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Exploring electric vehicle consumer behavior: impact of digital innovation, environmental concern, perceived value, and social influence on purchase intentions

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Background: Understanding the drivers and boundary conditions of electric vehicle (EV) adoption is critical to fostering sustainable transportation. Building on perceived value and planned behavior theories, this study proposes a moderated mediation model in which perceived value influences both sustainability perception and purchase intentions, with household income, technology trust, and environmental knowledge serving as moderators.
Methods: A cross-sectional survey of 496 licensed drivers familiar with EVs was conducted using validated multi-item scales. Data were analyzed in R using confirmatory factor analysis and structural equation modeling (lavaan), incorporating product-indicator interactions and 5,000-sample bootstrapping to test the direct, moderating, and mediating effects.
Results: Consumers' perceived value has a positive effect on sustainability perception (0.122, $p < 0.001$) and purchase intentions (0.002, $p < 0.001$). Household income also strengthens the relationship between perceived value and purchase intention (0.043, $p < 0.001$). Digital innovation (0.285, $p < 0.001$) and environmental concerns (0.411, $p < 0.001$) dynamically influenced the perception of sustainability at a significant level, although social influence was not significant. Compared with other variables, sustainability perception had the greatest effect on consumers' intention to buy an electric car (0.624, $p < 0.001$) and served as a mediator in three out of four indirect connections between perceived value and purchase intention. The moderating effects of technology trust and environmental knowledge were not supported.
Conclusion: These findings highlight the central roles of value and sustainability perceptions in EV adoption and identify income as a key boundary condition. Practical implications include tailoring incentives by income segment, investing in user-centric digital platforms, and emphasizing both economic and environmental benefits. Theoretically, this study extends technology acceptance models by integrating sustainability constructs and underscores the nuanced impact of socioeconomic factors on green consumer behavior.

KEYWORDS

electric vehicles, perceived value, sustainability perception, purchase intentions, digital innovation, environmental concerns, moderated mediation

1 Introduction

The automobile sector is a complex industry with various changes, one of which is electric vehicles (EVs), a global platform that has changed because of factors such as technology, government regulations, and the perceived effect of using electric automobiles on the environment (Rehman and Jajja, 2025). By 2020–2025, a global EV market that sold <3 million units per year climbed to more than 10 million units per annum, as the combined effects of reduced battery prices and reduced emissions requirements took hold. Governments and EV manufacturing companies are pouring money into charging networks, subsidies, and model differentiation, making EVs a key pillar of decarbonization plans and energy security (Evro et al., 2024). Using transportation, which contributes almost 25% of the worldwide emissions of CO_2, a high penetration of EVs is necessary to achieve global climate goals and mitigate air pollution problems in most cities (Işık et al., 2021).

Although the technology supporting the use of EVs supports this, its penetration into the consumer market is not evenly spread across geographies and demographics (Jaiswal et al., 2022). The decision to purchase is dependent on issues such as the price of purchase, range anxiety of the driving capacity, convenience of charging, and social norms that cannot be merely simplified by standard economic reasoning (Bhat et al., 2024). In such contexts, it is imperative that manufacturers, policymakers, and marketers interested in a faster uptake are deeply concerned with sophisticated knowledge of EV customer behavior (Han et al., 2024). Understanding the formation of intentions based on perceptions of value, environmental concern, digital innovation, and peer influence can contribute to the development of targeted interventions, including programmed incentive programs, education messages, and customer-friendly charging systems, which should mitigate the main obstacles to adopting the electric vehicle market (Han et al., 2024).

The primary objective of this research is to discover and measure the most critical factors that lead to the intention to purchase electric vehicles (EVs), which include perceived value, digital innovation, environmental concern, and social influence, and to determine how they influence consumer perceptions of sustainability and the final decision to purchase. A secondary objective was to explore the boundary conditions that strengthen or weaken these effects by examining the moderating roles of household income, technology trust, and environmental knowledge. Lastly, the current research examined the mediating role of perceived sustainability on purchase intention, thus ascertaining the psychological process that transforms estimates of value to a material EV ownership practice.

> *RQ1: How does perceived value influence EV sustainability perception and purchase intentions and to what extent does income moderate this effect?*
>
> *RQ2: What are the impacts of digital innovation, social influence, and environmental concerns on sustainability perception, and how do technology trust and environmental knowledge affect these relationships?*
>
> *RQ3: Does sustainability perception mediate the relationship between perceived value and purchase intention, and is this mediation contingent on consumers' environmental knowledge?*

By integrating consumer psychology with technological and environmental factors in a unified structural model, this study contributes meaningful information to the existing literature on sustainable transport and offers practical information to relevant stakeholders (Ketter et al., 2022). The findings can guide automakers in product development, assist policymakers in designing more effective incentive schemes, and help marketers craft messaging that resonates with diverse consumer segments, ultimately accelerating the transition to a low-carbon transportation future.

2 Literature review

2.1 Purchase intention in the adoption of electric vehicles

Purchase intention is the specific disposition of a consumer to make a plan or is willing or ready to acquire a commodity later and plays a key role in predicting real consumer behavior, particularly when it comes to adopting an electric vehicle (EV) (Srivastava et al., 2023). Against this background, where the expense of EVs, technological novelty, and infrastructural issues might keep consumers from purchasing an EV, their intention to purchase strongly affirms that consumers find cost–benefit trade-offs favorable and environmentally conscious and think of EVs as having a high social prestige (Foroughi et al., 2024). Studies have indicated that factors influencing purchase intention belong both to the cognitive side (e.g., product perception, fuel and maintenance savings, performance) and the emotional side (environmental concern, attachment to the green technology), but also to social sources of the behavior (social norms, government subsidies) (He et al., 2020; Wang et al., 2021). Using purchase intention, stakeholders will be able to estimate the success of marketing campaigns, policy, and technological measures that can reduce barriers to adoption and speed up the transition into sustainable transportation (Bhatia et al., 2024; Dadashzada et al., 2024).

2.2 Perceived value on EV adoption

Perceived value also plays a significant role in consumer decisions about the electric vehicles (EVs) (Wang et al., 2024; Zhang et al., 2021). Purchase intention strengthens as buyers believe the advantages of EV ownership may supersede, for example, in saving money in fuels and maintenance costs, incentives arranged by governments, less noise and environmental pluses, over the costs of a greater up-front price, range anxiety, and time to charge it (Featherman et al., 2021; Jia and Chen, 2021). The concept of functional, economic, social, and emotional value evaluates this multi-dimensional aspect, which can justify consumer willingness to invest in EV technology and, eventually, actual purchase (Bulawa et al., 2024).

> *H1: Perceived Value (PV) positively impacts Purchase Intentions (PI).*

The issue of the connection between perceived value and electric car purchasing intentions strongly relies on the level of income the consumer is brought to (Lv et al., 2023). Relative to those with lower incomes, higher-income people tend to convert a positive result on value measurement to specific buying intentions as they can afford early price premiums and are less put off by range or charging issues (Jia and Chen, 2021) (Kubli, 2022). On the other hand, lower-income buyers might need a stronger value position, for example, high subsidies leading to lower overall cost of ownership to translate many perceived benefits into concrete purchase intentions (Srivastava et al., 2023).

> *H1a: Moderating role of income between perceived value (PV) and Purchase Intention (PI).*

Perceived value also influences consumers' perception of consumers towards perceiving electric vehicles as an eco-friendly source of transportation (Cruz-Jesus et al., 2023). The consumer is also expected to appreciate the potential benefits of using an EV because the perceived net benefits will be experienced when the positive effects of EVs on lowering emissions, air quality, and other environmental interests are noticed to offset the costs (Parker et al., 2021). Such a high sustainability perception not only contributes to the appeal of EVs, but also creates the foundation of a stronger purchase intention due to a greater sense of environmental responsibility (Almansour, 2022; Xun et al., 2024).

> *H2: Perceived Value (PV) positively impacts Sustainability Perception (SP).*

2.3 Role of social influence on purchase decisions

Social influence is important in affecting the sustainability of electric vehicle (EV) purchasing, as perceived by consumers (Secinaro et al., 2022; Xun et al., 2024). When people witness other members of society in the form of family, friends, or Facebook connections engaging in positive statements about EVs, relaying stories of personal use of EVs, or employing the visible use of EVs, they absorb that information as social evidence stating that driving an EV fits within the collective values of caring about the environment (Chung and Chon, 2024). Such normative pressure will help potential buyers consider EV ownership not only an aspect of their personal choice but also a socially accepted way of ensuring cleaner air and lower emissions (Chang, 2023). Likewise, informational influence, which consists of getting experiences with other people regarding the efficiency of EVs and their effect on the environment, serves to minimize uncertainty and beliefs about the sustainability of EVs (Tripathy et al., 2022).

> *H3: Social Influence (SI) positively impacts EV Sustainability Perception (SP).*

2.4 Digital innovation in the EV market

Digital Innovation products are mobile applications that can find charging stations in real time, over-the-air update software to improve efficiency, and smart charging that relies on predictive analytics, bringing electric cars into the focus of consumers as more sustainable options (Li et al., 2024). Such technologies do not merely address practical issues, such as range anxiety or energy optimization, but also harbor future-proof, high-tech mobility systems that would work according to environmental intentions (Hannan et al., 2022). As vehicle-to-grid integration provides them with a convenient experience of connectivity, progressively better performance, and the ability to support the grid, electric vehicles appear as an eco-friendlier and more responsible mode of transport to buyers (Rehman and Jajja, 2025).

> *H4: Digital Innovation positively impacts Sustainability Perception.*

The benefit of digital innovation over sustainability perception depends on the extent to which consumers trust the technologies that underpin innovation (Yuen et al., 2023). When people feel highly assured of the dependability, safety, and quality of software upgrades, features based on data, and connection solutions, they would most likely trust these advancements as valid contributors to environmental sustainability (Alqahtani and Kumar, 2024). However, low technology trust can diminish the positive effects of perceived environmental advantages of digital functions, and these aspects would not be influential enough on the sustainability perception of consumers of electric vehicles (Featherman et al., 2021).

> *H4a: Moderating Role of Technology Trust between Digital Innovation and Sustainability Perception.*

2.5 Environmental concerns and green consumption

Increased environmental awareness makes consumers perceive electric cars as a more environmentally friendly method of transport (Nogueira et al., 2023). Given that people are concerned about air pollution, carbon emissions, and resource shortages, there is a growing perception of EVs, whose zero-tailpipe emissions and potential renewable sources of energy have direct solutions to these environmental concerns (Tuffour and Ewing, 2024). Consequently, the more concerned people are with the environment, the higher the level of sustainability ratings of EVs and the more willing a buyer is to appreciate and identify environmental advantages (Irfan and Ahmad, 2021).

> *H5: Environmental Concerns' positively impacts on Sustainability Perception.*

The impact of environmental interest on EV sustainability perception depends on consumers' environmental knowledge (Ju and

Kim, 2022). Those who believe more strongly in the ecological concepts and knowledge, that is, life cycle effects of vehicle production, advantages of renewable energy, and actual reductions in emissions, perceive the connection between their environmental concerns and the practical sustainability benefits of EVs better (Gautam and Bolia, 2024). On the other hand, individuals who do not have a good understanding of the environment might not be aware of the full extent of how EVs can help reduce damage to the environment, consequently reducing their concern about the environment to a positive perception of sustainability (Choo et al., 2024; Haghani et al., 2024).

> *H5a: Moderating Role of Environmental Knowledge between Environmental Concerns and Sustainability Perception.*

2.6 Influence of sustainability perception on purchase intention

Consumers form weaker purchase intentions when they feel that the electric vehicles (EVs) do not help in achieving environmental sustainability, particularly in lowering carbon emissions, conservation of energy, and other related motives such as cleaner air (Tsai et al., 2025). Such a higher brought about by sustainability perception offers moral as well as practical reasons, increasing the willingness of buyers to invest in EV technology, regardless of the possible higher cost (Yadav and Yadav, 2024). By absorbing EV ownership as an environmentally friendly action, buyers turn conceptual environmental advantages into practical inspiration to make a decision to buy (Hartmann et al., 2025).

> *H6: Sustainability Perception's positively impacts on Purchase Intentions.*

The relationship between sustainability perception and purchase intention is strong based on consumers' environmental knowledge of the consumers (Kumar et al., 2020). Those who managed to gain a greater level of understanding regarding the processes on the ecological plane and the life-cycle advantages provided by EVs are more likely to transform their sustainability-related perceptions into a concrete intention to buy it (Liu and Tao, 2021). Conversely, those with low environmental awareness can warn of the environmental advantages of EVs in theory, but still do not have sufficient understanding to fully transfer these impressions into their purchase patterns (Tripathy et al., 2022).

> *H6a: Moderating Role of Environmental Knowledge between Sustainability Perceptions and Purchase Intentions.*

2.7 Integration of behavioral theories

2.7.1 Theory of planned behavior (TPB)

According to the TPB, the intentions given by an individual concerning their behavior are the strongest or nearest predictive of the actual behavior the individual exhibits. There are three major players in determining this intention: attitudes, subjective norms, and perceived behavioral control (Ahmed et al., 2024). Attitudes indicate the positive or negative thoughts of an individual concerning their desire to do or perform the behavior in most cases premised on anticipated consequences (Bechler et al., 2021). Subjective norms are the perceived social pressure to carry out behavior or avoid significant others (Roh et al., 2022). The perception of behavioral control includes the perception of the individual about his/her capability to engage in the behavior, and it directly and equally affects intention and behavior (Lim and Weissmann, 2021). Combinations of these components explain why people behave or do not behave in a predictable manner; hence, TPB is an influential model in explaining a vastly broad number of behaviors, such as health decisions or adopting technology (Anayat et al., 2023). Recognizing which factor (attitude, social pressure, or beliefs about control) has the greatest impact on intention, it is possible to create an intervention that changes beliefs, builds confidence, or modifies social expectations, thus promoting desirable conduct.

2.7.2 Technology acceptance model (TAM)

TAM highlights the adoption of new technologies by considering two main beliefs namely perceived usefulness (PU) and perceived ease of use (PEOU) (Ünal and Uzun, 2020). Perceived usefulness represents how much an individual is of the view that the given technology will enhance their performance, whereas perceived ease of use is the view held by the individual that the technology will be easy and will not demand much effort to work with it (Liu et al., 2021). Collectively, these beliefs determine how a user feels towards the technology, which in turn determines his/her desired intention to use the technology, and finally, the actual behavior of usage (Ünal and Uzun, 2020). External factors, such as system design features, training, or organizational support, feed into PU and PEOU, making TAM both parsimonious and adaptable to various contexts (FakhrHosseini et al., 2022). By highlighting the central role of utility and usability in technology uptake, TAM guides designers and managers in prioritizing features and support mechanisms that maximize acceptance and sustained use.

2.7.3 Applicability of selected theories in EV context

This combination of TPB, TAM, and Perceived Value Theory is highly suited to the adoption of the electric vehicle (EV) adoption due of the collective capture of the highly multifaceted interaction of cognitive, technological, and behavioral factors determining the choice of sustainable consumption behavior. TPB is effective in covering both psychological and social factors of behavior, which demonstrates the attitude towards EVs and the perceived social pressures of consumers and their perceived behavioral control, including affordability, ease of use, and determination of the intention to make a purchase in an environmentally conscious environment. Comparatively, TAM can be defined as extremely relevant because EVs are dependent on new digital technologies and innovative approaches to delivering solutions such as smart charging, connected vehicle systems, and software-driven performance optimization. The TAM explains why the ease of use and perceived usefulness of this technological innovation will result in acceptance and adoption by consumers. Finally, Perceived Value Theory explicitly appreciates consumer assessments that entail balances among economic costs (e.g., the original price, cost of maintenance), as well as technological advantages (e.g., convenience and advanced functions) and environmental advantages (e.g., less emissions and less carbon footprint). This theory refers to the multi-dimensional value judgments that EV purchasing entails, which is why it will be more suitable to conduct a study of green or sustainable technological innovations.

3 Research methodology

3.1 Conceptual framework development

The conceptual framework integrates the established theoretical insights and the study's research questions and hypotheses into a unified model. Prior literature demonstrates that perceived value (PV), defined as consumers' assessment of benefits versus costs, strongly shapes both purchase intentions (PI) and sustainability perceptions (SP), leading to H1 (PV → PI) and H2 (PV → SP). To address RQ1 on how socioeconomic factors condition this relationship, income is introduced as a moderator of the PV–PI link (H1a). Complementary research on technology acceptance and green consumption underscores the roles of social influence (SI), digital innovation (DI), and environmental concerns (EC) in fostering sustainability perceptions, underpinning H3 (SI → SP), H4 (DI → SP), and H5 (EC → SP). Recognizing that trust and knowledge can strengthen or weaken these effects, Technology Trust (TT) is proposed to moderate the DI–SP path (H4a) and Environmental Knowledge (EK) to moderate the EC–SP link (H5a). Finally, consistent with TPB and mediation studies, sustainability perception is posited to drive purchase intentions (H6), with EK again moderating this SP–PI relationship (H6a), thereby addressing RQ2 and RQ3 regarding the mediating role of SP and the contingent influence of EK. Thus, this framework captures direct effects, moderating conditions, and mediation pathways to explain how value and social, technological, and environmental factors jointly determine EV adoption behavior (Figure 1).

3.2 Research design

A quantitative, cross-sectional survey design was employed, with data analyzed in R (v4.x) using lavaan (Rosseel, 2012) and semTools (Jørgensen et al., 2018) packages. A structured questionnaire using five-point Likert scales measured all constructs, and a minimum sample size of 300 was targeted to meet the "10 observations per parameter" guideline. Licensed drivers aged 18 and above who were familiar with EVs were recruited online, yielding <5% missing data per variable. The data were screened for univariate normality (skewness within ±2; kurtosis within ±7) and outliers. Confirmatory factor analysis assessed indicator reliability and construct validity, with Cronbach's α and composite reliability values exceeding 0.70 and average variance extracted (AVE) exceeding 0.50. Structural relationships, moderation effects (using product–indicator interactions for Income, Technology Trust, and Environmental Knowledge), and mediation pathways were tested in lavaan with 5,000 bootstrap samples, and all hypothesis tests were evaluated at $p < 0.05$.

3.3 Sampling procedure and its limitations

The use of cross-sectional surveys and non-probability convenience samples recruited through online websites and social networks, though very appropriate in the construction of a wide geographic range sample of licensed motorists and EV users, does not allow causal inference or even restricted generalizability. Because it is impossible to determine a temporal order in cross-sectional designs, causal relationships are

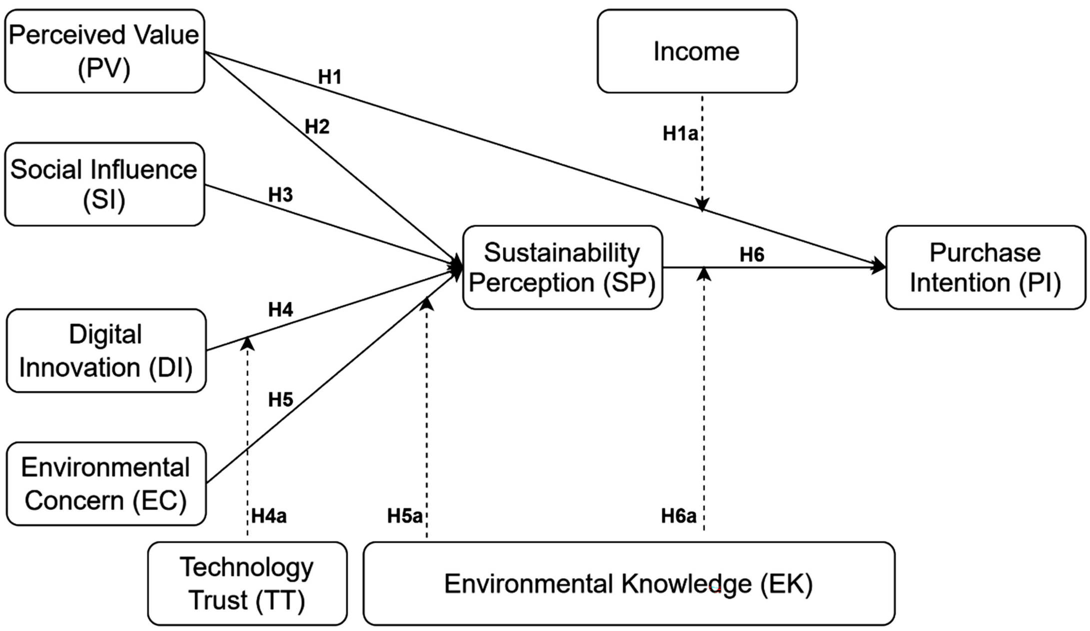

FIGURE 1
Conceptual framework of EV purchase intentions.

rather speculative; the use of actively engaged individuals online can also prove biased in terms of both demography and culture (e.g., it is likely to overrepresent a younger, tech-savvy population). To overcome these limitations, a longitudinal or experimental research design would be desirable to better estimate a causal effect, and a stratified random sampling strategy, a clearly defined sampling quota, or cross-national comparative designs should be used to facilitate the highest possible generalizability beyond the study sample and that demographic and cultural diversity are adequately covered.

3.4 Measurement scales

An overview of the measurement scales used in this study is presented below. All constructs were assessed based on multiple-item scales, which were obtained from well-established sources, and participants were asked to define whether they strongly agree or strongly disagree with it on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) (Table 1).

3.5 Sample profiles

An overview of respondents' demographic characteristics, including their educational attainment, age distribution, and annual income levels, offering context for the sample's representativeness and aiding interpretation of subsequent analyses (Table 2).

3.6 Detailed statistical procedures for replicability

Structural Equation Modeling (SEM) with R software (version 4.x) was performed in two steps, to be more specific, in the lavaan and semTools packages. First, Confirmatory Factor Analysis (CFA) was used to assess the reliability of measurement, convergent validity, and discriminant validity according to conventional standards (Cronbach's alpha and Composite Reliability > 0.70, Average Variance Extracted > 0.50). Structural path analyses were performed after validating the CFA. The moderating effects were Income, Trust in Technology, and Environmental Knowledge, which were exposed to the interaction product-indicator approach premises. Additionally, the mediation pathways were estimated and tested in terms of confidence and significance with the help of bootstrapping (5,000 bootstrap samples). The reasons behind the choice of bootstrapping were the potential non-normality of the distributions of the indirect effects and the enhanced precision and replicability of the mediation tests. That such researchers in the future will also be able to reproduce such methodological steps, will also be desirable, and such accountability, complete control, and openness are desirable.

TABLE 1 Measurement scales and their sources (author, year).

Component	Author(s) and year
Perceived value (PV)	Zeithaml (1988)
Social influence (SI)	Venkatesh et al. (2003)
Digital innovation (DI)	Warner and Wäger (2019)
Environmental concerns (EC)	Dunlap and Van Liere (1978)
Environmental knowledge (EK)	Milfont and Duckitt (2010)
Technology trust (TT)	McKnight et al. (2002)
Sustainability perception (SP)	Wang and Li (2019)
Purchase intention (PI)	Ajzen (1991)

TABLE 2 Demographic profile of respondents.

Category	Sub-category	Count	Percentage
Education	Graduates	236	47.58%
	Postgraduate or Higher Degrees	171	34.47%
	Professional Qualification	88	17.74%
Age	Below 30 years	69	13.91%
	30–40 years	252	50.80%
	40–50 years	149	30.04%
	Above 50 years	26	5.24%
Income	Below 1,000,000 per annum	87	17.54%
	Between 10 and 15 lakhs	145	29.23%
	Between 15 and 20 lakhs	133	26.81%
	Between 20 and 25 lakhs	82	16.53%
	Above 25 lakhs	49	9.8%
Total	All categories combined	496	100%

4 Results

4.1 Measurement model

Confirmatory factor analysis (CFA) was also used to evaluate the measure model: indicator reliability was very high, as the standardized loadings varied between 0.740 and 0.945, far exceeding the formally recommended adequacy level (0.70) to achieve convergent validity (Hair et al., 2010). TT1 had a low loading of 0.444 and was removed to enhance the validity of the model. The reason that internal consistency was confirmed lies in Cronbach's alpha values that are in the range of 0.836–0.946 and the composite reliability scores, which are above the recommended 0.70 requirement by surpassing 0.852 (Nunnally and Bernstein, 1994). Confirmation of convergent validity was also facilitated by the average variance extracted (AVE), which ranged between 0.611 and 0.811 and was higher than the minimum requirement of 0.50 (Fornell and Larcker, 1981). Discriminant validity was confirmed by the Fornell-Larcker criterion, and the square root of the AVE of all constructs (0.781–0.900) was found to be larger than their inter-construct correlations, and the HTMT ratios were all <0.85 (Henseler et al., 2015). All of these results agree that the measurement model is reliable and valid for use in structural analysis.

4.2 Structural model

The structural model showed that Perceived Value (PV) greatly influences Sustainability Perception (SP) (beta = 0.122, $p < 0.001$) and Purchase Intention (PI) of electric vehicles (beta = 0.002, $p < 0.001$) in

TABLE 3 Standardised loadings.

Construct	Indicator	Std. load
PI	PI1	0.853
	PI2	0.895
	PI3	0.827
	PI4	0.860
SP	SP1	0.895
	SP2	0.890
	SP3	0.924
	SP4	0.881
	SP5	0.846
PV	PV1	0.945
	PV2	0.853
	PV3	0.892
	PV4	0.861
SI	SI1	0.889
	SI2	0.930
	SI3	0.848
	SI4	0.841
	SI5	0.875
DI	DI1	0.934
	DI2	0.875
	DI3	0.901
	DI4	0.890
EC	EC1	0.821
	EC2	0.843
	EC3	0.905
	EC4	0.874
EK	EK1	0.873
	EK2	0.815
	EK3	0.740
TT	TT1	0.444
	TT2	0.896
	TT3	0.854
	TT4	0.844

a positive direction. Another factor that further enhances the relationship between PV and PI is income (beta = 0.043, $p < 0.001$). Digital Innovation (DI) (beta = 0.285, $p < 0.001$) and Environmental Concerns (EC) (beta = 0.411, $p < 0.001$) were two other factors found to have a significant contribution to the improvement of SP. Nevertheless, it was not true that SI affected SP meaningfully ($p > 0.05$, 0.019). Sustainability Perception emerged as a major predictor of Purchase Intention (BS = 0.624, $p = 0.001$). The moderating effects of Technology Trust between DI and SP, Environmental knowledge between EC and SP and Environmental knowledge between SP and PI were also not found to be significant in the hypothesis. Mediation analysis further confirmed that SP significantly mediated PV's effect of PV on PI in three out of the four examined indirect paths (e.g., indirect $\beta = 0.174$, $p < 0.001$), underscoring the pivotal role of sustainability perception in translating value perceptions into purchase intentions.

4.3 Common method bias

The single-factor test used by Harman revealed less variation, which was 48.8 percentage of the total variance compared to the widely accepted value of 50 percent. This finding implies that there is no single latent factor that dominates this data; hence, common method variance should not present a crucial issue in this research study.

4.4 Results outputs

This study provides an overview of the empirical results in two ways. First, the measurement model assessment was detailed, and the standardized factor loadings of all measuring items are provided in Table 3. Table 4 contains descriptive statistics and coefficients of internal consistency, including Cronbach's alpha, composite reliability, and average variance extracted (AVE), to evaluate convergent validity. Table 5 uses the Fornell-Larcker criterion to check discriminant validity, and Table 6 uses the ratio of HTMT to provide another test on discriminant validity. The findings of the structural model and mediation are then outlined. Table 7 describes the path coefficients, standard errors, test statistics, *p*-values, and results of each of the hypothesis tests. Finally, Table 8 summarizes the mediating effect of Perceived Value on Purchase Intentions based on the mediators of Sustainability Perception.

The factor loadings on all indicators were high, with a range of 0.740–0.945, which exceeded the commonly regarded cut-off value of 0.70 in the creation of convergent validity in reflective measurement models (Hair et al., 2010). When we have a loading of 0.70 or more, we can conclude that more than 50 percent of the variance of the indicator is explained by its respective construct, which points to the fact that the indicator is reliable. Although loadings of 0.50–0.70 are acceptable in some cases when composite reliability and AVE are fit, in this case, the loading corresponding to TT1 was very low at 0.444, even below this loosely set criteria. This suggests that TT1 does not reliably measure Technology Trust and should be reconsidered or removed in further analyses to enhance construct validity.

The measurement reliability of all the constructs was strong. Cronbach's alpha was between 0.822 and 0.946, which was beyond the minimum level of 0.70; thus, it shows great internal consistency. Similarly, the composite reliability values were between 0.856 and 0.949, and exceeded the suggested threshold of 0.70. To determine convergent validity, the average variance extracted (AVE) was also found in each construct of 0.611–0.811, surpassing the acceptable range of over 0.50 (Fornell and Larcker, 1981; Hair et al., 2010). Notably, Digital Innovation exhibits the strongest reliability and validity ($\alpha = 0.942$; CR = 0.945; AVE = 0.811), while Environmental Knowledge, with slightly lower but still acceptable metrics ($\alpha = 0.836$; CR = 0.852; AVE = 0.658), confirms that all the constructs reliably capture their intended dimensions.

Based on the Fornell–Larcker criterion (Table 6), the square root of each construct AVE (presented as the diagonal items, i.e., DI = 0.900, EC = 0.861, TT = 0.781) is greater than its correlations with any other construct (presented as the off-diagonal values in the same row and

TABLE 4 Descriptive statistics, internal consistency, and convergent validity of measurement constructs.

Component	Mean	SD	Skewness	Kurtosis	Cronbach's alpha	Composite reliability	AVE
DI	3.387	1.145	−0.355	−0.743	0.942	0.945	0.811
EC	3.620	1.148	−0.610	−0.579	0.918	0.920	0.742
EK	3.224	1.222	−0.143	−1.052	0.836	0.852	0.658
PI	3.764	1.078	−0.695	−0.344	0.914	0.918	0.738
PV	3.331	1.237	−0.283	−0.994	0.934	0.937	0.789
SI	3.209	1.129	−0.201	−0.763	0.939	0.944	0.770
SP	3.891	1.088	−0.934	−0.083	0.946	0.949	0.788
TT	3.050	0.979	0.392	−0.380	0.822	0.856	0.611

TABLE 5 Fornell–Larcker criterion matrix for assessing discriminant validity.

	DI	EC	EK	PI	PV	SI	SP	TT
DI	0.900							
EC	0.701	0.861						
EK	0.601	0.510	0.811					
PI	0.662	0.673	0.582	0.859				
PV	0.587	0.526	0.403	0.488	0.889			
SI	0.778	0.663	0.619	0.592	0.546	0.877		
SP	0.684	0.730	0.493	0.720	0.536	0.579	0.888	
TT	0.521	0.460	0.548	0.457	0.508	0.540	0.406	0.781

Perceived value (PV); Social influence (SI); Digital innovation (DI); Environmental concerns (EC); Environmental knowledge (EK); Technology trust (TT); Sustainability perception (SP); Purchase intention (PI).

TABLE 6 Heterotrait–Monotrait ratio (HTMT) matrix for assessing discriminant validity.

	PI	SP	PV	SI	DI	EC	EK	TT
PI	1.000							
SP	0.764	1.000						
PV	0.510	0.557	1.000					
SI	0.624	0.604	0.561	1.000				
DI	0.703	0.717	0.608	0.816	1.000			
EC	0.722	0.774	0.550	0.701	0.742	1.000		
EK	0.655	0.547	0.431	0.684	0.661	0.569	1.000	
TT	0.512	0.447	0.555	0.585	0.568	0.511	0.639	1.000

Perceived value (PV); Social influence (SI); Digital innovation (DI); Environmental concerns (EC); Environmental knowledge (EK); Technology trust (TT); Sustainability perception (SP); Purchase intention (PI).

column). This confirms that every construct possesses more variance in the related measurement items than another construct, hence having greater discriminant validity (Nunnally and Bernstein, 1994).

Similarly, the HTMT ratios (Table 6) are all well below the conservative threshold of 0.85 (e.g., the highest HTMT is 0.817 between DI and SI), confirming that constructs are empirically distinct and that discriminant validity is established according to (Henseler et al., 2015) recommendation.

The structural model outcomes indicate that the influence of Perceived Value (PV) on purchase intention (PI) towards electric vehicles is negative and remarkable (0.002, SE = 0.068, $p < 0.001$), thus supporting H1. The relationship is also moderated by income, which reinforces the PV-PI relationship (beta = 0.043, SE = 0.023, $p < 0.001$), agreeing with H1a. In addition, PV plays a significant positive role in Sustainability Perception (SP) (b = 0.122, SE = 0.031, $p < 0.001$), which validates H2. The Social Influence However, SI does not have a significant effect on SP (0.019 [SE = 0.045], $p > 0.05$); therefore, H3 is not supported. Digital Innovation (DI) by contrast increases SP by a significant margin ($\beta = 0.285$, SE = 0.048, $p < 0.001$), which confirms H4, but the moderating impact of Technology Trust (TT) on the relationship is not significant ($\beta = 0.038$, SE = 0.030, $p > 0.05$); hence, H4a is not justified. H5 is supported by the increased influence of Environmental Concerns (EC) on SP (0.411, SE = 0.040, $p < 0.001$), and the role of the moderator Environmental Knowledge (EK) is not significant in this combination (0.061, SE = 0.027, $p > 0.05$), so H5a was not supported. Lastly, the impact of SP on PI is also significant and positive (SP: 0.624, SE = 0.041, $p < 0.001$), confirming H6, while EK, in turn, does not moderate the SP-PI relationship (EK: −0.006, SE = 0.028, $p > 0.05$), thus disapproving H6a.

Mediation analysis reveals that Perceived Value exerts a significant positive indirect effect on EV Purchase Intentions through Sustainability Perception in three of the four examined paths. Specifically, the indirect effect estimates of 0.045 ($z = 2.920$, $p = 0.004$), 0.117 ($z = 3.663$, $p < 0.001$), and 0.174 ($z = 4.380$, $p < 0.001$) were all statistically significant, indicating that Sustainability Perception mediates the influence of Perceived Value on Purchase Intentions in these cases. In contrast, the second estimated path (−0.018; $z = -0.797$; $p = 0.426$) was not significant, suggesting no mediation for that specific relationship.

5 Discussion

This discussion integrates the study's findings with its objectives, hypotheses, and identified gaps in the literature. First, Perceived Value (PV) emerged as a significant predictor of both EV purchase intention (PI) and EV Sustainability Perception (SP), confirming H1 and H2. This underscores the centrality of a strong benefit–cost appraisal in driving both the cognitive recognition of EVs as sustainable and the motivational drive to purchase, echoing evidence from Bhat et al. (2024), who found that total cost-of-ownership perceptions critically shape EV

TABLE 7 Path coefficients and hypothesis testing results.

Hypothesis	Outcome	Predictor	Estimate	SE	Statistic	*p*-value	Accepted
H1	PI	PV	0.002	0.068	0.037	0.000	Yes
H1a	PI	PV*Income	0.043	0.023	1.88	0.000	Yes
H2	SP	PV	0.122	0.031	3.88	0.000	Yes
H3	SP	SI	−0.019	0.045	−0.424	0.000	No
H4	SP	DI	0.285	0.048	5.91	0.000	Yes
H4a	SP	DI*TT	−0.038	0.030	−1.26	0.000	No
H5	SP	EC	0.411	0.040	10.2	0.000	Yes
H5a	SP	EC*EK	−0.061	0.027	−2.28	0.000	No
H6	PI	SP	0.624	0.041	15.1	0.000	Yes
H6a	PI	SP*EK	−0.006	0.028	−0.231	0.000	No

TABLE 8 Indirect effects of perceived value on purchase intentions via sustainability perception.

Label	Est.	SE	z	*p*-value	Result
PV_SP_PI	0.045	0.015	2.920	0.004	Supported
PV_SP_PI	−0.018	0.022	−0.797	0.426	Not supported
PV_SP_PI	0.117	0.032	3.663	0.000	Supported
PV_SP_PI	0.174	0.040	4.380	0.000	Supported

adoption in Indian cities. Moreover, the moderating effect of income on the PV–PI link (H1a) highlights that high-income consumers translate value perceptions into purchase plans more readily, suggesting that financial capacity remains a boundary condition for adoption.

Second, Social Influence (SI) did not significantly impact sustainability perceptions (H3 not supported), diverging from prior findings that peer norms bolster green technology attitudes (Cruz-Jesus et al., 2023). This null result may reflect the nascent stage of EV diffusion in some markets, where social exemplars remain limited or informational cues outweigh normative pressures. Third, Digital Innovation (DI) strongly enhances SP (H4 supported), confirming that feature-rich digital ecosystems can elevate consumers' environmental evaluations of EVs (Almansour, 2022), emphasizing digital marketing's role in shaping green consumption. However, Technology Trust failed to moderate the DI–SP relationship (H4a not supported), implying that users may differentiate between feature utility and technology reliability when assessing sustainability outcomes (Alqahtani and Kumar, 2024), as noted in their analysis of cybersecurity concerns in connected vehicles.

Fourth, Environmental Concerns (EC) positively influenced SP (H5 was supported), reaffirming that ecological awareness directly augments perceptions of EVs' environmental contributions. However, Environmental Knowledge did not strengthen this link (H5a was not supported), suggesting that mere factual awareness may be insufficient to amplify concern-driven sustainability appraisals (Featherman et al., 2021) on the complex interplay between knowledge and risk perceptions in EV contexts. Finally, SP strongly predicted PI (H6 supported) and mediated PV's indirect effects on PI in multiple paths, establishing sustainability perception as a key psychological mechanism in EV adoption, mirroring the attitude-behavior nexus characterized (Bechler et al., 2021). The failure of EK to moderate the SP–PI link (H6a not supported) further underscores that cognitive beliefs about sustainability translate relatively uniformly into purchase intentions, regardless of detailed environmental literacy.

In contrast, the social influence dimension did not have significant effects on sustainability perceptions, as expected. This unanticipated finding might be due to the low-level adoption of EVs in our sample area, so there is less pressure to live up to the norms and less information to respond to. The differentiation between normative and informational social influences should be done explicitly in future studies to obtain clear differences. Moreover, the insignificance of the moderating effects of technology trust and environmental knowledge is probably associated with low demographic diversity in the sample (urban, higher education, and tech-savvy). Generalizability is possible, as future investigations can combine different demographics, resulting in various moderation effects.

Contrary to all theoretical predictions and prior empirical evidence, the effects of social influence on sustainability perceptions about electric vehicles were not significant in the sphere of the study case. This surprising result could be explained by the fact that the process of EV adoption has not reached the mature stage in the sampled region, some of the people did not own an EV, and there was no extensive discussion of whether an EV is good between peers, which contributes to weak normative pressure and the lack of informational cues. In addition, the measurement of our study failed to distinguish between informational (seeking advice) and normative (peer pressure-driven) dimensions of social influence, which may restrict the ability to explain the measurement. On the same note, the moderating effect of technology trust and environmental knowledge was not significant, probably because of the demographic homogeneity of our respondents, who were mostly within urban areas, with technology orientation and education. Future studies should examine the possibility of using multi-dimensional measures that clearly discriminate the informational and normative dimensions of social influence. Furthermore, more stratified, broader samples, using longitudinal or experimental designs, would more appropriately capture social changes and greatly improve the relevance, robustness, and representativeness of moderation studies.

5.1 Practical implications

This study offers several actionable insights to industry practitioners, policymakers, and marketers. First, automakers should emphasize the multifaceted benefits of electric vehicles—economic savings, performance reliability, and environmental impact—to strengthen perceived value messaging. Tailored financing and incentive programs that account for income disparities can amplify this effect, as higher-income segments are quicker in converting value perceptions into purchase decisions (Ahmed et al., 2024). Digital platforms and e-business channels must highlight the total cost of ownership calculators and sustainability dashboards to reinforce both value and green credentials (Almansour, 2022).

Second, the strong influence of digital innovation on sustainability perception suggests that manufacturers and charging-network operators should invest in seamless, user-friendly apps and over-the-air updates that communicate environmental benefits transparently. Ensuring robust cybersecurity for these systems is critical: trust in digital features can become a barrier if security concerns are not addressed; therefore, integrating AI-powered threat detection and clear privacy policies will bolster user confidence (Alqahtani and Kumar, 2024).

Finally, policymakers and urban planners should collaborate to expand and optimize charging infrastructure, as accessibility remains a core adoption hurdle in both metropolitan and last-mile delivery contexts (Chang, 2023; Bulawa et al., 2024). Educational campaigns that elevate environmental knowledge by linking ecological concerns to tangible EV benefits further strengthen sustainability perceptions, especially among less-informed consumer segments (Tripathy et al., 2022). Together, these strategies can reduce contextual barriers, enhance consumer readiness, and accelerate the transition to electrical mobility.

These results provide pragmatic recommendations for policymakers, at least in emerging economies. Personalized incentive packages based on income levels may greatly incentivize the use of EVs. Trust issues associated with technology can be addressed by investing in safe and more convenient digital platforms, and sustainability concern issues can be alleviated through special education campaigns that improve environmental knowledge. These multi-sided strategies are important for speeding up the process of adopting sustainable transportation.

5.2 Theoretical implications

These findings make several important theoretical contributions. First, by demonstrating that perceived value not only drives purchase intentions but also shapes sustainability perceptions, this study integrates value-based and environmental-attitude frameworks, thereby extending both perceived value theory and TPB in the context of green mobility. Second, the strong role of digital innovation in enhancing sustainability perceptions underscores the need to augment technology-acceptance models (e.g., TAM, UTAUT) with sustainability-oriented constructs, suggesting that "usefulness" in an EV setting includes environmental as well as functional utility. Third, the identification of income as a moderator of the value-intention link and the absence of moderating effects for technology trust and environmental knowledge highlight the importance of specifying boundary conditions in moderated mediation models. This advances methodological rigor by illustrating when and for whom these relationships hold. Finally, by positioning sustainability perception as a mediator between value assessments and purchase intentions, this research clarifies the psychological mechanism that translates cognitive evaluations into green behavioral intentions, thereby bridging gaps between attitude-behavior and value-behavior literature and offering a more holistic theoretical account of EV adoption.

6 Limitations and future research directions

Although this research provides good information on the intentions people have regarding EV adoption, a number of limitations related to the methodology are worth mentioning. However, the application of self-reported data exposes it to a potential risk of bias, that is, social desirability bias and other variants linked to the common method. This may have affected the validity of our results. There is a need to mention objectivity measures, such as actual purchase history or behavior-tracking software, to improve the future credibility of findings.

First, the cross-sectional design makes it impossible to develop causal inferences, and thus constrains the comprehension of the means of intention conversion into practicable purchasing behaviors in the long run. This limitation may be addressed in future studies in which a longitudinal or experimental research design should be adopted in order to reflect real changes in behavior and confirm the way intention leads to EV adoption.

Second, the research used a non-probability convenience design (in effect, most of the research participants were reached using online and social media), which may result in demographic bias and reduce the generalizability of the findings to a wide range of regional, socio-economic, and cultural backgrounds. Future studies need stratified random samples or cross-cultural comparisons to enhance representativeness and external validity and to know more about regional differences in the behavior of EV adoption.

Finally, the use of self-reported measures presents the possibility of common method and social desirability biases. Participants can either provide socially desirable answers or misjudge their genuine opinions and motifs to buy an EV. To reduce these limitations, it is advisable that in future research, objective measures such as actual sales performance, purchase histories, behavior monitors (mobile applications), or implicit attitude tests should be used to prove and enhance the validity and robustness of the results.

7 Conclusion

This study attempts to comprehensively identify the critical factors of EV adoption, including perceived value and digital innovation, environmental sensitivity, and socioeconomic moderators, as a composite moderated mediation framework. The conclusions focus on the direct and indirect functions of perceived value through sustainability perception in purchase intentions. These insignificant results associated with social influence and moderations point to the areas of research that should be explored in the future that require fine-tuning measurement and varying sampling techniques. In practice, this understanding facilitates specific measures to popularize the use of EVs, thereby reducing the gap in achieving sustainable transportation objectives. The analysis confirmed that perceived value, both directly and indirectly via enhanced sustainability perception, stimulates purchase intentions, with income strengthening the value–intention link. Digital innovation and environmental concerns emerged as key antecedents of sustainability perception, whereas social influence did not have a significant effect in the current sample. Sustainability perception itself proved to be the strongest predictor of purchase intentions, underscoring its role as a psychological bridge between value assessments and green buying behavior. Although technology trust and environmental knowledge did not function as moderators, as hypothesized, these null results highlight the need for further research on alternate contextual and cognitive boundary conditions. Practically, the findings suggest that automakers and policymakers should emphasize the economic and environmental merits of EVs, tailor incentives by income segment, and continue to innovate digitally while ensuring cybersecurity and the transparent communication of sustainability benefits. By clarifying the mechanisms and conditions under which consumers embrace electric mobility, this study advances theoretical models of green technology adoption and offers actionable guidance for accelerating the transition to a sustainable transportation future.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the respective authors and their institutional research committees. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or their legal guardians/next of kin, as the data collected pertained only to behavioral issues related to purchase intention.

Author contributions

SK: Writing – original draft, Methodology, Conceptualization, Investigation, Supervision, Funding acquisition, Project administration, Writing – review & editing. SC: Data curation, Methodology, Supervision, Project administration, Funding acquisition, Writing – review & editing, Software, Formal analysis, Writing – original draft. CB: Funding acquisition, Visualization, Writing – review & editing, Resources, Validation, Project administration. VR: Supervision, Validation, Resources, Writing – review & editing, Funding acquisition, Formal analysis, Visualization. GB: Resources, Funding acquisition, Visualization, Validation, Formal analysis, Writing – review & editing.

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