement the internal combustion engine (ICE) power (Chen, 2012). Debates persist on whether MHEVs qualify as 'true EVs' due to the ISG's auxiliary role. In contrast, FCEVs, like battery electric vehicles (BEVs), rely solely on electrical energy for propulsion but differ in energy storage. BEVs store electricity from chargers, while FCEVs generate their electric charges through a hydrogen-based chemical process, eliminating the need for grid charging (Bubeck et al., 2016; Hao et al., 2021).

6 Review of Literature

India unveiled the 'National Electric Mobility Mission Plan (NEMMP) 2020' in 2013 to address the urgent problems of national energy security, pollution, and the expansion of local manufacturing capabilities. The Indian government intended to transition to electric vehicles on a transactional basis by 2030 to comply with the Paris Agreement (Horizons.gc.ca, 2016, TechTimes, 2016).Numerous variables can motivate consumer buying behaviour (Sethi & Chandel, 2015). A review of literature discussing the factors that might influence consumers' electric car adoption behaviour was conducted. The first part of review was dedicated to understand the factors influencing consumer acceptance of electric vehicles. Second part of review focused on the 'Product attributes', considered vital by consumers while purchasing an electric vehicle.

6.2Environmental Concerns

Consumer adoption of electric vehicles in the USA was directed towards a strong preference for environmentalism and energy security. Consumers were found to prefer hybrid or electric vehicles to vehicles running on oil and gas. The results of the study indicated environmentally conscious behaviors that motivate green consumers to purchase such vehicles. The

results also indicated that people in developed economies weigh the ecological benefits of electric cars more than the social and economic benefits **(Fox, 2023)**. Pro environmental self-identity of consumers was found to have a significant impact on the perception and acceptance of electric vehicles (Schuitema et al; 2013). Further, it was claimed that one of the important motivations for electric vehicles' adoption was environmental benefits associated with the use of electric vehicles because they cause less environmental degradation and were eco-friendlier (Bockarjova & Steg, 2014). On the contrary, it was advised to consider environmental assessment of electric vehicles from a long-term perspective as it might put additional demand of energy and resources. It was also proposed that mining of lithium, which is the key element of battery in electric vehicles, and discharging and recycling of batteries would put a negative impact on environment, making it a controversial issue (Hacker et al; 2009, Bockarjova and Steg, 2014)

6.3. Government and Infrastructural Support

To spur the adoption of electric vehicles (EVs), government support through measures like tax incentives and subsidies significantly influences consumer choices (Chandra et al., 2010). Mobilizing a diverse set of stakeholders, including research institutes, renewable energy suppliers, financial institutions, EV manufacturers, power companies, policymakers, and consumers, is crucial for moving the EV category beyond a niche market (Chandra et al., 2010).Efforts are underway to establish a supportive framework, such as exploring zero-down payment schemes, allowing consumers to use savings on petroleum products to pay installments (Horizons.gc.ca, 2017). The tax structure for EVs in India, including a 12% GST, lower electricity prices, and no import charges, offers advantages over conventional vehicles (BloombergQuint, 2017). State governments and cities further incentivize EV adoption through subsidies, waived road tax, and eliminated registration fees (Salvi and Nambiar, 2013).However, the inadequate charging infrastructure in India, with approximately 350 charging stations compared to China's 215,000, poses a significant challenge (Bloomberg New Energy Finance report, 2017). Establishing a reliable electricity infrastructure, particularly in areas with power shortages, remains a daunting task (Deccan Chronicle, 2016). Unlike conventional vehicles, EVs primarily rely on home charging, presenting challenges for economies aiming to build a robust charging network (Tamor et al., 2015; Bunce et al., 2014). Improved infrastructure development is essential for overcoming these hurdles and encouraging regular EV use.

6.4. Perceived Economic Factors

The purchase price is a critical factor in the decision to buy a vehicle (Mau et al., 2008), and this holds true for electric vehicles (EVs), where perceived economic benefits are closely tied to price and maintenance costs (Ziegler, 2012). Studies reveal that price preferences vary among the population, especially when EV prices exceed those of traditional cars (Rasouli & Timmermans, 2013). Higher-income individuals tend to be less price-sensitive (Hackbarth & Madlener, 2013; Achtnicht et al., 2012; Hess et al., 2012; Molin et al., 2012; Mabit & Fosgerau, 2011; Potoglou & Kanaroglou, 2007; Valeri & Danielis, 2015), though findings vary (Jensen et al., 2013). Those prioritizing practical aspects over design are less affected by price (Glerum et al., 2014).Operational costs significantly influence EV adoption (Musti & Kockelman, 2011), with studies considering regular maintenance costs and energy costs as key factors (Hess et al., 2012; Mabit & Fosgerau, 2011). The advantage of lower energy costs positions EVs favorably against traditional vehicles (Mock & Yang, 2014), although some studies highlight higher marginal utility of fuel costs for EVs (Jensen et al., 2013).The high purchase price, mainly attributed to the costly battery (Deloitte, 2011), acts as a barrier to EV sales (Pamidimukkala et al., 2024; Corradi et al., 2023). Many argue for industry or government subsidies, especially in developing economies, to make EVs cost-competitive. In Austria, 36% of respondents emphasized the importance of EV pricing in their purchase decision, and 35% believed that pricing parity with conventional vehicles is crucial for accelerating EV adoption. Additionally, the impact of leasing battery costs negatively influenced purchase decisions (Glerum et al., 2014).

6.5Performance

Compared to conventional vehicles, a limited driving range has been identified as a major barrier to the widespread adoption of electric vehicles (EVs). Most studies suggest that driving range significantly influences EV adoption, although this effect is not always significant (Pandita et al; 2024; Hess et al., 2012). The marginal utility of driving range is higher for EVs than conventional vehicles (Jensen et al., 2013). A meta-analysis suggests that consumer preference for range may depend on the density of charging stations and charging time (Dimitropoulos et al., 2013).Consumers generally prefer vehicles with better performance. Electric vehicle performance is often attributed to engine power, acceleration time, and maximum speed. However, preferences for acceleration time vary among individuals. While males prefer faster acceleration, females may not prioritize it as strongly (Mabit & Fosgerau, 2011; Potoglou & Kanaroglou, 2007; Valeri & Danielis, 2015). Single individuals were found to value shorter acceleration times more than others (Potoglou & Kanaroglou, 2007)

6.7 Important Product Attributes While Adopting Electric Vehicles

In this part of the review, various credible sources discussing the technical attributes that consumers consider important while making an electric car purchase situation were explored. A brief of the same has been presented below:

6.8 Battery Replacement Cost

Replacing an electric vehicle's (EV) battery is the costliest maintenance aspect, potentially exceeding the expense of replacing an entire conventional car engine. Assessing total ownership cost involves considering the battery's service life, linked to the depth of discharge (DOD) – the recommended percentage for optimal battery cycles. Despite potential high replacement costs, EVs offset with lower maintenance needs. Upgrading to more efficient batteries can enhance EV performance. Recent advancements in cost-effective batteries have reduced prices over five years, but battery cost remains a significant EV expense. The emergence of affordable batteries signals a promising future for electric vehicles in the mainstream market.

6.9 Driving Range

Range anxiety often describes consumer concerns about electric vehicles (EVs). The range of an EV depends on the quality and number of batteries used in the car. However, several other factors can affect the driving range of electric cars, such as the weight and type of vehicle, terrain, weather, and the driver's performance**.** Driving range parity is a concept discussed concerning the challenges of adopting electric cars. This concept questions whether electric vehicles have a range similar to traditional combustion engines, typically around 500 kilometers or 310 miles, with batteries with a 1+ kWh/kg capacity. A higher driving range allows for a longer run on a single recharge. To achieve better acceptability and adoption, EVs must have a range equal to or greater than internal combustion engine cars.

6.10. Recharge Time

Charging electric vehicle (EV) batteries is crucial, predominantly relying on power grids from varied sources. Despite the convenience of home or public charging stations, grid limitations can impact charging speed. In India, inadequate charging infrastructure and unreliable power supply pose challenges for EV adoption. Charging times have evolved, with early systems taking hours, while advancements like AeroVironment's 'PosiCharge' in 1997 achieved a six to fifteen-minute charge. General Motors' 'Magne Charge' in 1998 offered a ten-minute recharge for a range of sixty to one hundred miles. However, research indicates varied preferences, as some users prefer longer recharge times, utilizing workplace hours or overnight charging, showcasing diverse perspectives on this critical EV adoption attribute.

6.11. Research Gap-Need of Study

While developed nations experience a gradual growth in the electric vehicle sector due to affluence, superior infrastructure, and supportive policies, the category remains niche even in these economies. In developing countries like India, the launch of electric vehicles is recent, and studies in this area are predominantly confined to developed economies. This study aims to bridge this gap by exploring factors influencing Indian consumers' preferences for electric vehicles, offering insights crucial for manufacturers and policymakers to refine the electric vehicle ecosystem in the country.

6.12. Objectives

The study aimed at:

- Investigating the Influential Factors Shaping Consumer Perceptions and Preferences in the Adoption of Electric Vehicles, Specifically Passenger Electric Cars.
- Identifying and Examining Varied Utilities Derived by Respondents from Specific Product Attributes, Aiming to Assist Electric Vehicle Manufacturers in Tailoring Offerings to Match Consumer Preferences.

6.13. Research Design

The research used a descriptive research design. In research design, descriptive research seeks to gain knowledge that can be used to methodically describe events, scenarios, or populations through systematic description. More particularly, it assists in answering the what, when, where, and how questions pertaining to the research dilemma instead of the way of the dilemma.

6.14. Questionnaire design and administration

After reviewing the literature, various themes influencing consumers' preference towards electric vehicles were identified. The themes were used to develop a questionnaire that was circulated amongst 250 existing car owners. The questionnaire helped achieve Objective I of the research. The sample consisted of diverse demographics as listed below:

Table 1: Demographic profile of respondents

Gender	Male	139
	Female	61
Monthly Income	20000-40000	39
	41000-60000	43
	61000-80000	71
	81000 & above	47
Educational Qualification	Higher Secondary	20
	Bachelor's Degree	49
	Post graduate	124
	Doctoral Degree	7
Occupation	Working	187
	Non-working	13

Source: Primary data

For achieving Objective-II, a separate questionnaire (conjoint questionnaire) was prepared using SPSS. The questionnaire was circulated to 300 car owners (details provided in section 5.5).

7. Sampling Technique

A judgmental sampling was used for selecting the respondents of the study where the respondents agreed to express their opinion towards Electric Cars. Moreover, respondents were selected based upon their suitability to act as a subject based upon the judgement of researchers. 217 questionnaires were collected back, of which 15 questionnaires were found to be incomplete and were not found suitable for the study. 2 questionnaires were found to be extremely skewed in their responses and hence were rejected. 200 questionnaires were found to qualify for the analysis after data cleaning process. For conjoint analysis, a convenience sampling was used. Questionnaire was circulated to 300 car owners who were looking to change their current cars.

7.1Statistical tools

For investigating the Influential Factors Shaping Consumer Perceptions and Preferences in the Adoption of Electric Vehicles, Specifically Passenger Electric Cars, exploratory factor analysis was performed. After identifying the initial factor structure, a confirmatory factor analysis was applied.
To achieve the second objective, we conducted a literature review to examine various electric vehicle (EV) attributes influencing consumer preferences and acceptance, including factors such as price, recharge time, driving range, etc. In this study, the attitude toward EV adoption was viewed as a decision consumers make among different vehicle alternatives characterized by various attributes. The assumption was that consumers would make purchase decisions by weighing trade-offs among different electric car attributes. Conjoint analysis was employed to identify optimal combinations of electric car attributes that maximize utility for consumers.

7.2Questionnaire Design for Conjoint Analysis

To create the questionnaire, 15 respondents—five from each price category listed in Table 3—were questioned in an unstructured way and asked the following questions:

- On a scale of 1 to 5, with 1 being very low and 5 being very high, please rate your awareness of electric cars.
- Considering India's goal to transition to an all-electric car fleet by 2030, as a potential car buyer, what factors would you take into account when purchasing an electric car? (Open-ended question)

For the purpose of the study, the respondents were encouraged to provide answers based on real-world purchasing scenarios.

Table 2: Attributes considered during Purchasing Electric car

Attribute	Frequency of repetition
Price*	**18**
Recharge time*	**16**
Design	2
Battery replacement cost	5
Driving range*	**12**
Brand	5

Source: Unstructured interview: primary data

Attributes considered by respondents while purchasing an electric car were as mentioned in table Price, recharge time and driving range were three attributes with highest frequency of repetition amongst other attributes mentioned by respondents. Therefore, Price, recharge time and driving range were selected to develop questionnaire for conjoint.
These attributes were used to prepare different profiles consisting of different levels (based on review of literature) of Price, Driving range and Recharge time for conjoint analysis. Levels of each attribute were based on comprehensive review of literature consisting of research articles, industry reports and newspaper articles.

Table 3: Different levels of attributes

Price (Hundred thousand)	Recharge Time	Driving Range
1 - 11.99	Above 6 hours	Under 150 km
12 - 24.99	2 to 6 hours	150 - 250 km
25 Lakh & above	0 to 2 hours	Above 250 km

Source: Review of literature and unstructured interview

Total numbers of combinations to conduct conjoint analysis were
3 (Price) X 3 (Recharge time) X 3 (Driving range) = 27

A set of comprehensive attribute combinations formed an orthogonal design, minimizing the risk of inaccurate or disinterested responses by limiting the permutations to nine. These permutations constituted the questionnaire to ensure procedural validity. From March 11 to August 12, 2023, 300 respondents were sampled at a private institution and various commercial centers in Jalandhar, Chandigarh & Ludhiana. Respondents were selected in parking lots of shopping malls based on their car's estimated price range, aligning with the three crucial factors in car buying within the Indian market.

7.3. Discussion on Results and Findings

Objective 1: Investigating the Influential Factors Shaping Consumer Perceptions and Preferences in the Adoption of Electric Vehicles, Specifically Passenger Electric Cars.
Exploratory Factor Analysis
The internal consistency of the surveys was examined using the reliability statistics. The factorial structure of customer acceptability and preference for electric cars was investigated for the particular sample. All items were subjected to an exploratory factor analysis with promax rotation and maximum likelihood extraction method. The sample adequacy was verified with a KMO (Kaiser-Meyer-Olkin) value of 0.911, confirming that reducing several variables into fewer factors was appropriate. Additionally, the dataset's correlations were suitable for EFA (Table 4), as indicated by the Bartlett test of Sphericity with a value of 0.000.

Table 4: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.811
Bartlett's Test of Sphericity	Approx. Chi-Square	4317.741
	Df	190
	Sig.	.000

A four-factor solution was found to be the best fit for the data using the maximum likelihood factor analysis with a cut-off point of 0.40 and Kaiser's criteria of eigenvalues greater than 1 (Field, 2009; Stevens, 1992). 75.275% of the variance was explained by this solution (Table 5).

Table 5: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.180	35.899	35.899	7.180	35.899	35.899	4.026	20.132	20.132
2	3.699	18.496	54.395	3.699	18.496	54.395	3.818	19.089	39.221
3	2.565	12.824	67.219	2.565	12.824	67.219	3.617	18.085	57.306
4	1.611	8.056	75.275	1.611	8.056	75.275	3.594	17.969	75.275

Extraction Method: Principal Component Analysis.

High factor loading statements on factor one indicates consumer concerns about environmental impact on electric vehicle acceptability. Due to severe air pollution levels, many Indian drivers are considering eco-friendly alternatives (Entrepreneur India, 2018). A recent poll found that 87% of Indians would choose electric vehicles to combat air pollution (Bloombergquint.com, 2018). The Indian electric vehicle market has grown due to increased public awareness and automaker investments (Entrepreneur India, 2018). Governmental support and infrastructure factors link to statements with significant factor loadings on factor two. The Indian government is actively investing in charging station networks and seeking collaborations for an extensive electric vehicle ecosystem (Indian Express, 2018). Propositions on factor three relate to perceptions of financial advantages, while factor four emphasizes electric car performance. Results of factor analysis have been shown below in table 6:

Table 6: Rotated Component Matrix[a]

	Component			
	1	2	3	4
I plan to transition to electric cars to contribute to solving India's pollution problem.	.867			
The adoption of electric cars appeals to me as a choice for cleaner fuel.	.864			
I view the use of electric cars as a crucial step toward a sustainable future.	.861			
I believe electric cars can mitigate the risk of respiratory diseases caused by emissions from conventional vehicles.	.858			
Adopting electric cars is seen as a positive step to reduce ozone layer depletion.	.826			
I am inclined to shift to electric vehicles if the Government of India promotes convenient purchase options like easy loans and lower interest rates.		.860		
Government policies favoring electric cars would motivate me to make the switch.		.855		
Subsidies from the Government of India for charging station usage would encourage my transition to electric cars.		.847		
Availability of sufficient service stations, supported by government initiatives, would make me consider shifting to electric cars.		.821		
Government efforts to build infrastructure, including roads and charging stations, would facilitate my transition to electric cars.		.802		
I believe electric cars have the potential to lower electricity costs.			.829	
Appropriate pricing would be a key factor influencing my decision to shift to electric cars.			.818	
Low maintenance costs compared to conventional vehicles would make electric cars more appealing to me.			.792	
Relatively cheaper private transport is a significant factor in my decision to shift to electric cars.			.772	
Waiving sales tax on the initial purchase of electric vehicles would incentivize my transition.			.765	

Maintaining speed without compromise is a crucial consideration for me to shift to electric cars.				.870
Quick recharging times would make electric cars more practical for me.				.855
Efficiency matching or exceeding existing vehicles is essential for my consideration of electric cars.				.848
Performance-oriented battery backup is a key factor in my decision to shift to electric cars.				.837
Lower chances of engine breakdown would significantly contribute to my preference for electric cars.				.816
Cronbach's alpha	.918	.909	.901	.936
Eigenvalues (percentage of variance)				75.275
KMO				0.811
Bartlett's test of Sphericity				
Approx. Chi Square				4317.741
Df				190
Significance				0.000
a. Rotation converged in 5 iterations.				

Source: Primary study

Confirmatory Factor Analysis

Assessing Reliability and Validity

Once the results of EFA reflected four different dimensions building consumer preference and acceptance towards electric cars adoption, CFA was deemed necessary to ascertain the validity of the measurement model/scale proposed.

Convergent validity and discriminant validity are the two criteria that Campbell and Fiske (1959) suggested be used to evaluate construct validity. Convergent validity in a confirmatory factor analysis looks at how much the variance of a latent variable is shared by its measurements. On the other hand, discriminant validity looks at how they differ from other concepts.

Convergent validity

The Fornell-Larcker (1981) criterion is primarily employed to quantify the extent of shared variance among the latent variables in the model. This criterion states that Average Variance Extracted (AVE; values above 0.7 are considered very well) and Composite Reliability (CR; an acceptable value of CR is above 0.7) can be used to evaluate the convergent validity of the measurement model (Bagozzi & Yi, 1988; Fornell & Larcker, 1981; Hair et al; 1995; Nunnally, 1978). As indicated in Table 8, the average variance explained, and composite reliability values were determined to be within acceptable bounds, indicating convergent validity.

Table 7: Composite reliabilities (CR), and AVE results

Dimension	CR	AVE
Environmental Factors	0.901	0.663
Governmental aid and infrastructure	0.921	0.741
Perception of economic benefits	0.911	0.696
Performance	0.903	0.641

Source: Primary study

Discriminant validity

The results of the constructs' discriminant validity are compiled as a factor correlation matrix. The table shows that all of these values are higher than the constructs' correlation values. Thus, it can be concluded that the characteristics (items) that have been identified are valuable indicators of the adoption behaviour of electric cars.

Table 8: Discriminant validity of the constructs (square root of the AVE and correlations)

	Environmental Factors	Governmental aid and infrastructure	Perception of economic benefits	Performance
Environmental Factors	**0.716**			

Governmental aid & infrastructure	-0.565	**0.764**		
Perception of economic benefits	0.530	-0.333	**0.733**	
Performance	0.052	0.058	0.078	**0.704**

Source: Primary study

Note: (a) The bold fonts in the leading diagonals are the square root of AVEs, (b) off-diagonal elements are correlations among constructs

Evaluating the fitness of a measurement model

In CFA, several Fitness Indexes reflect how fit the model is to the data at hand. There are three model-appropriate categories: Absolute Fit, Incremental Fit, and Parsimonious Fit. The choice of index to choose from each category to report depends on which literature is being referred. The information concerning the model fit category, their level of acceptance, and comments are presented in Table 9:

Table 9: Fitness Indices

Model fit category	Name of index	Level of acceptance	Observed values
Absolute fit	RMSEA	RMSEA < 0.08 (Browne and Cudeck, 1993)	0.021
	GFI	GFI > 0.90, (Joreskog and Sorbom, 1984)	0.927
Incremental fit	CFI	CFI > 0.90, (Bentler, 1990)	0.911
Parsimonious fit	Chisq/df	Chisq/df < 3.0, (Marsh and Hocevar, 1985)	2.113

Source: Primary study

The results, as mentioned above were in accordance with the prescribed model fit indices validating the CFA.

Objective 2: Identifying and Examining Varied Utilities Derived by Respondents from Specific Product Attributes, Aiming to Assist Electric Vehicle Manufacturers in Tailoring Offerings to Match Consumer Preferences.

Conjoint analysis is a tool for developing customer-centric products. Conjoint analysis allows researchers to answer questions about attributes essential to the consumer.

The benefit of conjoint analysis is that it asks the respondent to make choices by trading off one feature against another to maximize utility. The full-profile approach was used, where respondents ranked various profiles per their preference. The individual profiles define a complete product and consist of different levels for all factors (attributes) of interest.

Formulation of Problem: Based on the review of literature and interaction with customers, the attributes were selected. A partial list of nine combinations was chosen for study.

Construct the Stimuli: The fractional factorial design was used to decrease the number of profiles from twenty-seven to nine, which respondents had to rank as per their preference.

Table 10: Electric car attributes profile

Combination No	Price	Recharge Time	Driving Range	Rank
1	25Lakhs-Above	0-2hHours	Below150KMs	
2	1-11.99Lakhs	2-6Hours	Above250KMs	
3	25Lakhs-Above	Above6Hours	Above250KMs	
4	1-11.99Lakhs	0-2hHours	150-250KMs	
5	12-24.99Lakhs	0-2hHours	Above250KMs	
6	25Lakhs-Above	2-6Hours	150-250KMs	
7	12-24.99Lakhs	2-6Hours	Below150KMs	
8	12-24.99Lakhs	Above6Hours	150-250KMs	
9	1-11.99Lakhs	Above6Hours	Below150KMs	

Source: Primary data

Decision on the Form of Input Data: Metric form of rating was used to collect responses on a scale of one to nine (One as least preferred to nine as highly preferred).
The basic **conjoint analysis model** is represented by the following formula where:

U(X) = overall utility of an alternative
= the part-worth contribution or utility associated with the *j*th level ($j, j = 1, 2, \ldots k_i$) of the *i* th attribute ($i, i = 1, 2, \ldots m$)
x_{jj} = 1 if the *j* th level of the *i* th attribute is present
= 0 otherwise
k_i = number of levels of attribute *i*
m = number of attributes

The importance of an attribute, I_i, is defined in terms of the range of the part worth, across the levels of that attribute:
The attribute's importance is normalized to ascertain its importance relative to other attributes, $W_{i=}$

$$W_i = \frac{I_i}{\sum_{i=1}^{m} I_i}$$

:

Table 11: Utilities

Utilities			
		Utility Estimate	Std. Error
Price	1-11.99 Hundred Thousand	-.131	.103
	12-24.99 Hundred Thousand	.391	.103
	25 hundred Thousand and Above	-.104	.103
Recharge Time	Above 6 Hours	-.121	.103
	2-6 Hours	.003	.103
	0-2 Hours	.148	.103
Driving Range	Below150 KMs	-.151	.103
	150-250 KMs	.021	.103
	Above250KMs	.141	.103
(Constant)		5.000	.074

Source: Primary data

Utility table describes the utility coefficients for each level of attribute. Higher is the utility coefficient, higher is the utility. In case of price, respondents were found to derive maximum utility in the price range of 12-24.99 lakhs (Utility coefficient: .391) followed by a price range of 25 Lakhs and above (Utility coefficient: -.104) and 1-11.99 Lakhs (Utility coefficient: -.131).
In case of recharge time, respondents were found to derive maximum utility in the recharge time of 0-2 Hours (Utility coefficient: .148) followed by recharge time of 2-6 Hours (Utility coefficient: .003) and above 6 Hours (Utility coefficient: -.121).
In case of driving range, respondents were found to derive maximum utility in the driving range of above 250 KM (Utility coefficient: .141) followed by driving range of 150-250 KM (Utility coefficient: .021) and below 150 KM (Utility coefficient: - .151).
Hence, it could be concluded that respondents assigned maximum utility to these three combinations:

Table 12: Top three utility combinations

Utility Order	Price (in Lakhs)	Recharge time (in Hours)	Driving range (in KMs)
1	12-24.99	0-2	Above 250
2	25 Lakhs & above	2-6	150-250
3	1-11.99	Above 6	Below 150

Source: Primary data

Table 13 shows the attribute providing maximum utility to respondents. Price (44.857) was found to be most important of attribute followed by driving range (28.129) and recharge time (27.014).

Table 13: Most important attribute

Importance Values	
Price	44.857
Recharge Time	27.014
Driving Range	28.129
Averaged Importance Score	

Source: Primary data

Table 14: Correlation table

Correlations		
	Value	Sig.
Pearson's R	.930	.000
Kendall's tau	.778	.002
a. Correlations between observed and estimated preferences		

Source: Primary data

Table 14 shows whether the correlation between observed and estimated preferences was significant. As prudent from the analytics, the correlation between observed and estimated preferences was found to be significant, which signaled the appropriateness of the conjoint model for studying consumer preference toward electric vehicles.

8. Findings

According to the results of factor analysis, statements with high factor loadings on factor one corresponded to environmental factors influencing the preference for and acceptance of electric cars among consumers. Dangerous levels of air pollution have prompted Indian drivers to consider entering the market for environmentally friendly vehicles (Entrepreneur India, 2018). In addition, according to a new survey, 87 percent of Indians would purchase an electric vehicle if it helped reduce air pollution (Bloombergquint.com, 2018). Increasing awareness of the harmful effects of air pollution among Indians and the massive investments made by automakers in this area have ensured the continued growth of the Indian electric vehicle market (Entrepreneur India, 2018). Governmental aid and infrastructure-related factors corresponded to statements with high factor loadings on factor 2. In this regard, the Indian government is investing in the development of a network of private and public charging stations. The government of India is also working to establish a comprehensive ecosystem for electric vehicles and is seeking cooperation from numerous stakeholders (Indian Express, 2018). The perception of economic benefits corresponds to statements with high factor loadings on factor three. The performance of electric cars corresponded to statements with high factor loadings for factor four.

Product managers and product development teams may find the results of conjoint analysis particularly useful for gaining consumer insights regarding their preferred electric vehicle options. According to the study, electric cars with a price tag of Rs. 12-24.99 Lakhs, a recharge time of 0-2 hours, and a driving range of over 250km on a single charge are the most popular. The second most popular option was electric vehicles with a price tag of Rs. 25 Lakhs or more, a recharge time of 2-6 hours, and a driving range of 150-250 kilometers on a single charge. The third most popular option was an electric vehicle with a price tag between Rs.1 and 11.99 Lakhs, a recharge time greater than 6 hours, and a range of fewer than 150 kilometers on a single charge.

9. Conclusion and Implications

Electric vehicles have captured the attention of the global automobile industry. With the government of India pushing for complete electrification as early as 2030, there is much going on in the Indian electric car segment. Almost 40 percent of Indian car users want to pay less for an electric vehicle. Another 30 percent are willing to pay in parity to a conventional car. Only 15 percent of Indian car users are willing to pay more. An electric version of a car is priced at least 25 percent more than that of a similar petrol or diesel version. Relatively low awareness about electric cars in India and the possible effects of unawareness may also be an obstacle that marketers must address (Frost & Sullivan, 2017; Orr et al; 2017)

The findings of this research have multifaceted implications for a market as diverse as India. These findings will help automakers understand the factors behind electric vehicle adoption and offer electric cars as per customers' preferences. However, they will also help policymakers devise policies to ease the electric vehicle adoption process. Since Indian consumers have shown a pro-environmental attitude towards electric car adoption (Bloombergquint.com, 2018), developing

joint marketing campaigns highlighting the environmentally friendly aspects of electric cars by government agencies and automakers shall be of use to help ease electric car adoption process by creating needed awareness to masses still stuck between the choices of electric over traditional vehicles. Since perceived economic benefit was another factor in customers' decision to buy electric cars, stakeholders (Government and automakers) must strategize their actions accordingly. Indian consumers were found to be skeptical regarding the price of electric vehicles, as per myriad surveys (Business Standard, 2018). Hence, the role of the government to subsidize electric car adoption (Times of India, 2018**)** and the role of automakers to educate customers about electric vehicles partially offsetting the cost of acquisition due to the relatively lesser need for regular maintenance over traditional vehicles (Autoblog.com, 2011) must be strategized. Performance was yet another factor playing an essential role in the adoption of electric cars, with the current status of Government officials refusing to use electric cars made by home-grown carmakers - Mahindra and Mahindra and Tata Motors - due to poor performance and low mileage (Business Today, 2018), automakers need to benchmark performance standards with global giants. Product development collaborations with global brands can be a righteous step in this direction.
The conjoint analysis results could be of particular use to product managers and product development teams in getting consumer insights about preferred electric vehicle choices. As per the study, the most preferred combination was electric cars with a price tag of Rs. 12-24.99 Lakhs, having a recharge time of 0-2 hours, and driving a range above 250km on a single charge. Electric cars with a price tag of Rs. 25 Lakhs and above, having a recharge time of 2-6 hours and a driving range of 150-250 km in a single charge were the second most preferred choice. The third preferred choice was an electric car with a price tag of Rs.1-11.99 Lakhs, having a recharge time of above 6 hours, and capable of traveling below 150km on a single charge.

10. Limitations

The study was conducted in Punjab region of India only. The study thus might not be a representative of India. Future studies must be conducted using a diverse set of population from various states of India. Only three product attributes were used for studying consumer utilities wiz; Price, Recharge time and Driving range. More number of attributes could be taken to create rich attribute profiles for electric cars and hence to provide electric carmakers a rich insight into combination of key attributes having maximum utility to Indian consumers. The study was cross-sectional in design. However, given the novelty of this area and the candor with which it is growing, electric car adoption behavior may go through many robust changes. A longitudinal design thus may be of particular use to gauze at the consumers' preference towards electric cars.

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