

Article

Revisiting Electric Mobility: How Individual Perceived Value Shapes Battery Electric Vehicle Adoption—Insights into Technophilia, Range Anxiety, and Battery Cost in China

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Abstract

As transportation-related environmental pressures intensify, understanding the psychological mechanisms underlying battery electric vehicle (BEV) adoption has become increasingly important. Drawing on the Value–Attitude–Behavior (VAB) framework, this study investigates how perceived green value, hedonic value, and utilitarian value shape Chinese consumers' attitudes and purchase intentions toward BEVs, while examining the moderating roles of technophilia, range anxiety, and battery cost. A cross-sectional online survey was conducted in China, yielding 596 valid responses. Partial Least Squares Structural Equation Modeling (PLS-SEM) and Necessary Condition Analysis (NCA) were employed for data analysis. The results show that perceived hedonic value exerts the strongest positive effect on Attitude Toward Using BEVs ($\beta = 0.591, p < 0.001$), followed by perceived utilitarian value ($\beta = 0.135, p < 0.001$) and perceived green value ($\beta = 0.074, p = 0.026$). Attitude Toward Using significantly predicts BEV purchase intention ($\beta = 0.151, p = 0.002$). Technophilia significantly moderates the relationship between attitude and purchase intention ($\beta = -0.096, p = 0.002$), whereas the moderating effects of range anxiety and battery cost are not significant. The structural model explains 40.9% of the variance in attitude and 24.2% of the variance in purchase intention. NCA results further reveal that hedonic value constitutes the most critical necessary condition for forming favorable attitudes toward BEVs ($d = 0.079, p < 0.001$). This study contributes to the sustainable mobility literature by extending the VAB framework through the integration of multidimensional perceived value and necessary condition logic within the Chinese BEV context. The findings highlight that experiential and technological enjoyment, rather than environmental concern alone, has become a central driver of BEV adoption in emerging electric mobility markets.



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conditions of the [Creative Commons](https://creativecommons.org/licenses/by/4.0/)[Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.**Keywords:** perceived value; technophilia; range anxiety; battery cost; battery electric vehicles

1. Introduction

China has emerged as the world's largest EV market, bolstered by robust government support and extensive infrastructure development [1]. National policies have been instrumental in promoting EV adoption. Moreover, numerous jurisdictions have set deadlines to phase out internal combustion engine (ICE) vehicles, signaling a collective commitment to

cutting greenhouse gas emissions and tackling climate change [2]. Despite rapid technological progress, China remains heavily dependent on ICE vehicles. This has driven a sharp rise in vehicle ownership and intensified both environmental and energy pressures. In 2022, China produced only 105 million tons of oil but consumed 710 million tons, leaving a deficit of more than 600 million tons [3]. That same year, vehicle emissions exceeded 11.7 billion tons, accounting for over 80% of the country's air pollutants, while ICE vehicles contributed an estimated 10–15% of total CO₂ emissions and 25–40% of PM_{2.5} particles [4]. With 239 out of 338 prefecture-level cities grappling with air quality issues, the need for sustainable transportation solutions has never been more urgent.

The industrialization and commercialization of BEVs are essential for building sustainable supply chains and supporting global climate goals. BEV adoption enhances energy security, mitigates environmental degradation, and improves air quality, positioning the automotive industry as a central driver in the transition to a low-carbon future [5]. While China's BEV sector is rapidly expanding, bolstered by policy and innovation, consumer purchase intentions remain limited, suggesting substantial untapped market potential [6,7].

Prior research highlights that perceived hedonic value—how enjoyable and satisfying the BEV experience is—significantly shapes consumer purchase intentions [8]. However, the specific role of hedonic value has been underexplored [9]. Likewise, perceived utilitarian value—the practical benefits and functional performance of BEVs—substantially influences consumer attitudes and purchase decisions, yet few studies have fully addressed this dimension [10]. Meanwhile, well-documented barriers such as high upfront costs, battery expenses, and range anxiety continue to impede BEV adoption [11,12]. High battery costs not only raise purchase prices but also heighten consumer concerns about long-term maintenance and replacement. At the same time, range anxiety, defined as the fear that a BEV may not cover sufficient distance between charges, remains a major psychological barrier to adoption.

Beyond the environmental and energy-security rationale, vehicle electrification has become embedded in a broader global restructuring of the automotive industry. Governments worldwide are promoting electric mobility not only to reduce transport-related carbon emissions and air pollution, but also to secure strategic advantages in battery technologies, charging infrastructure, software-defined vehicles, and global automotive value chains. Recent discussions on net-zero transport emphasize that the transition toward electrified mobility involves not only climate-policy commitments but also complex industrial, technological, and geopolitical dynamics, including competition over battery supply chains, charging ecosystems, and future mobility platforms. From this perspective, China's rapid BEV development should be understood as part of both a domestic sustainability transition and a wider global competition for leadership in the next-generation automotive industry. Therefore, examining Chinese consumers' BEV adoption intentions provides insights that are relevant not only to China's low-carbon mobility transition but also to broader debates on how electrification reshapes global transport systems and automotive markets.

This study advances the Value–Attitude–Behavior (VAB) framework within the BEV domain by assessing how perceived green, hedonic, and utilitarian value influence consumer attitudes, which then translate into purchase intentions [13–15]. It further explores the moderating roles of technophilia, range anxiety, and battery cost in modulating these relationships. To deepen the analysis, the study incorporates Necessary Condition Analysis (NCA), providing a novel lens for identifying critical factors that determine consumer adoption behavior. By advancing the theoretical application of the VAB model and integrating NCA, this research offers essential insights for BEV manufacturers to forecast market demand and optimize strategies across investment, production, and marketing [16–18]. Ultimately, these findings contribute to a deeper understanding of consumer needs, sup-

port the refinement of industry strategies, and offer actionable guidance for the ongoing industrialization and commercialization of BEVs in China.

Specifically, we clarified that prior BEV adoption studies often focus on single-dimensional perceived value, direct effects, and sufficiency-based analyses, leaving three key gaps: (1) lack of multidimensional consideration of green, hedonic, and utilitarian value; (2) insufficient attention to moderating mechanisms such as technophilia, range anxiety, and battery cost; and (3) limited application of necessity-based analysis to identify critical baseline conditions. To address these gaps, our study introduces a methodological combination of Partial Least Squares Structural Equation Modeling (PLS-SEM) and Necessary Condition Analysis (NCA). This integrated approach allows us to examine both sufficient and necessary conditions for BEV adoption, directly addressing the limitations of previous research while providing novel insights into the attitude–intention mechanism.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature on the Value–Attitude–Behavior (VAB) framework and electric vehicle adoption, identifies gaps in previous research, and presents the contributions of this study. Section 3 describes the research design, measurement instruments, sample selection, and data collection procedures. Section 4 presents the results of the PLS-SEM and Necessary Condition Analysis (NCA), along with interpretation of key findings. Section 5 discusses the theoretical and practical implications, highlighting contributions to both the academic literature and BEV industry practices. Finally, Section 6 concludes the study, outlines its limitations, and provides directions for future research. Overall, this structure offers a clear progression from theoretical background to empirical analysis, followed by the discussion and conclusions, guiding the reader through the study’s objectives, methodology, results, and implications in a logical and comprehensive manner.

2. Literature Review and Hypothesis Development

2.1. Literature Review

Introduced by Mehrabian and Russell (1974), the Value–Attitude–Behavior (VAB) framework has become an influential theoretical model in psychology, marketing, and consumer behavior research [19]. The framework explains how external value-related stimuli shape individuals’ internal evaluative states, such as emotions, cognitions, and attitudes, which subsequently influence behavioral responses, including purchase intention and product adoption. In sustainable consumption research, the VAB framework is particularly useful because it links consumers’ perceptions of product value with their attitudinal formation and behavioral decisions.

Previous studies have applied the VAB framework across various consumer contexts. For instance, Vergura et al. [20] found that retail environmental cues can trigger emotional responses and influence shopping behavior. Kim and Yi [21] demonstrated that visual and auditory advertising stimuli shape brand attitudes through affective pathways. Similarly, Guo et al. [22] showed that website design elements, including aesthetics and navigation, affect online shopping behavior through users’ emotional responses. These studies confirm the explanatory power of the VAB framework in linking external stimuli, internal psychological states, and consumer behavior.

In the electric vehicle adoption literature, the VAB framework has also been used to explain how technological attributes, environmental messages [20], policy incentives, and perceived value influence consumers’ attitudes and purchase intentions [21]. Existing studies have shown that perceived green value can promote pro-environmental behavior and green product adoption [22], hedonic value can enhance emotional gratification and purchase preference [23,24], and utilitarian value can shape consumers’ evaluations of prod-

uct performance and functional benefits. These findings provide an important foundation for understanding BEV adoption from a value-based perspective.

However, several limitations remain in the existing literature. First, many studies on EV or BEV adoption have focused mainly on environmental concern, policy incentives, and economic benefits, while the role of hedonic and experiential value has received relatively limited attention [22,25]. This limitation is important because BEVs are no longer perceived only as low-carbon transportation tools; they are increasingly associated with intelligent cockpits, digital interaction, driving pleasure, and lifestyle upgrading. Second, previous research often treats perceived value as a general or single-dimensional construct, which makes it difficult to distinguish how green value, hedonic value, and utilitarian value differently shape consumer attitudes. Third, most prior studies have concentrated on direct effects within the VAB framework [26], but have paid insufficient attention to boundary conditions that may influence whether positive attitudes are translated into actual purchase intentions. Factors such as technophilia, range anxiety, and battery cost may strengthen or weaken this attitude–intention relationship, yet they have not been fully integrated into a unified model. Fourth, existing studies have mainly relied on regression or SEM-based sufficiency logic, which explains whether certain factors are sufficient to increase purchase intention. However, little is known about whether some value perceptions constitute necessary conditions that must be present before favorable attitudes or purchase intentions can emerge.

Addressing these limitations, the present study makes several key contributions to the BEV adoption literature. First, it extends the VAB framework by conceptualizing perceived value as multidimensional (green, hedonic, and utilitarian), allowing a more detailed understanding of how each dimension uniquely shapes consumer attitudes. Second, it integrates moderating mechanisms, including technophilia, range anxiety, and battery cost, to examine the conditions under which positive attitudes translate into purchase intentions. Third, the study introduces methodological innovation by combining Partial Least Squares Structural Equation Modeling (PLS-SEM) with Necessary Condition Analysis (NCA), exploring both sufficient and necessary conditions for BEV adoption. Fourth, it provides context-specific empirical evidence by focusing on Chinese consumers, offering insights specific to the world's largest BEV market with unique policy support, charging infrastructure, and digital consumer culture. Finally, the findings highlight practical implications for sustainable mobility, emphasizing the importance of experiential and hedonic factors as foundational conditions for BEV adoption, suggesting that enjoyment and interactive vehicle features are prerequisites for other value perceptions to influence attitudes. Overall, these contributions clarify the novelty of the study and provide a coherent theoretical and practical foundation for understanding BEV adoption behavior in emerging markets.

2.2. Hypothesis Development

2.2.1. Perceived Green Value (PGV)

Perceived green value pertains to the recognized advantages and expenses associated with the acquisition and utilization of eco-friendly products [27]. It represents consumers' belief in a product's contribution to environmental protection. Perceived green value plays a pivotal role in shaping consumers' attitudes [28] and behaviors towards environmentally friendly products and services. It covers how consumers view the environmental advantages and disadvantages of using eco-friendly products [29]. When consumers recognize a significant green value in a product [30], they tend to adopt more environmentally responsible behaviors, such as recycling, lowering energy use, and opting for eco-friendly products instead of traditional options.

Kim et al. highlighted that perceived green value significantly influences consumers' eco-friendly behaviors and their propensity to purchase sustainable products [31]. This indicates that consumers prioritizing environmental sustainability tend to make buying decisions that reflect their ecological values, thereby boosting the demand for environmentally friendly products [30]. Additionally, individuals with a higher perceived green value are more inclined to adopt sustainable practices in their daily lives, such as using public transportation, conserving water, and supporting eco-friendly companies [32,33]. This shows that perceived green value not only influences purchasing decisions but also shapes post-consumption behaviors that support environmental conservation.

In the electric vehicle (EV) market, perceived green value has been shown to significantly affect willingness to pay a premium for EVs [34]. Consumers who view EVs as environmentally friendly are more likely to incorporate ecological considerations into their purchase decisions, despite the potentially higher upfront costs. Reference [35] further highlights that EV adoption is driven not only by functional benefits but also by the perceived environmental utility offered by the vehicle.

Such effects may be especially pronounced in China due to unique socio-political and cultural factors. China has implemented strong national environmental policies, such as the "Dual Carbon" (carbon peak and carbon neutrality) goals and aggressive air-pollution control strategies which have significantly increased the visibility and social importance of environmental protection. In major urban areas, public discourse and government promotion have normalized green consumption as a socially desirable and responsible behavior [36,37]. Younger Chinese consumers, in particular, tend to associate BEVs with low-carbon lifestyles, civic responsibility, and alignment with national sustainability goals. Moreover, in densely populated cities such as Beijing, Shanghai, and Shenzhen where air pollution concerns are more salient, the perception that BEVs help reduce emissions further strengthens consumers' positive attitudes toward environmentally friendly mobility options. These contextual factors suggest that perceived green value may exert a stronger attitudinal influence in China compared with other markets.

Overall, perceived green value captures an increasingly important dimension of consumer decision-making in China, where rising environmental awareness, government-backed sustainability initiatives, and social desirability of green behaviors jointly elevate the role of environmental value in shaping attitudes toward BEVs. Thus, the hypothesis is proposed as follows:

H1. *Perceived green value has a significant positive impact on Attitude Toward Using.*

2.2.2. Perceived Hedonic Value (PHV)

Perceived hedonic value encompasses the pleasure and attitude consumers derive from using a product. Chitturi et al. found that this enjoyment plays a crucial role in influencing consumer decision-making [38], impacting both their purchase intentions and overall attitude. This factor is crucial in the intention to use electric vehicles [39]. The importance of perceived hedonic value should not be underestimated when assessing the intention to purchase electric vehicles [40]. It encompasses the pleasure derived from the sensory, enjoyable, and emotional elements of the shopping experience.

Empirical studies by Kesari & Atulkar have confirmed the presence of hedonic and utility shopping values, including the expenditure of money and the achievement of attitude [41,42]. This influences consumer behavior significantly. The study further suggests that hedonic shopping values may lead to impulsive shopping behaviors, whereas utility values typically do not. Furthermore, Venkatesh and Bala enhanced the traditional Technology Acceptance Model (TAM) by incorporating hedonic experiences as an external variable [43]. Their study revealed that the additional enjoyment derived from a technol-

ogy affects its perceived usability. It was also discovered that users' pro-environmental behaviors and innovative product developments consider the environmental utility of a technology. Specifically, users who advocate for environmental protection and innovation have been shown to impact both their consumption patterns and enjoyment of technology.

In the context of electric vehicles, research consistently shows that consumers evaluate not only the functional aspects of EVs but also the pleasure associated with the driving and ownership experience. Reference [39] further argue that modern consumer behavior should be understood through a broader lens that includes sensation, aesthetics, emotion, and enjoyment, all of which are central to hedonic value. This perspective helps explain why hedonic experiences increasingly shape consumption patterns in technologically advanced and experience-driven markets.

These mechanisms may be especially salient in China, where urban mobility and consumer culture are deeply intertwined with digitalization, lifestyle upgrading, and aesthetic expectations. Chinese consumers, particularly younger urban residents, exhibit strong preferences for technologically enhanced, visually appealing, and emotionally engaging products, partly driven by the rise of digital consumerism, social media influence, and widespread acceptance of smart devices. The integration of immersive infotainment systems, augmented-reality dashboards, autonomous-driving features, and personalized in-car environments in BEVs amplifies the hedonic experience and reinforces the perception that driving an EV is enjoyable, modern, and reflective of an upgraded lifestyle.

Moreover, China's highly competitive domestic EV market dominated by brands such as BYD, NIO, Xiaomi and XPeng places substantial emphasis on design aesthetics and user experience, further elevating the importance of hedonic value. In dense urban areas, where driving ranges are shorter and daily commutes are more experiential than functional, the emotional gratification, comfort, smooth driving sensation, and smart-car interaction become critical factors shaping attitudes toward BEVs. Given this context, perceived hedonic value is expected to exert a strong positive influence on consumers' attitudes toward using BEVs in China. Thus, the following hypothesis is proposed:

H2. *Perceived Hedonic value has a significant positive impact on Attitude Toward Using.*

2.2.3. Perceived Utility Value (PUV)

Perceived utility value captures how consumers evaluate a product's functional performance and practical benefits. This comprehensive assessment of a product's overall quality is crucial for purchase decisions, encompassing intrinsic product attributes such as model, quality, user experience and functional design, as well as external factors including brand reputation, company image and after-sales support. Sweeney and Soutar highlighted that perceived utility value strongly influences consumers' overall product evaluations and subsequent buying behavior [44]. In the context of Battery Electric Vehicles (BEVs), perceived utility value significantly shapes consumer attitudes, as it reflects evaluations of vehicle performance, technological reliability and operational convenience [33,45].

Perceived utility value in the EV domain includes functional considerations such as ease of charging, acceleration, battery endurance, maintenance convenience, charging costs, service station coverage, vehicle size and cabin or luggage space [46]. Prior studies confirm that reductions in long-term fuel and maintenance expenses can offset the higher upfront costs of BEV purchases, increasing the likelihood of adoption [47]. A longer driving range also enhances consumer acceptance, while limited range or inadequate charging infrastructure hinders adoption and usage. Recent research emphasizes the importance of reliable charging networks [48]. Furthermore, [49] found that higher perceived utility value reinforces consumers' positive reactions to product functionality and improves

purchase evaluations, while insufficient functional understanding or perceived inadequacy negatively affects decision-making [17].

These dynamics are particularly salient in the Chinese BEV market, where functional value plays an especially critical role due to unique socio-economic and infrastructural factors. Chinese consumers tend to be more price-sensitive and utility-oriented than consumers in many Western markets, which makes evaluations of long-term operational savings a strong predictor of attitudes toward BEVs. Differences in fuel costs, maintenance requirements and license plate restrictions in major cities such as Beijing, Shanghai and Guangzhou further amplify the importance of functional and economic utility.

China has rapidly expanded its charging infrastructure and now hosts the world's largest charging network. However, regional disparities remain significant. Consumers in first-tier cities benefit from dense urban charging facilities and widespread home-charging availability, which enhances the perceived convenience and practicality of BEVs. Consumers in second- and third-tier cities may perceive utility differently due to heavier reliance on public charging and concerns about intercity travel. These variations make functional utility a central dimension of BEV evaluation.

Given the importance of functional reliability, convenience and economic benefit in the Chinese market, perceived utility value is expected to have a significant positive effect on attitudes toward BEVs. Thus, the following hypothesis is proposed:

H3. *Perceived utility value has a significant positive impact on Attitude Toward Using.*

2.2.4. Attitude Toward Using (ATU)

Attitude Toward Using arises when consumers measure their actual experiences against their prior expectations [50]. When the actual experience surpasses expectations, consumers tend to be satisfied; if it falls short, they are likely to feel dissatisfied. Attitude Toward Using is shaped by several factors, such as product quality, service quality, pricing, brand image, and customer expectations [45,51]. The performance, durability, and reliability of a product directly affect Attitude Toward Using. Additionally, service quality, including the speed of service, the attitude, and professionalism of employees, etc., also influence Attitude Toward Using [52]. Furthermore, the reasonableness of the price and value for money are also important factors affecting Attitude Toward Using [53]. The level of customer expectations determines their evaluation criteria for products or services [50,54], and the reputation and image of a brand can affect customer expectations and attitude [55,56].

The Value–Attitude–Behavior (VAB) theory is widely used in consumer behavior research, especially in explaining Attitude Toward Using. By analyzing how external stimuli influence the internal states of individuals and their behavioral responses, the VAB theory helps to understand the decision-making process of consumers and the mechanism of attitude formation. Donovan and Rossiter (1982) [57] found that stimuli in the retail environment (such as in-store music and lighting) can affect consumer emotions, thereby influencing their shopping behavior and attitude. Eroglu et al. (2001) [58] studied how visual and auditory stimuli in advertising affect consumer brand attitudes through emotional responses. Hasan explored how website design (such as attractive interfaces and easy navigation) affects online shopping behavior and attitude through user emotional responses [59]. The VAB theory provides a powerful theoretical framework for understanding Attitude Toward Using by analyzing the relationship between external stimuli, internal states, and behavioral responses, helping to explain the decision-making process of consumers. Consequently, the following hypothesis is proposed by this study:

H4. *Attitude Toward Using has a significant positive impact on BEV purchase intention.*

2.2.5. Technophilia (TEC)

Technophilia describes the enthusiasm and acceptance consumers show towards innovative technologies [60,61], especially within the electric vehicle (EV) sector [62]. Consumers exhibiting strong technophilia generally hold favorable views on the latest technological advancements in EVs [63], like autonomous driving and smart connectivity, which often leads to greater satisfaction. Technophilia represents consumers' positive attitude and interest in new technology, influencing how they perceive and experience product features. This positive attitude can amplify or diminish the impact of external stimuli (such as new technology in EVs) on consumers' internal states (Attitude Toward Using BEVs). Technophiles are more sensitive to the positive stimuli of new technology [64], resulting in higher satisfaction. This favorable attitude further enhances their purchase intention [65]. Additionally, technophilia acts as a buffer; when the actual experience of new technology falls short of expectations, technophiles may be more tolerant and not significantly reduce their attitude, thus maintaining a higher purchase intention [43]. Technophilia affects consumers' internal states [66], namely their attitude with the product and their expectations for new technology. High technophiles are more likely to feel satisfied and pleased when experiencing new technology, which enhances their overall perceived value of the product. Moreover, technophiles tend to have stronger positive emotional responses, such as excitement and value, when experiencing new technology [67]. They are inclined to have a higher sense of identification with the functions and advantages of new technology, enhancing their attitude [68]. Meanwhile, satisfaction, as an internal state of the organism, is more likely to translate into purchase intention through the moderating effect of technophilia. For high technophiles, high satisfaction is more likely to translate into strong purchase intention because of their higher interest and acceptance of new technology [69]. Technophilia moderates the relationship between Attitude Toward Using and purchase intention by affecting how external stimuli influence consumers' internal states [70].

Technophiles are more sensitive to the presence of innovative technological features and tend to interpret advanced functionality as an indicator of product superiority. This heightened responsiveness increases the likelihood that positive attitudes toward BEVs will be translated into strong purchase intentions. Furthermore, technophiles exhibit higher tolerance toward technological imperfections because their enjoyment and identity derived from new technologies compensate for minor shortcomings. Thus, for consumers with high technophilia, a favorable attitude toward BEVs is more readily converted into strong purchase intentions. Conversely, for low-technophilia consumers, concerns about technology complexity or unfamiliarity may weaken the conversion of attitude into intention. Consequently, this study proposes the following hypothesis:

H5. *Technophilia moderates the relationship between Attitude Toward Using and BEV purchase intention.*

2.2.6. Range Anxiety (RAY)

Range anxiety concerns the fear that the battery range of electric vehicles (EVs) may be inadequate, impacting Attitude Toward Using and influencing their purchasing decisions [71]. Under the framework of the Value–Attitude–Behavior (VAB) theory, environmental stimuli impact an individual's emotional and cognitive states [72], thereby affecting their behavioral responses. Stimulus factors are external environmental or product characteristics, such as the technological features and range of EVs. Organism factors are internal states of individuals, such as Attitude Toward Using and range anxiety. Response factors encompass individual behavioral reactions, such as the influence of range anxiety on consumers' experiences with electric vehicle (EV) features, which in turn affects their attitude and willingness to buy. Range anxiety, as a detrimental stimulus, could diminish the posi-

tive effects of attitude on purchasing decisions. High range anxiety might lead to reduced satisfaction with EVs, potentially dampening purchase intentions even if other aspects are satisfactory [73]. Moreover, range anxiety might lower overall Attitude Toward Using with electric vehicles (EVs), consequently diminishing the positive influence of attitude on their willingness to purchase [74]. Range anxiety, as an internal state of consumers, directly affects their attitude and purchase intention. A comprehensive charging infrastructure can mitigate range anxiety, thus improving satisfaction and bolstering the intention to purchase electric vehicles. Rauh et al. (2015) [73] demonstrated that range anxiety markedly impacts both attitude and the intent to purchase electric vehicles. They found that consumers experiencing high range anxiety show substantially lower purchase intentions compared to those with low range anxiety [73].

This moderating mechanism holds particular relevance in China due to pronounced regional differences in charging infrastructure and mobility patterns. Consumers in first-tier cities generally benefit from well-developed charging networks, higher station density, and shorter average daily travel distances. These conditions collectively reduce the perceived risks associated with limited driving range. Under such circumstances, favorable attitudes toward BEVs are more readily translated into purchase intentions, as concerns about range reliability pose minimal psychological barriers.

In contrast, consumers in second- and third-tier cities or suburban regions often engage in longer commuting distances or intercity travel. These mobility patterns heighten concerns about battery capacity and charging accessibility, thereby intensifying range anxiety. For these consumers, even a positive attitude toward BEVs may not fully convert into a strong purchase intention if doubts about range sufficiency persist. High range anxiety, therefore, substantially weakens the attitude–intention relationship.

Moreover, Chinese consumers tend to prioritize practicality, reliability, and functional security in vehicle-related decisions. Within this cultural and market environment, range anxiety operates as a salient risk cue that undermines confidence in a BEV's capability to meet everyday mobility needs. As a result, behavioral intention can be suppressed despite generally favorable attitudes. Conversely, when consumers perceive charging availability as adequate and battery performance as trustworthy, this sense of functional assurance strengthens the conversion of positive attitudes into purchase intentions. This study suggests the following hypothesis:

H6. *Range anxiety moderates the relationship between Attitude Toward Using and BEV purchase intention.*

2.2.7. Price of Battery Cost (PBC)

High battery prices can reduce Attitude Toward Using with battery electric vehicles (BEVs) and affect their purchase intentions. High battery prices may increase purchase costs, leading consumers to feel an excessive economic burden, which impacts their attitude with BEVs [73]. Battery prices not only directly affect Attitude Toward Using but also indirectly influence purchase intentions by moderating the effect of attitude on purchase intentions. High battery costs can reduce the positive influence of Attitude Toward Using on their willingness to purchase electric vehicles (EVs), thereby impacting purchase decisions. Besides economic considerations, the cost of batteries also influences the psychological perceptions of consumers regarding electric vehicles [75]. High battery prices may cause consumers to have doubts about their purchasing decisions [76].

Within the Value–Attitude–Behavior (VAB) framework, battery cost operates as a stimulus factor that influences consumers' internal states by activating price sensitivity, perceived financial risk, and concerns about future depreciation. These internal cognitive responses shape the strength of the relationship between Attitude Toward Using and purchase intention. When battery costs are perceived as high, consumers may question

whether a positive attitude toward BEVs is sufficient to justify the substantial financial investment. Under such conditions, even favorable attitudes may fail to translate into strong purchase intentions, as the perceived economic risk overrides attitudinal positivity. Conversely, when battery costs are perceived as reasonable or declining, the financial barrier is reduced, enabling positive attitudes to more effectively convert into purchase intentions.

This moderating mechanism is particularly meaningful in China due to the strong price sensitivity of Chinese automobile consumers and the structural role that battery packs play in vehicle cost. The phase-out of national purchase subsidies and the rising cost of raw materials for lithium-ion batteries have heightened Chinese consumers' awareness of battery-related expenses. Moreover, BEVs in China experience rapid technological upgrading cycles, which make consumers especially concerned about battery depreciation and replacement costs over time. These economic and psychological concerns magnify the impact of battery cost on the attitude–intention relationship. When battery costs appear high, consumers may adopt a cautious approach, weakening the conversion of positive attitudes into purchase intentions. In contrast, declining battery prices, economies of scale in domestic battery production, and greater transparency in battery warranties enhance consumers' perceived economic security, strengthening the extent to which positive attitudes lead to firm purchase intentions. Therefore, this study proposes the following hypothesis:

H7. *Price of battery cost moderates the relationship between Attitude Toward Using and BEV purchase intention.*

2.2.8. BEV Purchase Intention (BPI)

Purchase intention refers to an individual's subjective likelihood and willingness to engage in a future purchasing action [77,78]. It reflects not only a consumer's evaluative judgment toward a product but also their motivational readiness to act [79,80]. In the context of environmentally friendly products, prior studies have consistently shown that positive environmental attitudes strengthen the linkage between cognitive evaluations and pro-environmental purchasing behaviors.

However, BEV purchase intention has evolved rapidly in recent years due to technological advancements and structural changes in the mobility ecosystem [81]. Contemporary research emphasizes that BEV purchase decisions are shaped by a combination of infrastructure readiness, policy incentives, environmental attitudes, and technological sophistication [82]. Recent findings reveal that charging infrastructure availability is one of the strongest determinants of BEV purchase intention [83]. Consumers are significantly more likely to adopt BEVs when public charging density, home-charging accessibility, and fast-charging coverage are perceived as reliable and widely available. Likewise, policy incentives, such as purchase subsidies, tax reductions, free license plates, and non-monetary benefits, have been shown to substantially shape consumer intention, especially in emerging markets like China [77,80]. Further, contemporary studies highlight the significant role of environmental concern and green attitudes in driving BEV adoption. Consumers who are more aware of air-pollution risks and climate impacts demonstrate stronger purchase intentions toward low-emission vehicles [84,85]. These findings align with the VAB framework, suggesting that environmental stimuli and pro-environmental values shape internal attitudes and, subsequently, behavioral responses [86,87].

Technological improvements in battery performance, driving range, smart infotainment systems, and autonomous-driving features also play a central role [20,88]. Recent work confirms that consumers attribute higher purchase intention to BEVs that provide greater range, lower charging time, enhanced digital connectivity, and intelligent cockpit functions [89–91]. These innovations strengthen both hedonic and utilitarian evaluations, making BEVs more appealing to mainstream consumers. BEV purchase intention as a multi-

dimensional construct shaped by functional, psychological, and contextual factors [9,85,92]. Consistent with the VAB framework, external stimuli—such as charging infrastructure, environmental pressures, technological benefits, and policy incentives—shape internal evaluations and ultimately influence consumers' likelihood of adopting BEVs [61,93]. Arising from the analysis discussed, the framework for the model posited in this research is shown below (Figure 1).

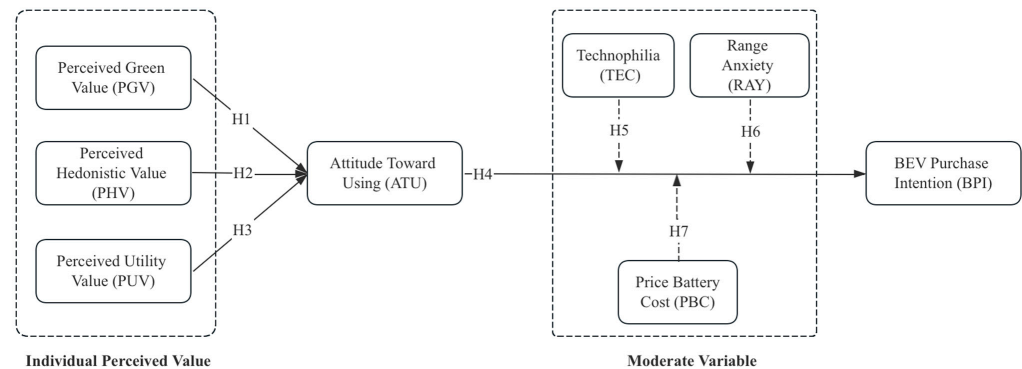


Figure 1. Conceptual framework.

3. Methodology

3.1. Research Design

We designed a structured questionnaire to collect quantitative data on Chinese consumers' intentions to purchase battery electric vehicles (BEVs). The questionnaire consisted of three sections. The first section included screening questions to ensure that participants met the eligibility criteria. Specifically, only Chinese residents who had not previously purchased a BEV but had some prior exposure to BEVs, such as test-drive experience or participation in BEV-related communities, were invited to continue the survey. Respondents who had previously purchased a BEV were excluded. The second section measured the key constructs in the theoretical model using established Likert-scale items, while the final section collected demographic information.

The sample was selected to capture the perceptions and intentions of potential BEV consumers in China. A purposive sampling strategy was adopted because the study aimed to investigate consumers with basic knowledge of, or prior exposure to, BEVs. This sampling approach helped ensure that respondents were able to provide meaningful evaluations of perceived green value, hedonic value, utilitarian value, Attitude Toward Using BEVs, and purchase intention. The survey was conducted online in November 2023 through WJX, a widely used online survey platform in China. Respondents were recruited through BEV enthusiast communities, online discussion groups, and BEV test-drive events. A total of 620 responses were collected, of which 596 (Table 1) valid responses were retained after removing incomplete or inconsistent questionnaires [94]. Written informed consent was obtained from all participants before data collection.

It should be noted that this recruitment strategy may introduce sample selection bias. Because respondents were recruited from BEV-related communities and test-drive activities, they may have higher BEV awareness, stronger technological interest, and more favorable attitudes toward BEVs than the general population. Therefore, the findings should be interpreted as reflecting the perceptions of potential or engaged BEV consumers rather than all Chinese consumers. Where available, demographic and geographic information was reported to improve sample transparency. However, detailed variables such as city-tier classification, household charging access, residential parking conditions, and specific levels of prior BEV exposure were not fully measured in the survey. Accordingly, claims regarding

differences between first-tier and second-/third-tier cities are treated as contextual interpretations rather than directly tested empirical comparisons. Future research should collect more detailed regional and infrastructure-related information to examine heterogeneity in BEV adoption more rigorously.

Table 1. Respondent profiles. Respondent profiles (n = 596).

Variable	Category	Frequency	Percent	Cumulative Percent
Sex	Female	264	44.3	44.3
	Male	332	55.7	100
Age	18–25	76	12.8	12.8
	26–35	149	25	37.8
	36–45	176	29.5	67.3
	45 or above	195	32.7	100
Edu	High School or Below	144	24.2	24.2
	College Diploma	117	19.6	43.8
	Bachelor's Degree	109	18.3	62.1
	Master's Degree or Above	226	37.9	100
Income (Monthly)	3000–5000	162	27.2	27.2
	5001–10,000	224	37.6	64.8
	10,001–15,000	130	21.8	86.6
	15,001–20,000	55	9.2	95.8
	20,001 or above	25	4.2	100
	Total	596	100	100

To reduce the potential influence of common method bias, several procedural remedies were adopted during questionnaire design and data collection. Participation was anonymous, respondents were informed that there were no right or wrong answers, and item wording was kept clear and neutral. In addition, data were collected through multiple online channels and at different time points. Because all constructs were measured using self-reported Likert-scale items, common method bias was further assessed using the full collinearity VIF approach commonly applied in PLS-SEM research. The results showed that all full collinearity VIF values were below the recommended threshold of 3.3, suggesting that common method bias was unlikely to substantially affect the findings.

This study employed both Partial Least Squares Structural Equation Modeling (PLS-SEM) and Necessary Condition Analysis (NCA). The integration of these two methods provides complementary analytical value. PLS-SEM was used to examine whether perceived value dimensions, attitude, and moderating variables exert statistically significant net effects on BEV purchase intention. In this sense, PLS-SEM follows a sufficiency logic by identifying whether increases in specific predictors are associated with higher levels of attitude or intention. However, significant SEM paths do not indicate whether a predictor is indispensable for achieving a high level of the outcome. NCA addresses this limitation by identifying whether a minimum level of a condition must be present for a high level of the outcome to occur. Thus, NCA adds a necessity-based perspective and helps determine whether certain value perceptions function as baseline requirements rather than merely influential predictors.

3.2. Measures and Data Analysis

In this survey, all items were adapted from existing research—see Appendix A. All measurement items in this study were adapted from established scales in the prior literature. To ensure linguistic accuracy and cultural appropriateness, we employed a multi-step scale development procedure. First, original English items were selected based on strong

prior validation in studies of technophilia, range anxiety, perceived value, and behavioral intention. Second, the items were translated into Chinese by two bilingual researchers, followed by a back-translation by two independent translators who were not involved in the initial translation. Discrepancies between the translations were reviewed and resolved through iterative refinement. Third, an expert panel comprising three scholars in consumer behavior and sustainable mobility assessed the clarity, content validity, and cultural relevance of the translated items. Finally, a pilot test with 32 respondents was conducted to evaluate linguistic comprehensibility and item reliability. Based on the pilot feedback, several items related to technophilia and range anxiety were slightly rephrased to better match Chinese consumers' interpretive norms. These procedures enhance the validity and reliability of the measurement instruments.

Each survey item utilized a five-point Likert scale, ranging from "strongly disagree" to "strongly agree," to gauge respondent agreement. Adhering to academic norms, this research incorporates both Partial Least Squares Structural Equation Modeling (PLS-SEM) and Necessary Condition Analysis (NCA) to investigate the required and adequate conditions affecting consumers' intentions to purchase Battery Electric Vehicles (BEVs). The PLS-SEM approach includes a measurement model, specifying relationships between latent constructs and observed variables, and a structural model, detailing interactions among the latent constructs.

3.3. Sampling Limitation and Generalizability

The integration of PLS-SEM and NCA provides complementary analytical value. PLS-SEM is used to examine whether perceived value dimensions, attitude, and moderating variables exert statistically significant net effects on BEV purchase intention. In this sense, PLS-SEM follows a sufficiency logic: it explains whether increases in specific predictors are associated with higher levels of attitude or intention. However, significant SEM paths do not indicate whether a predictor is indispensable. NCA addresses this limitation by identifying whether a minimum level of a condition must be present for a high level of the outcome to occur. Thus, NCA adds a necessity logic to the analysis and helps determine whether certain value perceptions represent baseline requirements rather than merely influential predictors.

In this study, the NCA results complement the PLS-SEM findings by showing that hedonic value is not only the strongest predictor of attitude in the structural model, but also the most important necessary condition for achieving favorable attitudes toward BEVs. The bottleneck results further translate this necessity logic into practical thresholds, indicating the minimum levels of perceived green, hedonic, and utilitarian value required to reach higher levels of attitude. These thresholds are meaningful for decision-making because they suggest that manufacturers and policymakers should not only maximize positive predictors, but also ensure that essential baseline conditions, especially experiential enjoyment and user interaction quality, are sufficiently met before other promotional or functional arguments can effectively influence consumer attitudes.

4. Result

4.1. PLS-SEM Result

4.1.1. Assessing the Outer Measurement Model

The robustness of measurement models is evaluated through tests for reliability and validity. Reliability testing assesses the internal consistency and stability of questionnaire scales, primarily using Cronbach's alpha coefficient and composite reliability (CR). Scores above 0.7 in both Cronbach's alpha and CR are indicative of strong reliability (Table 2). The

Cronbach's alpha coefficients and CR values for all questionnaires in this study surpass the 0.7 threshold, confirming the high reliability of the data collected.

Table 2. Reliability and convergent validity.

Construct	Item	Loading	VIF	Cronbach's Alpha	rho_A	CR	AVE
BPI	BPI1	0.901	3.184	0.925	0.925	0.947	0.817
	BPI2	0.903	3.266				
	BPI3	0.917	3.599				
	BPI4	0.894	3.004				
ATU	ATU1	0.917	3.097	0.905	0.908	0.94	0.84
	ATU2	0.919	3.007				
	ATU3	0.914	2.698				
PBC	PBC1	0.92	3.651	0.936	0.937	0.954	0.838
	PBC2	0.915	3.892				
	PBC3	0.93	4.24				
	PBC4	0.898	3.019				
PGV	PGV1	0.9	2.731	0.897	0.913	0.928	0.762
	PGV2	0.875	2.722				
	PGV3	0.866	2.544				
	PGV4	0.85	2.185				
PHV	PHV1	0.908	3.515	0.94	0.94	0.957	0.847
	PHV2	0.929	4.582				
	PHV3	0.934	4.692				
	PHV4	0.909	3.55				
PUV	PUV1	0.8	1.817	0.814	0.82	0.877	0.642
	PUV2	0.783	1.738				
	PUV3	0.826	2.332				
	PUV4	0.794	2.286				
RAY	RAY1	0.921	2.68	0.881	0.897	0.926	0.807
	RAY2	0.906	2.783				
	RAY3	0.867	2.131				
TEC	TEC1	0.911	3.515	0.94	0.942	0.957	0.846
	TEC2	0.929	4.582				
	TEC3	0.93	4.692				
	TEC4	0.91	3.55				

The validity of a measurement model is assessed using both convergent and discriminant validity tests. As shown in Table 2, all indicators exhibit Average Variance Extracted (AVE) values greater than 0.5, confirming strong convergent validity for the model [95]. Discriminant validity is evaluated using the Fornell–Larcker criterion and the Heterotrait–Monotrait Ratio (HTMT). According to the Fornell–Larcker criterion, the square root of the AVE for each variable exceeds its correlations with other variables [95]. Moreover, the ratio of HTMT values for the variables fall beneath 0.9, confirming the measurement model possesses significant discriminant validity.

To evaluate discriminant validity, the Heterotrait–Monotrait Ratio (HTMT) was assessed for all latent construct pairs. HTMT values below 0.85 (conservative threshold) or 0.90 (liberal threshold) indicate satisfactory discriminant validity (Table 3). The vast majority of HTMT values fall well within acceptable ranges (0.001–0.672), demonstrating that the constructs are empirically distinct. The interaction terms (RAY $\times$ BSA, TEC $\times$ BSA, PBC $\times$ BSA) also show very low HTMT values, which is expected because interaction terms are orthogonal transformations of their constituent variables and do not reflect conceptual overlap. Perceived hedonic value (PHV) and technophilia (TEC) exceed conventional thresholds (HTMT = 1.064). Although the HTMT value between perceived hedonic value (PHV) and technophilia exceeds the conventional threshold, this result should be interpreted with

caution rather than taken as sole evidence of construct redundancy. HTMT is an important but not exclusive criterion for assessing discriminant validity. In this study, additional validity checks, including the Fornell–Larcker criterion, cross-loadings, VIF values, factor loadings, AVE, Cronbach’s alpha, and composite reliability, were also examined. These results provide supporting evidence that PHV and technophilia remain distinguishable constructs. Conceptually, PHV refers to the enjoyment, pleasure, and emotional gratification associated with BEV use, whereas technophilia reflects a broader individual tendency to accept, enjoy, and identify with new technologies. Their relatively high association is theoretically understandable in the BEV context, because intelligent cockpit systems, digital interaction, and smart mobility features may simultaneously increase hedonic enjoyment and appeal to technology-oriented consumers. Therefore, the elevated HTMT value indicates conceptual closeness, but the combined measurement evidence does not suggest serious construct overlap.

Table 3. Heterotrait–Monotrait Ratio (HTMT).

	BAI	BSA	PBC	PGV	PHV	PUV	RAY	TEC	RAY × BSA	TEC × BSA	PBC × BSA
BAI											
BSA	0.339										
PBC	0.373	0.118									
PGV	0.543	0.262	0.355								
PHV	0.327	0.672	0.069	0.283							
PUV	0.067	0.221	0.160	0.112	0.096						
RAY	0.221	0.154	0.174	0.275	0.084	0.308					
TEC	0.327	0.672	0.069	0.283	1.064	0.096	0.084				
RAY × BSA	0.039	0.103	0.014	0.106	0.023	0.045	0.098	0.023			
TEC × BSA	0.243	0.279	0.038	0.182	0.400	0.042	0.017	0.400	0.001		
PBC × BSA	0.110	0.012	0.108	0.095	0.047	0.076	0.031	0.047	0.162	0.058	

The Fornell–Larcker criterion was applied to further assess discriminant validity (Table 4). The square root of the Average Variance Extracted (AVE) for each construct (diagonal values) is greater than the correlations between that construct and any other construct (off-diagonal values). This indicates that each latent variable explains more variance in its own indicators than in those of other constructs, satisfying the recommended threshold for discriminant validity (Fornell & Larcker, 1981) [95]. Overall, the Fornell–Larcker results support satisfactory discriminant validity across all constructs. Combined with HTMT and reliability indicators, the measurement model demonstrates robustness and is suitable for subsequent structural analysis.

Table 4. Fornell–Larcker criterion.

	BPI	ATU	PBC	PGV	PHV	PUV	RAY	TEC
BPI	0.904							
ATU	0.312	0.916						
PBC	0.347	0.11	0.916					
PGV	0.494	0.241	0.322	0.873				
PHV	0.305	0.622	0.066	0.261	0.92			
PUV	0.049	0.192	0.137	0.09	0.085	0.801		
RAY	0.201	0.137	0.156	0.245	0.076	0.262	0.898	
TEC	0.307	0.622	0.066	0.261	1.00	0.086	0.076	0.92

Note: The bold diagonal elements represent the square root of the Average Variance Extracted (AVE) for each construct, whereas the off-diagonal elements represent the correlations among latent constructs.

4.1.2. Measurement Validity and Collinearity Assessment

Discriminant validity and collinearity were assessed using multiple complementary criteria rather than relying solely on the HTMT ratio. Although HTMT provides a stringent evaluation of discriminant validity, it is not the only indicator of construct distinctiveness. To ensure the robustness of the measurement model, additional criteria including VIF values, Cronbach's alpha, composite reliability (CR), Average Variance Extracted (AVE), and factor loadings were examined collectively.

All VIF values were below the recommended threshold of 3.3, indicating no critical multicollinearity among constructs. This suggests that the latent variables do not exhibit redundancy and that the structural estimates are not inflated due to collinearity. Cronbach's alpha and CR values for all constructs exceed 0.70, demonstrating strong internal consistency reliability. This ensures that the measurement items consistently capture their intended constructs. AVE values are above 0.50, confirming adequate convergent validity. Each construct explains more than half of the variance in its observed indicators. Item loadings were all above 0.70, further supporting convergent validity and indicating that the indicators are strongly associated with their underlying constructs. HTMT values were reviewed to assess discriminant validity. Although PHV and TEC exhibited a relatively high HTMT value, additional evidence from VIF, CR, AVE, and factor loading analyses confirms that conceptual overlap does not threaten the model's psychometric integrity. The constructs remain empirically distinguishable and theoretically justified.

Overall, the combined results across multiple metrics demonstrate that the measurement model exhibits satisfactory reliability, convergent validity, discriminant validity, and no significant multicollinearity issues, providing a solid foundation for subsequent structural model analysis.

4.1.3. Inspecting the Inner Structural Model

To check for collinearity, variance inflation factors (VIFs) were calculated for all predictors in the structural model. As indicated in Table 5, the VIF values ranged from 1.012 to 1.696, remaining below the commonly accepted threshold of 3, thereby confirming that collinearity does not pose a problem. Additionally, a bootstrapping procedure involving 5000 samples was carried out to assess the significance of the proposed hypotheses.

Table 5. Assessment of structural model.

	Original Sample (O)	Standard Deviation	T Value	p Values	VIF	f-Square	Result
ATU -> BPI	0.151	0.048	3.148	0.002	1.696	0.018	Supported
		BPI; $R^2 = 0.242$; Q^2 predict = 0.675					
PGV -> ATU	0.074	0.033	2.222	0.026	1.079	0.009	Supported
PHV -> ATU	0.591	0.036	16.445	0	1.078	0.551	Supported
PUV -> ATU	0.135	0.029	4.709	0	1.012	0.031	Supported
		ATU; $R^2 = 0.409$; Q^2 predict = 0.637					
RAY $\times$ ATU -> BPI	0.044	0.036	1.246	0.213	1.055	0.003	Not Supported
TEC $\times$ ATU -> BPI	−0.096	0.031	3.096	0.002	1.182	0.018	Supported
PBC $\times$ ATU -> BPI	−0.065	0.038	1.717	0.086	1.046	0.006	Not Supported

The results indicate that (Table 5) ATU has a significant positive effect on BPI ($\beta = 0.151$, $p = 0.002$), supporting the central assumption of the Value–Attitude–Behavior (VAB) framework that favorable attitudes toward BEVs increase consumers' purchase intentions. The explanatory power of the model for BPI is moderate ($R^2 = 0.242$), while the Q^2 predicted value of 0.675 indicates satisfactory predictive relevance. Regarding the antecedents of ATU, all three perceived value dimensions significantly influence consumers'

attitudes toward BEVs. Perceived hedonic value (PHV) shows the strongest positive effect on ATU ($\beta = 0.591$, $p < 0.001$, $f^2 = 0.551$), indicating that enjoyment, driving pleasure, and experiential satisfaction are the most influential factors shaping favorable attitudes toward BEVs. Perceived utilitarian value (PUV) also has a significant positive effect on ATU ($\beta = 0.135$, $p < 0.001$), suggesting that functional benefits and practical utility remain important considerations. In comparison, perceived green value (PGV) exerts a smaller but still significant effect on ATU ($\beta = 0.074$, $p = 0.026$), implying that environmental considerations contribute to positive attitudes, although they are less influential than experiential and functional factors. The model explains 40.9% of the variance in ATU ($R^2 = 0.409$), with a Q^2 predict value of 0.637, indicating good predictive capability.

For the moderating effects, technophilia significantly moderates the relationship between ATU and BPI ($\beta = -0.096$, $p = 0.002$). The negative interaction coefficient suggests that the positive influence of ATU on purchase intention becomes weaker at higher levels of technophilia. One possible explanation is that highly technophilic consumers may already possess intrinsic interest in advanced mobility technologies, making their purchase intentions less dependent on attitudinal evaluation alone. In contrast, consumers with lower levels of technophilia may rely more strongly on favorable attitudes when forming BEV purchase intentions.

4.2. Necessary Condition Analysis

4.2.1. Necessity Analysis Ceiling Diagram

Necessary Condition Analysis (NCA) provides a unique approach to examining complex causal relationships by pinpointing the indispensable conditions that impact outcome variables. Diverging from traditional methods, NCA not only identifies these critical conditions but also measures their scope and limitations. This method is particularly valuable for uncovering “indispensable yet insufficient” links between dependent and independent variables [96]. Complementing standard sufficiency evaluations, NCA quantitatively assesses necessary conditions needed to attain particular outcome levels, providing insights into their influence and revealing potential constraints [97].

Initially, latent variable scores were generated through the PLS-SEM method, as outlined by Hines & Czerwinski. Subsequently, the NCA was conducted using Smart-PLS software 4.0, adhering to the established procedures [98]. The initial step in Necessary Condition Analysis (NCA) consists of plotting a ceiling line that intersects the highest data points on an x–y graph, effectively defining the limits of necessary conditions (Figure 2).

Following this, an assessment was carried out to determine the statistical significance of effect sizes (d) for latent variable scores, utilizing a random sample size of 10,000 [96,99]. The CR-FDH line, appropriate for evaluating survey data on a five-point Likert scale, was used in the NCA results interpretation. Table 6 shows that Perceived Green Value (PGV) ($d = 0.01$, $p = 0.003$), Perceived Hedonic Value (PHV) ($d = 0.079$, $p < 0.001$), and Perceived Utility Value (PUV) ($d = 0.048$, $p = 0.001$) are crucial for BEC Adapting attitude (ATU). Furthermore, ATU ($d = 0.01$, $p = 0.027$) significantly affects BEV Purchase Intention (BPI).

Additionally, ATU itself appears as a necessary condition for BPI ($d = 0.01$, $p = 0.027$), meaning that a certain minimum level of positive attitude must be present before consumers develop meaningful purchase intentions. This supports the VAB framework, where organism-level attitudes serve as essential gateways for behavior. The NCA results reveal that hedonic value is the most critical baseline requirement, followed by utility and green value. These findings highlight that BEV adoption is not driven solely by environmental motivations; rather, consumers first require sufficient experiential enjoyment and functional utility before positive attitudes and subsequently purchase intentions can emerge.

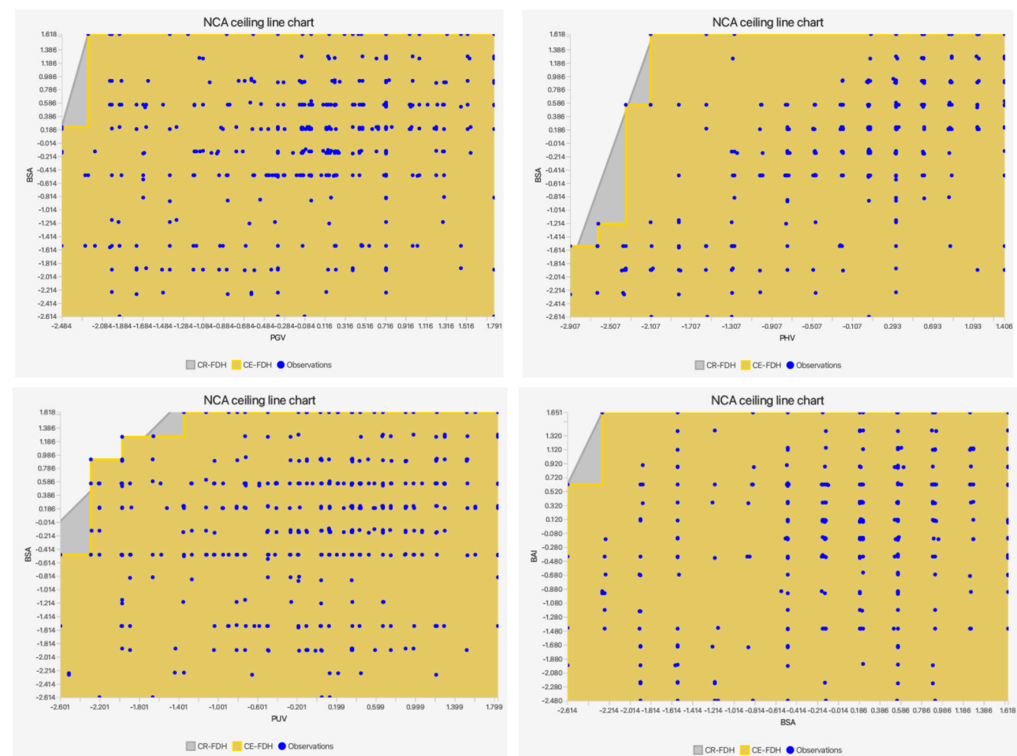


Figure 2. Scatter plots of Necessary Condition Analysis.

Table 6. Necessary Condition Analysis result (Method: CR-FDH).

	Effect Size	Ceiling	Slope	Condition Inefficiency	Outcome Inefficiency	Rel. Inefficiency	Abs. Inefficiency	<i>p</i> Value
PGV	0.01	1	5.317	93.871	67.084	97.983	17.727	$p < 0.01$
PHV	0.079	3	4.219	80.824	17.559	84.191	15.367	$p < 0.001$
PUV	0.048	6	1.454	74.908	61.723	90.396	16.982	$p < 0.001$
ATU	0.01	1	3.093	92.108	74.994	98.026	17.137	$p < 0.05$

The bottleneck analysis provides insight into the minimum threshold levels of key antecedents required to achieve specific performance levels in Attitude Toward Using (ATU) and BEV Purchase Intention (BPI). As shown in Table 7, reaching a 70% level of ATU requires Perceived Green Value (PGV), Perceived Hedonic Value (PHV), and Perceived Utility Value (PUV) to meet minimum values of 2.461, 2.381, and 2.36, respectively. These thresholds indicate that consumers must perceive at least a moderate level of environmental benefit, experiential enjoyment, and functional utility before forming a sufficiently positive attitude toward BEVs. Notably, PHV and PUV show slightly lower threshold requirements compared to PGV, suggesting that experiential and functional aspects may more efficiently elevate attitude formation relative to purely environmental motivations.

At the 100% ATU level, the minimum requirements decrease slightly (PGV = 2.222, PHV = 2.08, PUV = 1.487), reflecting condition inefficiency patterns characteristic of NCA results. These lower thresholds imply that once attitudes reach very high levels, they are less constrained by these value perceptions, although a minimal presence is still necessary.

For behavior-level outcomes, achieving a 70% BPI level requires ATU to be no less than 2.547, whereas achieving 100% BPI requires ATU to be at least 2.28. This reinforces the critical role of attitude as a necessary gateway for intention: without sufficient attitudinal positivity, purchase intention cannot reach higher performance levels. Overall, the bottleneck results highlight that BEV adoption depends not only on high values of predic-

tors but on satisfying specific minimum psychological thresholds. Manufacturers should therefore ensure that BEVs provide baseline levels of enjoyment, functional convenience, and perceived environmental benefit to unlock higher levels of consumer attitude and purchase intention.

Table 7. Bottleneck table (CE-FDH).

ATU	PGV	PHV	PUV	BAI	ATU
0.00%	NN	NN	NN	0.00%	NN
10.00%	NN	NN	NN	10.00%	NN
20.00%	NN	2.883	NN	20.00%	NN
30.00%	NN	2.782	NN	30.00%	NN
40.00%	NN	2.682	NN	40.00%	NN
50.00%	NN	2.582	NN	50.00%	NN
60.00%	NN	2.481	NN	60.00%	NN
70.00%	2.461	2.381	2.36	70.00%	NN
80.00%	2.381	2.281	2.069	80.00%	2.547
90.00%	2.302	2.18	1.778	90.00%	2.414
100.00%	2.222	2.08	1.487	100.00%	2.28

Although several NCA effects reached statistical significance, the observed effect sizes were relatively small. Therefore, the necessity relationships identified in this study should be interpreted cautiously and understood as relative rather than absolute necessity effects. Such modest necessity effects are common in consumer behavior research, where behavioral outcomes are typically influenced by multiple interacting psychological and contextual factors.

4.2.2. Interpretation of NCA Results

The NCA results indicate that hedonic value exhibits a higher necessity effect size than green value, suggesting that hedonic value represents a minimum psychological requirement for forming a favorable attitude toward BEVs in the Chinese context. In NCA logic, a higher necessity effect size means that without meeting a certain threshold of hedonic value, such as driving enjoyment, interaction with intelligent cockpit features, or emotional pleasure, consumers are unlikely to develop a positive attitude toward BEVs, regardless of how strong the environmental (green) value may be. This finding highlights a shift in the motivational structure of BEV adoption: while environmental value contributes to attitude formation, it is not a necessary condition, whereas hedonic experience is.

From a theoretical perspective, this challenges the conventional VAB assumption that green value is the dominant driver in sustainable product adoption. Instead, it positions hedonic value as a critical baseline condition that must be met before other stimuli can exert influence. Practically, this means that BEV manufacturers and policymakers must prioritize the experiential dimension—smooth acceleration, immersive infotainment systems, intelligent interfaces, quiet driving, and overall “fun-to-drive” qualities before emphasizing environmental or cost benefits. Without delivering sufficient hedonic appeal, efforts to highlight green utility will have limited impact. The bottleneck table further shows that even modest increases in hedonic value substantially reduce the minimum conditions needed for favorable attitudes, demonstrating its leverage effect on adoption likelihood.

5. Implications

5.1. Theoretical Implications

This study makes several contributions to the theoretical understanding of consumer behavior in the BEV context. First, it extends the Value–Attitude–Behavior (VAB) frame-

work to a rapidly evolving sustainable technology domain. The findings demonstrate that perceived green, hedonic, and utilitarian value operate as critical external stimuli that shape internal evaluative states, which subsequently influence purchase intention. This supports and advances the original propositions of Mehrabian and Russell by providing empirical evidence that the stimulus–organism–response mechanism remains robust in the context of emerging low-carbon transportation technologies.

Second, the study integrates VAB with perceived value theory to offer a multidimensional interpretation of how consumers evaluate BEVs. By showing that green, hedonic, and utilitarian value contribute differentially to attitude formation, the research enriches prior studies (e.g., Sweeney & Soutar) that conceptualize perceived value as a single overarching construct. The results clarify how each value dimension acts as a unique psychological stimulus within the VAB sequence, deepening theoretical understanding of sustainable consumption decision-making.

Third, the identification of technophilia, range anxiety, and battery cost as moderating variables adds novel insight into the boundary conditions of the VAB framework. The negative moderating effect of technophilia suggests that the influence of Attitude Toward Using BEVs on purchase intention becomes weaker at higher levels of technological enthusiasm. One possible explanation is that highly technophilic consumers may already possess intrinsic motivation toward advanced mobility technologies, causing their purchase intention to depend less on attitudinal evaluation alone. By contrast, consumers with lower technophilia may rely more strongly on favorable attitudes when forming BEV purchase intention. In contrast, range anxiety and battery cost weaken this translation, highlighting the role of practical and psychological constraints. These findings align with previous work on individual differences and perceived risk, while also revealing new dynamics specific to BEV adoption in China. This study advances the theoretical landscape by demonstrating that BEV adoption is shaped not only by functional and economic considerations but also by emotional, experiential, and technological factors. Future research should explore how these stimuli evolve over time as technologies mature, and examine the applicability of the extended VAB framework in other sustainability domains such as renewable energy or low-carbon consumer products.

5.2. Practical Implications

This study offers several practical implications for BEV manufacturers, marketers, and policymakers, and these implications should be interpreted in line with the empirical scope of the findings. The results show that perceived hedonic value has the strongest effect on Attitude Toward Using BEVs, followed by perceived utilitarian value and perceived green value. Therefore, strategies aimed at promoting BEV adoption should not rely solely on environmental messaging, but should also emphasize consumers' experiential and functional evaluations.

First, for manufacturers and marketers, the findings suggest that improving the hedonic experience of BEVs may be particularly important. Since hedonic value shows the strongest effect on attitude and is also identified by NCA as a necessary condition for favorable attitudes, manufacturers should prioritize features that enhance driving enjoyment, intelligent cockpit interaction, comfort, digital connectivity, and overall user experience. However, this does not imply that environmental or functional attributes are unimportant. Rather, green and utilitarian values should be communicated as complementary benefits that strengthen consumer attitudes when a satisfactory experiential baseline has been established.

Second, the significant role of utilitarian value indicates that consumers still consider practical and functional factors when evaluating BEVs. Manufacturers and dealers may

therefore provide clearer information on vehicle reliability, charging convenience, maintenance costs, battery durability, and long-term operating savings. Such information can help consumers make more informed evaluations and may strengthen positive attitudes toward BEVs.

Third, technophilia significantly moderates the relationship between attitude and purchase intention, suggesting that technology-oriented consumers may be more likely to translate favorable attitudes into purchase intentions. Accordingly, marketing strategies may benefit from segmenting consumers according to their level of technological interest. For consumers with high technophilia, communication can emphasize smart mobility features, intelligent driving assistance, connectivity, and digital interaction. For consumers with lower technological enthusiasm, firms may need to reduce perceived complexity and provide more accessible explanations of BEV technologies.

The findings suggest that BEV adoption strategies should be evidence-driven and balanced. In the Chinese BEV market, experiential enjoyment and technological appeal appear to play a particularly important role in shaping attitudes, while functional reliability, cost transparency, and infrastructure support remain necessary practical conditions for strengthening consumer confidence and purchase intention.

6. Conclusions

This study examined the psychological mechanisms influencing Chinese consumers' purchase intentions toward battery electric vehicles (BEVs) based on the Value–Attitude–Behavior (VAB) framework. By integrating perceived green value, perceived hedonic value, perceived utilitarian value, technophilia, range anxiety, and battery cost into a unified model, this research provides a more detailed understanding of how value perceptions and technology-related factors shape BEV adoption intentions.

The empirical results show that perceived hedonic value has the strongest positive effect on Attitude Toward Using BEVs, followed by perceived utilitarian value and perceived green value. This finding suggests that Chinese consumers' attitudes toward BEVs are shaped not only by environmental considerations, but also by enjoyment, driving experience, intelligent interaction, and functional utility. Furthermore, Attitude Toward Using BEVs has a significant positive effect on purchase intention, supporting the basic logic of the VAB framework.

The study also found that technophilia significantly moderates the relationship between Attitude Toward Using and BEV purchase intention. This indicates that consumers with stronger technological enthusiasm are more likely to translate positive attitudes into purchase intentions. In contrast, the moderating effects of range anxiety and battery cost were not statistically significant. Therefore, this study does not claim that range anxiety or battery cost significantly weakens the attitude–intention relationship. Instead, the findings suggest that these two factors should be understood mainly as direct practical concerns that may influence purchase intention, rather than as confirmed moderators in this model. The NCA results further indicate that hedonic value constitutes the most important necessary condition for forming favorable attitudes toward BEVs. This means that a minimum level of experiential enjoyment, such as driving pleasure, intelligent cockpit interaction, comfort, and digital connectivity, may be required before consumers develop strong positive attitudes toward BEVs. This finding complements the PLS-SEM results and highlights the importance of considering both sufficient and necessary conditions in BEV adoption research.

This study contributes to the BEV adoption literature by extending the VAB framework through a multidimensional perceived value perspective and by combining PLS-SEM with NCA. The findings suggest that BEV adoption in China is driven not only by green

and functional considerations, but also by hedonic and technological experience. For practitioners, the results imply that manufacturers should emphasize enjoyable driving experiences, intelligent vehicle features, and functional reliability, while policymakers and industry stakeholders should continue to improve charging infrastructure.

7. Limitation and Future Research

This study identified several limitations. First, the research framework was evaluated using a sample of Chinese consumers, focusing on perceived value, which may limit the generalizability of the findings to other contexts. Second, the study did not take into account samples from diverse geographical and ethnic backgrounds, which could address this issue. Although this research is based on solid theoretical principles, the cross-sectional survey design might introduce methodological biases. Lastly, future research on consumers' perceptions of green, hedonic, and utilitarian value may need to collect data at multiple time points and include control variables to enhance robustness. Although this study collected 620 responses and retained 596 valid cases, the sampling approach may introduce potential bias. Participants were recruited through BEV enthusiast groups, online discussion forums, and test-drive events, which may attract individuals who already hold more favorable attitudes toward electric vehicles. As a result, the sample may overrepresent consumers with positive predispositions toward BEVs, potentially inflating the strength of certain attitudinal relationships. This sampling limitation should be considered when interpreting the generalizability of the findings. Future studies may benefit from probability-based sampling or broader community-based recruitment to obtain a more balanced distribution of attitudes.

Given these limitations, several avenues for future research are recommended. Longitudinal studies would allow for the examination of temporal changes in perceived value, attitudes, and adoption behaviors as technology and infrastructure mature. Incorporating behavioral or revealed-preference data, such as actual purchase records, usage logs, or charging behavior, would strengthen the validity of adoption models and overcome biases associated with self-reported intentions. Experimental and quasi-experimental designs, including field tests, A/B marketing experiments, and policy simulation studies, could help isolate causal mechanisms within the Value–Attitude–Behavior framework and examine how consumers respond to specific technological, economic, or informational stimuli. Mixed-methods approaches may also provide deeper insights into how consumers negotiate functional, emotional, and psychological trade-offs when evaluating BEVs. Finally, future research could extend the enhanced VAB framework to other domains of sustainable consumption, such as renewable energy products, shared mobility systems, and low-carbon household technologies, to further test its theoretical generalizability.

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Appendix A. Questionnaire Items

Construct	Item	Measurement Items	Resource
PGV	PGV1	I feel that BEVs have a positive impact on the environment compared to conventional vehicles.	[100–102]
	PGV2	BEVs are more environmentally friendly than gasoline-powered cars.	
	PGV3	I believe that choosing a BEV is a step toward a more sustainable future.	
	PGV4	I believe that owning a BEV reflects positively on my commitment to environmental sustainability.	
PHV	PHV1	Driving a BEV is a fun and pleasurable experience for me.	[16,17,103]
	PHV2	The modern look of BEV enhances my driving enjoyment	
	PHV3	I feel that driving a BEV is exciting because of the innovative technology.	
	PHV4	Driving a BEV gives me a sense of prestige and status.	
PUV	PUV1	I am satisfied with the lower maintenance costs of BEV compared to traditional vehicles.	[104,105]
	PUV2	The convenience of driving a BEV fits well with my daily routine.	
	PUV3	The technology in BEV enhances its overall functionality.	
	PUV4	I believe that BEV is more energy-efficient than traditional vehicles.	
RAY	RAY1	I often worry that BEV will run out of battery while driving.	[106]
	RAY2	I worry that I will not be able to find a charging station when I need one.	
	RAY3	I worry that charging BEV will take too long during trips.	
	TEC1	I am very interested in the advanced technology used in BEVs.	
TEC	TEC2	I believe that BEVs represent the future of automotive technology.	[106,107]
	TEC3	I easily adapt to new technological updates in BEVs.	
	TEC4	I like exploring all the technological options and settings in BEV.	
	PBC1	I believe the purchase price of BEVs is affordable for me.	
PBC	PBC2	Even though BEVs are expensive, I believe they offer better value compared to gasoline cars.	[106]
	PBC3	I expect BEV's battery to last for a long time without needing replacement.	
	PBC4	I am satisfied with the financial savings from charging my BEV compared to using gasoline.	
	BPI1	I believe buying a BEV is a good decision.	
BPI	BPI2	My friends and family would support my decision to purchase a BEV.	[93,107,108]
	BPI3	I believe that buying a BEV is a way to contribute to environmental protection.	
	BPI4	I intend to purchase a BEV within the next year.	
	ATU1	I have a positive attitude toward using a battery electric vehicle.	
ATU	ATU2	I find using a battery electric vehicle to be a pleasant experience.	
	ATU3	I think using a battery electric vehicle is a good idea.	

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