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EMPIRICAL ANALYSIS AND MODEL TO ENHANCE EV AUTOMOBILE MARKET COMPETITIVENESS

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Abstract: With the rapid development of China's new energy vehicle (NEV) industry, the electric vehicle (EV) market has become increasingly competitive, making customer loyalty and brand retention critical for sustainable business growth. This study investigates EV consumers in mainland China and constructs a structural equation model (SEM) in which Customer Perception and Innovation and Technological Achievements serve as independent variables; Service Quality and Market Competitiveness act as mediators; and Customer Loyalty and Retention function as the dependent variable. Utilizing a questionnaire-based survey, data were collected from 437 respondents who either had prior experience with or a strong purchase intention toward EVs. Empirical analysis using SEM reveals that both customer perception and technological innovation exert significant positive effects on service quality, which in turn enhances market competitiveness and indirectly fosters customer loyalty. Among all paths, market competitiveness plays the most pivotal mediating role in influencing customer retention intentions, with the highest path coefficient ($\beta = 0.63$, $p < 0.001$). The study further identifies that service quality serves as a dual mediator within the model, acting as a vital bridge between internal customer perceptions and external market performance. Theoretically, this research integrates Resource-Based View (RBV) and Expectation Confirmation Theory (ECT) to innovatively propose and validate a "dual mediation pathway" mechanism, thereby enriching the existing analytical framework on EV consumer behavior. Practically, the findings offer empirical insights for EV companies in crafting customer-centric brand strategies, service management approaches, and technological innovation trajectories. Finally, the study suggests that future research could enhance model generalizability through longitudinal tracking, multi-regional sampling, and the incorporation of affective or policy-related variables, thus contributing to the continuous optimization and high-quality development of the EV market.

Key words: Electric Vehicles; Customer Perception; Technological Innovation; Service Quality; Market Competitiveness; Customer Loyalty and Retention; Structural Equation Modeling (SEM)

1. Introduction

Between 2020 and 2025, the global electric vehicle (EV) industry has experienced an era of rapid expansion. According to data from the International Energy Agency (IEA, 2025), global EV sales surged from approximately 3 million units in 2020 to over 17 million units in 2024, with market penetration increasing from 4% to over 18%. It is projected that by 2025, annual global EV sales will exceed 20 million units, accounting for more than one-quarter of the global automotive market. China has taken a dominant position in this landscape, not only leading in EV sales volume but also controlling nearly 75% of the global lithium battery supply chain and over 60% of critical raw material processing (Shen et al., 2022). In 2024, BYD surpassed Tesla to become the world's top-selling EV manufacturer, capturing over 16% of the global market share (IEA, 2025). In contrast, although the United States and European countries have accelerated their EV transitions under policy incentives and carbon neutrality goals, their progress remains comparatively slower due to high vehicle costs and underdeveloped charging infrastructure (Cui et al., 2021). Moreover, the rapid proliferation of EVs has introduced new challenges to power grid systems, particularly in the domain of Vehicle-to-Grid (V2G) integration. Scholars have thus proposed the adoption of intelligent charging systems and predictive load-balancing models to optimize grid performance (Razzaque et al., 2025). On the technological front, global efforts to expand EV charging infrastructure have intensified. However, challenges such as the lack of unified standards and concerns regarding system security persist (Acharige et al., 2022). Taken together, the period from 2020 to 2025 marks a critical phase in the global EV industry's transition from policy-driven expansion to technological maturity. Its continued development will depend on cost reduction, infrastructure enhancement, strategic policy guidance, and transnational industrial collaboration (Jung, Schröder, & Timme, 2023).

China's electric vehicle (EV) market has witnessed remarkable expansion in recent years. In 2022, EV sales in China reached approximately 6.9 million units, accounting for about 26% of total new vehicle sales that year (Wang, 2024). The upward trend continued in 2023 with sales surpassing 9 million units, and by 2024, annual EV sales further climbed to around 12.87 million units (ScienceDirect, 2023). Market penetration is projected to reach 20–22% by 2025 (Li et al., 2022). This sustained growth is primarily driven by a series of government incentives, including purchase subsidies, exemption from vehicle purchase taxes, preferential license plate policies, and the dual-credit regulatory system (Liu et al., 2023; Wang, 2024). Simultaneously, China has rapidly expanded its charging infrastructure. By the end of 2023, the country had deployed more than 3.3 million public charging points (ScienceDirect, 2025; Wang, 2024). Leading metropolitan areas such as Shanghai have emerged as exemplary cases in the development of high-power charging stations, public service integration, and local policy support (MDPI, 2024). On the industrial front, China controls between 70% and 85% of the world's lithium battery material production capacity, giving it a significant cost advantage—with battery manufacturing costs per vehicle up to €10,000 lower than those in Europe or the United States (ScienceDirect, 2025; Business Insider, 2024). This advantage has empowered domestic brands such as BYD and CATL to strengthen their global competitiveness. Notably, BYD accounted for more than 16% of global EV sales in 2024, surpassing Tesla (Business Insider, 2024). Nevertheless, the industry also faces emerging challenges, including market saturation, the exit of some small and medium-sized manufacturers (Wang, 2024), uneven geographic distribution of charging infrastructure, and growing pressure on the national power grid (ScienceDirect, 2025). In response, scholars have undertaken extensive research on optimizing charging networks, forecasting consumer behavior, and evaluating the effectiveness of policy incentives. For example, Chen et al. (2023) developed integrated models combining complex network theory and evolutionary game dynamics to assess the impact of subsidies on infrastructure deployment. Others have proposed spatiotemporal demand-based optimization strategies for charging systems (ScienceDirect, 2025). In summary, China's EV industry has evolved from a policy-driven phase to one increasingly shaped by technological innovation and market competition. Future development is expected to focus on intelligent charging systems, coordinated grid integration, and the construction of a sustainable industrial model in the context of post-subsidy transitions.

In China's electric vehicle (EV) market, consumer purchase decisions are shaped by a dual influence of subjective perception and technological innovation achievements. Customer perception encompasses consumers' subjective evaluations of vehicle performance, intelligent features, safety, and brand image (Wang et al., 2024; Zang et al., 2024). In contrast, innovation and technological achievements reflect tangible competencies such as investment in cutting-edge technologies, autonomous driving capabilities, and smart cockpit systems, which represent the "hard power" of EV brands. Within this decision-making process, service quality functions as the first mediating variable, translating customer cognition into perceived satisfaction through dimensions such as pre-sales experience, after-sales service, accessibility of charging infrastructure, and maintenance efficiency (Chen et al., 2023; Shen & Lee, 2023). Subsequently, market competitiveness acts as the second mediating variable, represented by factors such as price advantage, differentiated innovation capabilities, and ecosystem integration (e.g., community-based user engagement and AI-assisted services). These dimensions reinforce consumer network effects and brand stickiness (Zang et al., 2024; Wang et al., 2024). Empirical studies have demonstrated that core functionality, product reliability, and perceived quality positively affect brand loyalty through the mediating role of customer satisfaction (Shen & Lee, 2023). At the same time, incentive mechanisms and optimized charging networks not only enhance service quality perceptions but also contribute to the strengthening of market competitiveness (Chen et al., 2023). Collectively, these factors significantly improve customer loyalty and retention, providing both theoretical grounding and empirical validation for the development of long-term competitive advantage among Chinese EV brands.

Against the backdrop of China's rapidly emerging electric vehicle (EV) industry, customer perception and innovation and technological achievement are regarded as two core drivers of brand success. Customer perception reflects consumers' subjective evaluations of EV products, encompassing aspects such as exterior design, driving experience, safety performance, environmental value, and overall brand image (Wang et al., 2024). A positive customer perception can directly enhance consumer satisfaction, trust, and favorable brand attitudes. Concurrently, innovation and technological achievement signify a firm's breakthroughs in key domains such as intelligent systems, battery range, and autonomous driving. These accomplishments not only enhance product functionality but also contribute to the brand's technical authority and industry reputation (Zang et al., 2024). These two dimensions often exert their influence on consumer behavior through service quality as a mediating variable. High-quality services—such as pre-sale consultation, convenience of charging infrastructure, responsiveness in after-sales maintenance, and seamless digital platform experiences—are instrumental in converting positive perceptions into tangible satisfaction and loyalty (Shen & Lee, 2023). Moreover, in an increasingly competitive market environment, market competitiveness emerges as another key mediating variable. A brand offering high cost-performance, product differentiation, strong user community engagement, and well-integrated smart service systems is more likely to attain irreplaceability in the consumer's mind, thereby fostering greater brand loyalty and repeated usage intention (Zang et al., 2024). Empirical evidence suggests that perceived quality and technological acceptance positively impact customer loyalty and retention through the mediating effects of service experience and brand strength (Chen et al., 2023). Notably, these relationships are particularly pronounced in China's fast-growing and policy-driven EV market. From a strategic perspective, EV brands that continuously optimize customer perception factors, invest in technological advancements, and enhance both service quality and market competitiveness are more likely to achieve long-term consumer stickiness and greater market share.

Service quality, as the first mediating variable, plays a pivotal role in bridging and translating a firm's innovation capabilities into customer perception. Traditionally associated with after-sales maintenance, technical support, and routine servicing, service quality has now extended to emerging domains such as intelligent customer service systems, Over-the-Air (OTA) software updates, responsiveness of online platforms, and personalized service experiences (Shen & Lee, 2023). When consumers form positive evaluations regarding vehicle performance and technological sophistication, firms that provide efficient and consistent service experiences can significantly enhance customer satisfaction and trust, thereby reinforcing brand image (Wang et al., 2024). Particularly in China, the convenience and digitalization of the service experience have become core determinants in the EV purchase decision-making process. Market competitiveness, as the second mediating variable, reflects a firm's ability to transform favorable customer perception and technological strengths into sustained market advantage. In the context of the EV industry, competitiveness is no longer solely defined by pricing or production volume; rather, it hinges on a brand's capacity to deliver differentiated user value. This includes an integrated intelligent ecosystem, long-range battery performance, network effects, and active user communities (Zang et al., 2024). Firms that can continuously innovate and offer customized solutions on the foundation of high service quality are more likely to retain a competitive edge in an intensely contested market, thereby fostering consumer stickiness and retention (Chen et al., 2023). Multiple empirical studies have confirmed that high-quality service significantly enhances perceived customer value, while robust market competitiveness strengthens brand loyalty intentions. Together, they jointly contribute to the elevation of customer loyalty and long-term purchase intention (Zang et al., 2024; Shen & Lee, 2023). Therefore, in designing customer-centric strategic frameworks for EV enterprises, it is essential to recognize the foundational role of service quality and the strategic importance of market competitiveness. The interplay between the two will significantly enhance the brand's capacity for sustainable development.

More specifically, customer loyalty and retention—as key dependent variables for assessing the long-term competitiveness of electric vehicle (EV) brands—have emerged as central themes in recent research on China's EV industry. As the market transitions from being policy-driven to market-oriented, it has become increasingly important for firms not only to attract new users but also to cultivate stable customer relationships that support sustainable development (Shen & Lee, 2023). Customer loyalty extends beyond repeated purchase intentions; it encompasses a customer's continued positive preference and emotional attachment to a brand, even in the face of price fluctuations or competitive alternatives. Customer retention goes a step further, reflecting ongoing usage behavior, willingness to recommend the brand, and long-term engagement with brand-related communities (Wang et al., 2024). In China's intensely competitive market environment, loyalty and retention are shaped by multiple interconnected factors, including customer perception, service quality, technological achievements, and brand competitiveness (Zang et al., 2024). Leading brands such as BYD, Geely, and Tesla China have actively enhanced customer loyalty by upgrading product performance, developing intelligent service ecosystems, and improving user community management. Empirical studies have found that service quality plays a significant mediating role in fostering customer loyalty—efficient after-sales service and high-quality customer interactions significantly improve satisfaction and translate into loyalty behavior (Chen et al., 2023). At the same time, a brand's market competitiveness—reflected in technological leadership, price sensitivity, brand culture, and customer identification—exerts a decisive influence on customer retention (Zang et al., 2024). As Chinese consumers increasingly seek both functional and emotional value in EVs, customer loyalty and retention have evolved from mere outcome variables into critical strategic indicators. They now serve as essential benchmarks for business strategy development, service system design, and brand value assessment. Accordingly, gaining a deeper understanding of the formation mechanisms behind loyalty and retention is crucial for Chinese EV firms aiming to enhance customer lifetime value, reduce churn rates, and achieve sustainable long-term growth.

2. Literature Review

2.1 Research Theory

This study adopts Expectation-Confirmation Theory (ECT) to explain the formation mechanism of customer loyalty and retention and complements it with the Resource-Based View (RBV) to analyze how firms enhance market competitiveness and achieve sustained customer relationship management through technological and service-based advantages. Originally proposed by Oliver (1980), ECT was developed to explain how post-purchase satisfaction influences repurchase intentions. With the evolution of service marketing and technological products, ECT has since been widely applied to domains such as electric vehicles (EVs), smart technologies, and digital platforms. In the EV context, ECT posits that consumers form pre-purchase expectations regarding vehicle performance, intelligent systems, service experience, and environmental value. Whether these expectations are "confirmed" during actual usage largely determines the customer's eventual satisfaction and brand loyalty (Li et al., 2021). Wang et al. (2024) emphasize that Chinese EV consumers often hold strong expectations concerning smart cockpit functionality, human-vehicle interaction systems, and battery range. When such expectations are met—or even exceeded—during use, they significantly enhance brand identification and continued usage intentions. The core pathway of ECT includes initial expectations → confirmation → satisfaction → loyalty intentions. Within this pathway, service quality is viewed as the primary medium for actual confirmation experiences. Shen and Lee (2023) demonstrate that factors such as after-sales responsiveness, charging convenience, and the thoroughness of pre-sales service significantly influence customer satisfaction with EV brands. A positive evaluation of service quality can often compensate for unmet expectations in other areas. Chen et al. (2023), in their study on charging infrastructure optimization in Chinese cities, further confirm that the degree of infrastructure completeness directly impacts customer satisfaction with service systems, which in turn positively influences loyalty. Accordingly, this study adopts ECT as its theoretical foundation, proposing that customer perception and innovation and technological achievement influence customer loyalty and retention through the mediating mechanisms of service quality and market competitiveness. The model not only reflects a clear logical progression but also exhibits strong practical applicability within the context of China's evolving EV market.

Secondly, the Resource-Based View (RBV), proposed by Barney (1991), posits that in order to achieve sustained competitive advantage, a firm must possess internal resources that exhibit the "VRIN" attributes—Valuable, Rare, Inimitable, and Non-substitutable. Within the context of the new energy vehicle (NEV) industry, RBV emphasizes the strategic importance of both technological innovation capabilities and organizational service competencies as key resource categories (Zang et al., 2024). Chinese EV brands such as BYD, NIO, and XPeng have exemplified the application of RBV by investing in proprietary technologies including battery systems, autonomous driving platforms, and vehicle operating systems. These internally developed assets have created distinctive and hard-to-replicate core competencies, enabling these brands to rapidly scale in a highly competitive market landscape. Moreover, RBV asserts that the mere possession of resources is insufficient; firms must be able to effectively integrate and operationalize these resources through organizational capabilities to translate them into market performance. In this study, innovation and technological achievement represents the accumulation of technological resources, while service quality reflects the firm's operational capabilities in managing and delivering those resources. Market competitiveness serves as the external manifestation of how well these internal resources are leveraged in the marketplace. Zhang and Duan (2022) provide empirical support for this framework, demonstrating that Chinese EV firms with robust technological capabilities must also strengthen their service responsiveness, customer interaction effectiveness, and channel management systems in order to foster genuine customer loyalty. In other words, hardware innovation alone is not sufficient to build enduring customer relationships; it must be complemented by service-oriented and market-driven mechanisms that convert resource advantages into loyalty outcomes. Thus, RBV provides this study with a robust theoretical lens to conceptualize the process from resource investment → capability integration → market performance → customer loyalty. The inclusion of RBV not only deepens the theoretical foundation of this research but also enhances its explanatory power in the strategic management and customer relationship management domains of EV brand development.

2.2 Research Hypotheses

In the electric vehicle (EV) sector, customer perception (CP) is regarded as a central psychological variable influencing consumer attitudes and behavioral intentions. It is widely used to assess users' subjective evaluations of products, service systems, and overall brand image. In the context of China's EV market, consumers hold increasingly high expectations toward intelligent experiences, vehicle safety, aesthetic design, and environmental performance. The perceived quality in these dimensions significantly affects consumers' overall evaluations of service systems (Wang et al., 2024). Empirical studies have shown that when consumers form positive perceptions of a firm's value propositions, technological capabilities, and brand credibility, they are more likely to exhibit higher satisfaction and tolerance during service encounters. This, in turn, enhances their subjective evaluations of service quality (SQ) (Li et al., 2021). Specifically, service quality involves not only the timeliness and reliability of after-sales support, but also includes the professionalism of sales consultants, the usability of digital interaction platforms, and the accessibility of charging networks. All of these factors are closely aligned with the customer's initial perceptual expectations. Shen and Lee (2023), in their study on China's NEV market, found that positive customer perceptions of product technological sophistication and functionality often elevate expectations toward service performance, which in turn influence the evaluation of service quality. Furthermore, Li et al. (2021) argue that within the framework of Expectation-Confirmation Theory (ECT), customer perception serves as a prior condition for forming service quality assessments. That is, only when customers hold favorable perceptions of a product or brand are they more inclined to interpret subsequent service experiences positively. Therefore, service quality is not formed in isolation, but is rather a reactive construct, activated or confirmed based on prior cognitive foundations. In summary, customer perception is not only an antecedent to purchase decisions but also a key predictor in the evaluation mechanism of service quality. A positive perception enhances customer acceptance at critical service touchpoints, thereby improving overall service quality perception. Therefore, this study proposes the following hypothesis:

H1：Customer Perception (CP) has a positive correlation with Service Quality (SQ)

Within the electric vehicle (EV) industry, Innovation and Technological Achievements (ITA) are widely recognized as critical drivers in shaping consumers' perceptions of high service value. As Chinese EV brands continue to evolve toward intelligent, electrified, and connected technologies, consumers are increasingly attentive to the embedded innovations in EVs—such as autonomous driving systems, smart cockpits, human-machine interaction experiences, and fast-charging battery technologies (Zang et al., 2024). Through continuous technological advancement, firms not only enhance the performance and reliability of their products but also indirectly improve the overall service experience during the vehicle usage process. For example, Over-the-Air (OTA) update technology enables remote diagnostics and system maintenance, significantly enhancing service efficiency and responsiveness. The integration of onboard data platforms with customer service systems further allows for highly personalized and predictive service management (Zhang & Duan, 2022). Li et al. (2021) suggest that technological innovation constitutes a critical component of product competitiveness and can also influence customer evaluations of service quality through perceived service capability. When users observe that a vehicle offers robust self-updating capabilities, low system failure rates, and user-friendly operation, they often attribute such technological excellence to the company's service-level competence, thus forming more favorable evaluations of overall service quality. Zang et al. (2024) further highlight that EV service quality is shaped not only by traditional human resources but also by the firm's technological system architecture—such as real-time data feedback from service platforms, predictive diagnostics of vehicle conditions, and behavior-based user modeling. These innovative features are increasingly integrated into the service process itself, even redefining the structure of the traditional service value chain. In summary, sustained investment in innovation and technology not only optimizes the product offering but also significantly enhances the intelligence, interactivity, and satisfaction of service processes. When customers encounter this type of "technology-driven service experience," they are more likely to assign higher levels of trust and evaluation to the service system. Therefore, this study proposes the following hypothesis:

H2：Innovation and Technological Achievements (ITA) have a positive correlation with Service Quality (SQ)

Service Quality (SQ) is not only a critical indicator for assessing the effectiveness of customer relationship management but is also widely regarded as a key driver of Market Competitiveness (MC). Within the electric vehicle (EV) industry, as consumers increasingly value product-added services and holistic brand experiences, service quality has emerged as a central component in building differentiated advantages and enhancing brand attractiveness (Zang et al., 2024). High service quality does more than improve customer satisfaction and loyalty; it can also strengthen market competitiveness through mechanisms such as positive word-of-mouth, customer retention, and increased brand trust (Zhang & Duan, 2022). From the perspective of the Resource-Based View (RBV), service quality is considered a rare and inimitable organizational capability that holds significant strategic value (Zang et al., 2024). Firms that provide stable, efficient, and personalized service experiences—enabled by digital technologies, intelligent customer service platforms, responsive support mechanisms, and comprehensive after-sales systems—are more likely to establish strong competitive barriers in the marketplace. Li et al. (2021) found that customer satisfaction with service systems directly influences their willingness to recommend the brand and engage in repeat purchases. These behaviors, in turn, significantly boost a firm's customer acquisition rate and brand identity, thereby enhancing its overall market competitiveness. Furthermore, Shen and Lee (2023), in their empirical study of China's NEV market, revealed that service quality is highly correlated with customer satisfaction and remains a significant predictor of market performance—even after controlling for brand image and technological factors. This validates the direct and substantial influence of service quality on market competitiveness. Within the value chain that connects customer perception to market feedback, service quality functions both as a bridge and an amplifier—transforming internal service capabilities into external competitive advantages. Therefore, the following hypothesis is proposed:

H3：Service Quality (SQ) has a positive correlation with Market Competitiveness (MC)

In the increasingly competitive landscape of the electric vehicle (EV) industry, Market Competitiveness (MC) not only determines a firm’s current market performance but also exerts a profound influence on Customer Loyalty and Retention (CLR). Market competitiveness typically manifests as a firm’s comprehensive advantages in pricing, technological innovation, brand recognition, marketing strategies, distribution channel control, and ecosystem integration. The extent to which these competitive advantages can be converted into customer loyalty behaviors is critical in evaluating an EV brand’s long-term viability (Zang et al., 2024). This is particularly evident in China’s rapidly evolving NEV market, where consumers are highly informed and brand-switching behavior is frequent. Companies that establish strong product and service differentiation are more likely to retain customers and foster sustained purchase and recommendation behaviors (Zhang & Duan, 2022). Empirical evidence suggests that strong market competitiveness can significantly shape consumers perceived relative brand value, thereby reinforcing their behavioral loyalty (Li et al., 2021). When firms build distinct competitive advantages through technological innovation, intelligent user experiences, community engagement, and high value-for-money offerings, consumers are more likely to develop identification and trust, which in turn strengthens their intention to repurchase and remain engaged. Wang et al. (2024) highlight that EV brands with strong market competitiveness are more likely to elicit emotional attachment and brand loyalty from customers, as the competitive strength itself creates a perception of "irreplaceability" in the consumer's mind. Moreover, Zang et al. (2024) found that brands with pronounced competitive advantages tend to exhibit higher Customer Lifetime Value (CLV) and more stable customer retention rates. Therefore, enhancing market competitiveness is not merely a strategy for capturing market share, but also a foundational mechanism for building long-term customer relationships and solidifying brand loyalty. Therefore, the following hypothesis is proposed:

H4：Market Competitiveness (MC) has a positive correlation with Customer Loyalty and Retention (CLR)

Customer Perception (CP) is widely recognized in consumer behavior research as a key antecedent influencing Customer Loyalty and Retention (CLR). In the electric vehicle (EV) industry, its role extends beyond a direct effect and increasingly operates through multiple mediating mechanisms to influence customer-related outcomes. Consumers' overall impressions of EV brands—such as aesthetic design, technological sophistication, safety features, environmental attributes, and user reputation—are often translated into service quality (SQ) evaluations at various customer touchpoints. Subsequently, service quality enhances market competitiveness (MC), which ultimately fosters customer loyalty and retention (Li et al., 2021; Shen & Lee, 2023). From the perspective of Expectation-Confirmation Theory (ECT), a customer's favorable perception of a product establishes elevated service expectations. When a firm fulfills or exceeds these expectations through excellent service delivery, it cultivates loyalty on an emotional level (Wang et al., 2024). Shen and Lee (2023) emphasize that EV customers evaluate service systems based on their initial perceptions during both the purchase and usage stages, and this service satisfaction strongly influences retention behaviors and word-of-mouth intentions. Zang et al. (2024) further demonstrate how service quality functions as a critical bridge between perceived value and market competitiveness. Only when the service experience is superior can a firm construct a perception of irreplaceable market value and gain a sustainable competitive advantage. Similarly, Zhang and Duan (2022) found that in China's new energy vehicle market, customers' initial perceptions influence brand stickiness through their evaluations of service quality and the broader brand ecosystem, which in turn drive loyalty and retention. Customer perception, therefore, does not merely exert a direct influence on loyalty outcomes. Instead, it transforms into behavioral intentions through two essential mediating pathways: "service experience fulfillment" and "market value construction." This forms a complete perception–experience–behavior chain that underpins long-term customer engagement. Therefore, the following hypothesis is proposed:

H5：Customer Perception (CP) has a significant indirect positive impact on Customer Loyalty and Retention (CLR) through Service Quality (SQ) and Market Competitiveness (MC).

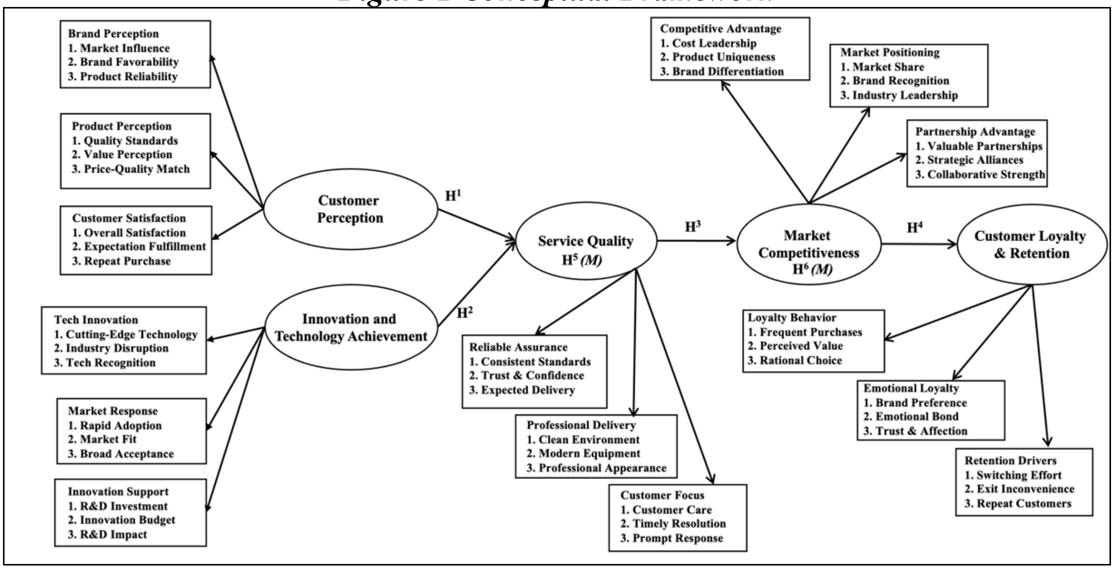
In China's electric vehicle (EV) market, Innovation and Technological Achievements (ITA) have emerged as critical drivers of customer behavior. However, scholars increasingly recognize that technological innovation alone does not directly lead to customer loyalty. Rather, its influence is mediated through the transformation of service systems and enhancement of market competitiveness, which in turn affect Customer Loyalty and Retention (CLR) (Zang et al., 2024; Zhang & Duan, 2022). With the widespread adoption of cutting-edge technologies such as Over-the-Air (OTA) updates, intelligent human–machine interaction systems, and autonomous driving support platforms, firms have not only improved product functionality but have also fundamentally reshaped their service processes—making them more efficient, intelligent, and personalized (Wang et al., 2024). This technology-driven service optimization significantly enhances customer satisfaction across the pre-sales, purchase, and post-sales stages (Li et al., 2021). Shen and Lee (2023) argue that customer satisfaction with the service system serves as a critical bridge between technological innovation and loyalty behaviors. Especially in the smart vehicle segment, customers often perceive technology-related experiences as integral to the overall service experience. For instance, the accessibility of fast-charging systems and the stability of autonomous driving features are closely associated with perceived service quality. From the perspective of the Resource-Based View (RBV), technology is considered a strategic resource that only creates sustainable competitive advantage when successfully transformed into differentiated service capabilities and market performance (Zang et al., 2024). Zhang and Duan (2022) further support this view by demonstrating that Chinese NEV companies that translate technological innovations into perceivable customer value are more likely to enhance market attractiveness and user stickiness, which ultimately strengthens customer loyalty. In this context, technological achievements influence customer loyalty not through a direct pathway, but through two key mediating mechanisms: enhancement of service value and construction of market competitiveness. Firms can only maximize customer lifetime value when technological advantages are deeply embedded in the service system and transformed into real market impact. Therefore, the following hypothesis is proposed:

H6：Innovation and Technological Achievements (ITA) have a significant indirect positive impact on Customer Loyalty and Retention (CLR) through Service Quality (SQ) and Market Competitiveness (MC).

2.3 Conceptual Framework

Based on the aforementioned literature review and research hypotheses, the researcher has developed a conceptual framework to explore the key pathways influencing Customer Loyalty and Retention (CLR) within China's electric vehicle (EV) industry. The model positions Customer Perception (CP) and Innovation and Technological Achievements (ITA) as the main independent variables, representing consumers' subjective evaluations of EV product functionality, intelligence level, and brand value, as well as the firm's technological capabilities and R&D commercialization outcomes. These two antecedent variables have been widely recognized in previous studies as being significantly associated with customer satisfaction and behavioral intentions. They also serve as the foundational points for building trust and interaction between the product and user ends of the brand. To capture the mechanisms through which these perceptions influence loyalty outcomes, the study incorporates Service Quality (SQ) and Market Competitiveness (MC) as dual mediating variables. Service Quality reflects customers' overall experience and satisfaction with pre-sale, in-sale, and post-sale service systems—including response efficiency, service convenience, after-sales infrastructure, and personalized interactions. It plays a key role in concretizing customer expectations and technological capabilities into perceived service value. Market Competitiveness, on the other hand, captures the firm's comprehensive ability in product differentiation, customer value delivery, brand strength, and market positioning—elements that are often shaped by the interplay of service performance and operational technology. Service Quality functions as the first-level mediator, bridging subjective customer perception with the firm's market value. Market Competitiveness then acts as the second-level mediator, further enhancing the firm's ability to attract and retain customers. Together, these two layers of mediation convey the cumulative impact of perception and innovation on customer loyalty outcomes. At the outcome level, Customer Loyalty and Retention (CLR) serves as the dependent variable, capturing consumers' sustained brand preference, repeat usage intentions, and willingness to engage in positive word-of-mouth—particularly in a highly competitive and diversified market landscape. By introducing service and competitiveness as sequential mediating pathways, the model not only identifies multidimensional factors affecting loyalty but also elucidates the full mechanism through which perceptual and cognitive drivers are translated into behavioral outcomes in China's EV market. This conceptual framework is theoretically grounded in Expectation-Confirmation Theory (ECT) and the Resource-Based View (RBV). ECT highlights the psychological assessment process whereby consumers evaluate whether actual experiences confirm prior expectations, which in turn shapes satisfaction and loyalty. RBV emphasizes how internal resources, such as innovation and service capabilities, are transformed into sustainable external market advantages. Together, these two theoretical lenses underpin the model's logic: beginning with customer perception and technological innovation, progressing through service experience and competitive positioning, and ultimately culminating in loyal behavioral responses.

Figure 1 Conceptual Framework



Source: Design by the researcher (2025)

3. Research Methodology

3.1 Research Method

This study adopts a quantitative research method aimed at systematically investigating the factors and structural pathways that influence Customer Loyalty and Retention (CLR) in the electric vehicle (EV) industry through a structured questionnaire survey. Quantitative methods are known for their efficiency, objectivity, and replicability, making them especially suitable for causal analysis and structural model testing with large sample sizes. The study is centered around six core variables: Customer Perception (CP), Innovation and Technological Achievements (ITA), Service Quality (SQ), Market Competitiveness (MC), Customer Loyalty and Retention (CLR), and a contextual industry variable—EV usage scenarios. The questionnaire was developed based on established measurement scales in relevant literature and utilized a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) to assess the respondents' degree of agreement with each statement. To ensure the validity and reliability of the instrument, the survey underwent expert review and revision by three scholars specializing in new energy vehicles. The final questionnaire consisted of two sections: measurement items for the core variables and demographic information, ensuring both structural completeness and multidimensional usability for subsequent analyses.

3.2 Research Design

This study adopted a stratified random sampling method to ensure the representativeness of the sample and to minimize potential biases related to gender, age, income level, or brand preference. Stratification was conducted based on key demographic characteristics, including: gender (male, female, undisclosed), marital status (single, married, divorced, widowed), age group (25 years and below, 26–45 years, 46–60 years, 61 years and above), educational background (below college, bachelor's, master's, doctoral degree), monthly income (below RMB 5,000; RMB 5,001–8,000; RMB 8,001–12,000; above RMB 12,000), and EV brand usage (e.g., BYD, Geely, Tesla China, etc.).To reach a wide and balanced respondent base, the sampling process combined both online and offline recruitment strategies. On the online side, the questionnaire was widely disseminated through digital platforms such as Wenjuanxing (Questionnaire Star). Offline, the survey was distributed in targeted locations including EV showrooms, community-based charging stations, and new energy vehicle owner groups. This dual-channel approach enabled the inclusion of respondents at different stages of the EV purchase journey and with varying levels of usage experience, thereby improving the diversity and generalizability of the sample.

3.3 Research Sample

The target population of this study comprises consumers in mainland China who either have experience using electric vehicles (EVs) or possess a strong intention to purchase one. This includes current EV owners, prospective buyers, and potential customers who closely follow developments in the new energy vehicle market. To ensure statistical significance and representativeness, the sample size was determined using Yamane's (1967) formula, which is commonly applied in social science research. With a 95% confidence level and a ±5% margin of error, the minimum required sample size was calculated to be 400 respondents. Considering the possibility that some responses might be invalidated due to logical inconsistencies, incomplete answers, or non-compliance, the researcher added a 20% buffer to the minimum required sample. Accordingly, an additional 80 questionnaires were distributed, resulting in a total of 480 questionnaires issued. This sampling strategy enhanced the completeness and usability of the collected data and improved the external validity and robustness of the study findings. It ensured that a sufficient number of valid responses were obtained for subsequent statistical analysis, including structural equation modeling (SEM).

4. Data Analysis

4.1 Descriptive Analysis

The basic information reveals the typical characteristics of electric vehicle consumers: a preference for domestic brands, a focus on middle-aged and young married individuals, higher education levels, and medium income levels. These data provide important insights into the differences in brand loyalty across different groups and offer theoretical support and practical guidance for EV companies to develop precise market segmentation and brand strategies.

Table 1 Basic Information of Samples

Basic Information		Frequency	Percent
EV brands	BYD	176	40.3
	Geely Auto	133	30.4
	Tesla China	128	29.3
Gender	Male	238	54.5
	Female	189	43.2
	Prefer not to disclose	10	2.3
Marital Status	Single	152	34.8
	Married	262	60.0
	Divorced	17	3.9
	Widowed	6	1.4
Education	Diploma or under	142	32.5
	Bachelor's degree	217	49.7
	Master's degree	55	12.6
	Doctor's degree	23	5.3
Age	≤ 25 years	142	32.5
	26-45 years	217	49.7
	46-60 years	55	12.6
	≥ 61 years	23	5.3
Monthly Income	≤ 5,000 yuan	73	16.7
	5,001-8,000 yuan	140	32.0
	8,001-12,000 yuan	129	29.5
	> 12,000 yuan	95	21.7
	Total	437	100.0

The scores for each dimension were generally above average, reflecting that electric vehicle consumers have an overall positive attitude towards brand performance. However, the data also reveal potential areas for improvement in technological innovation, service experience, and emotional loyalty. These statistical findings provide important evidence for subsequent causal path analysis and offer strategic insights for electric vehicle brands in terms of market positioning, service enhancement, and increasing customer stickiness.

Table 2 Descriptive Statistical Analysis of Variables

Variable	Min	Max	Mean	Std. Deviation	Skewness	Kurtosis
Customer Perception (CP)	1	5	3.37	0.971	-0.871	-0.335
Brand Perception (BP)	1	5	3.372	1.117	-0.622	-0.708
A1, Market Influence	1	5	3.371	1.28	-0.317	-0.904
A2, Brand Favorability	1	5	3.396	1.296	-0.334	-1.002
A3, Product Reliability	1	5	3.35	1.274	-0.344	-0.884
Product Perception (PP)	1	5	3.352	1.081	-0.592	-0.656
A4, Quality Standards	1	5	3.318	1.255	-0.29	-0.871
A5, Value Perception	1	5	3.41	1.25	-0.317	-0.904
A6, Price-Quality Match	1	5	3.327	1.262	-0.339	-0.892
Customer Satisfaction (CS)	1	5	3.386	1.102	-0.682	-0.536
A7, Overall Satisfaction	1	5	3.38	1.289	-0.381	-0.917
A8, Expectation Fulfillment	1	5	3.405	1.266	-0.415	-0.772
A9, Repeat Purchase	1	5	3.373	1.255	-0.396	-0.79
Innovation and Technological Achievement (ITA)	1.111	4.778	3.314	0.95	-0.906	-0.394
Tech Innovation (TI)	1	5	3.353	1.127	-0.732	-0.615
B1, Cutting-Edge Technology	1	5	3.368	1.281	-0.418	-0.833
B2, Industry Disruption	1	5	3.327	1.319	-0.409	-0.904
B3, Tech Recognition	1	5	3.364	1.316	-0.342	-0.973
Market Response (MR)	1	5	3.304	1.097	-0.683	-0.628
B4, Rapid Adoption	1	5	3.366	1.288	-0.384	-0.897
B5, Market Fit	1	5	3.261	1.289	-0.276	-0.975
B6, Broad Acceptance	1	5	3.281	1.26	-0.28	-0.877
Innovation Support (IS)	1	5	3.285	1.111	-0.689	-0.684
B7, R&D Investment	1	5	3.32	1.29	-0.356	-0.903
B8, Innovation Budget	1	5	3.265	1.272	-0.26	-0.932
B9, R&D Impact	1	5	3.261	1.292	-0.328	-0.891
Service Quality (SQ)	1	5	3.349	0.966	-0.855	-0.402
Reliable Assurance (RA)	1	5	3.301	1.179	-0.548	-0.823
C1, Consistent Standards	1	5	3.311	1.301	-0.341	-0.908
C2, Trust & Confidence	1	5	3.327	1.322	-0.367	-0.954
C3, Expected Delivery	1	5	3.366	1.322	-0.379	-0.971
Professional Delivery (PD)	1	5	3.346	1.124	-0.654	-0.629
C4, Clean Environment	1	5	3.359	1.338	-0.383	-0.988
C5, Modern Equipment	1	5	3.284	1.28	-0.273	-0.924
C6, Professional Appearance	1	5	3.394	1.303	-0.359	-1.004
Customer Focus (CF)	1	5	3.4	1.13	-0.585	-0.751
C7, Customer Care	1	5	3.414	1.31	-0.332	-1.049
C8, Timely Resolution	1	5	3.398	1.296	-0.346	-0.944
C9, Prompt Response	1	5	3.387	1.308	-0.323	-0.985
Market Competitiveness (MC)	1.111	5	3.353	0.951	-0.857	-0.431
Competitive Advantage (CA)	1	5	3.345	1.108	-0.63	-0.738
D1, Cost Leadership	1	5	3.38	1.286	-0.366	-0.936
D2, Product Uniqueness	1	5	3.343	1.271	-0.349	-0.909
D3, Brand Differentiation	1	5	3.311	1.265	-0.287	-0.909

Market Positioning (MP)	1	5	3.397	1.13	-0.668	-0.565
D4, Market Share	1	5	3.396	1.3	-0.431	-0.872
D5, Brand Recognition	1	5	3.371	1.312	-0.384	-0.901
D6, Industry Leadership	1	5	3.405	1.268	-0.375	-0.834
Partnership Advantage (PA)	1	5	3.317	1.109	-0.632	-0.706
D7, Valuable Partnerships	1	5	3.362	1.257	-0.346	-0.87
D8, Strategic Alliances	1	5	3.304	1.343	-0.3	-1.056
D9, Collaborative Strength	1	5	3.27	1.273	-0.215	-0.958
Customer Loyalty and Retention (CLR)	1	5	3.307	0.99	-0.853	-0.426
Loyalty Behavior (LB)	1	5	3.307	1.119	-0.575	-0.732
E1, Frequent Purchases	1	5	3.288	1.276	-0.34	-0.895
E2, Perceived Value	1	5	3.272	1.26	-0.31	-0.875
E3, Rational Choice	1	5	3.359	1.329	-0.339	-1.002
Emotional Loyalty (EL)	1	5	3.303	1.128	-0.629	-0.709
E4, Brand Preference	1	5	3.281	1.3	-0.301	-0.92
E5, Emotional Bond	1	5	3.302	1.282	-0.323	-0.924
E6, Trust & Affection	1	5	3.325	1.294	-0.328	-0.938
Retention Drivers (RD)	1	5	3.313	1.105	-0.662	-0.577
E7, Switching Effort	1	5	3.279	1.28	-0.329	-0.886
E8, Exit Inconvenience	1	5	3.311	1.295	-0.301	-0.938
E9, Repeat Customers	1	5	3.348	1.261	-0.34	-0.868

4.2 Reliability Analysis

All variables in this study recorded Cronbach's α values above 0.8, demonstrating that the measurement items for each construct possess high internal consistency and reliability. These results affirm that the questionnaire is a reliable instrument for measuring the constructs of interest. This solid level of reliability ensures the dependability and consistency of the collected data, thereby providing a strong foundation for subsequent analyses and enhancing the overall validity of the research findings.

Table 3 Reliability Analysis of the Formal Test

Reliability Analysis of Cronbach's α				
Research Variable		Items	Cronbach's α	
Customer Perception (CP)	Brand Perception (BP)	3	0.841	0.911
	Product Perception (PP)	3	0.826	
	Customer Satisfaction (CS)	3	0.836	
Innovation and Technology Achievement (ITA)	Tech Innovation (TI)	3	0.829	0.910
	Market Response (MR)	3	0.821	
	Innovation Support (IS)	3	0.832	
Service Quality (SQ)	Reliable Assurance (RA)	3	0.862	0.909
	Professional Delivery (PD)	3	0.823	
	Customer Focus (CF)	3	0.833	
Market Competitiveness (MC)	Competitive Advantage (CA)	3	0.839	0.914
	Market Positioning (MP)	3	0.852	
	Partnership Advantage (PA)	3	0.829	
Customer Loyalty &	Loyalty Behavior (LB)	3	0.837	0.914

Retention (CLR)	Emotional Loyalty (EL)	3	0.844
	Retention Drivers (RD)	3	0.831

4.3 Validity Analysis (CFA) – Correlation and Structural Fit

4.3.1 Customer Perception (CP)

The Customer Perception (CP) measurement model demonstrates excellent fit quality within the current sample. It accurately reflects consumers' psychological structure in terms of brand perception, product perception, and overall satisfaction, thereby providing a solid theoretical and empirical foundation for subsequent path analysis and causal inference.

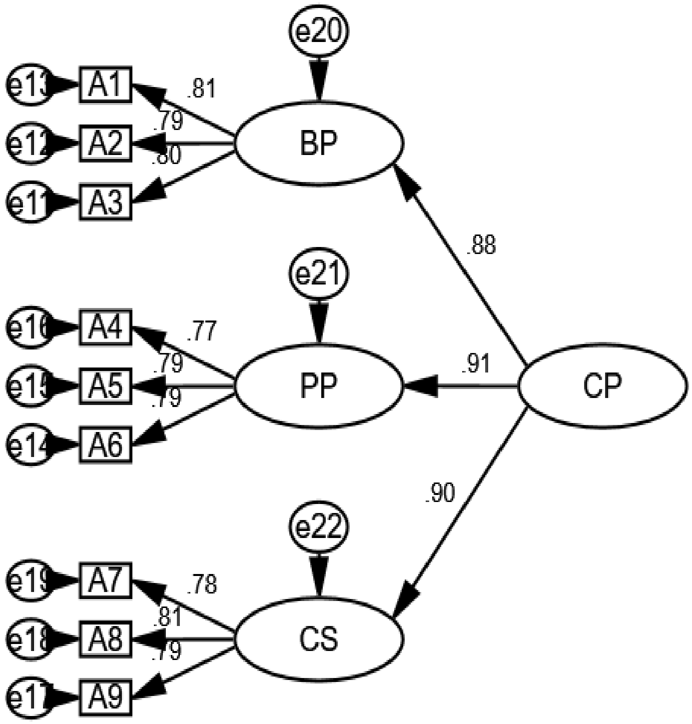


Table 4 Fit of the Customer Perception (CP) Measurement Model

Customer Perception (CP) Model Fit Indices								
Index	χ^2	df	p	χ^2/df	GFI	RMSEA	RMR	CFI
Criterion	–	–	>0. 05	<3	>0. 9	<0. 10	<0. 05	>0. 9
Value	27. 342	24	0. 289	1. 139	0. 986	0. 018	0. 027	0. 998
Index	TLI	AGFI	IFI	PGFI	PNFI	PCFI	SRMR	NFI
Criterion	>0. 9	>0. 9	>0. 9	>0. 5	>0. 5	>0. 5	<0. 1	>0. 9
Value	0. 998	0. 974	0. 998	0. 526	0. 658	0. 666	0. 017	0. 987

Convergent Validity of Customer Perception (CP), the results of the convergent validity test further support the measurement quality of the CP construct. As shown in the table, all factor loadings exceed the commonly accepted threshold of 0.5, indicating strong indicator reliability. Moreover, the Composite Reliability (CR) values for the CP dimension are all greater than 0.7, and the Average Variance Extracted (AVE) values exceed 0.5, meeting the recommended criteria for convergent validity. These results confirm that the CP construct exhibits strong internal consistency and valid measurement convergence.

Table 5 Convergent Validity of Customer Perception (CP)

Convergent Validity of Customer Perception (CP)					
Latent Variable	Item	Standardized Factor Loading	SMC	AVE	CR
Brand Perception (BP)	A1	0.807	0.651	0.638	0.841
	A2	0.79	0.624		
	A3	0.798	0.637		
Product Perception (PP)	A4	0.772	0.596	0.613	0.826
	A5	0.789	0.622		
	A6	0.787	0.62		
Customer Satisfaction (CS)	A7	0.781	0.611	0.63	0.836
	A8	0.813	0.66		
	A9	0.787	0.619		

4.3.2 Innovation and Technological Achievement (ITA)

The ITA measurement model demonstrates excellent fit performance within this study's sample, providing a solid foundation of reliability and validity. The dimensions and measurement items of the model accurately reflect users' perceptions of electric vehicle brands in terms of innovation, research and development, technological adoption, and market acceptance. These results provide robust support for subsequent path analysis and mechanism exploration.

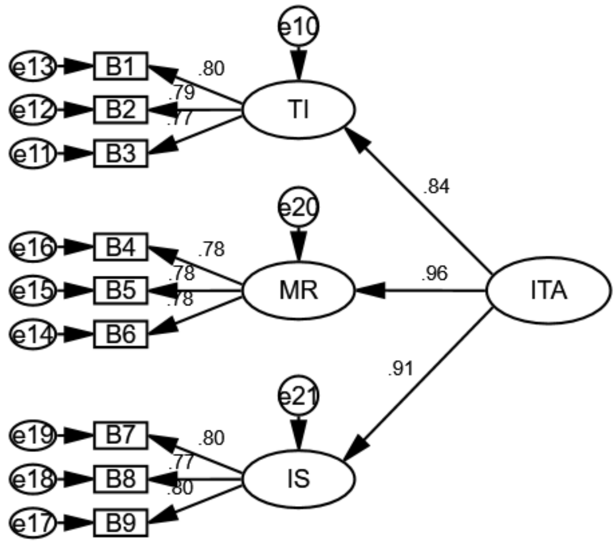


Table 6 Fit of the Innovation and Technological Achievements (ITA) Measurement Model

Innovation and Technological Achievements (ITA) Model Fit Indices								
Index	χ^2	df	p	χ^2/df	GFI	RMSEA	RMR	CFI
Criterion	−	−	>0. 05	<3	>0. 9	<0. 10	<0. 05	>0. 9
Value	26. 877	24	0. 31	1. 12	0. 986	0. 017	0. 029	0. 999
Index	TLI	AGFI	IFI	PGFI	PNFI	PCFI	SRMR	NFI
Criterion	>0. 9	>0. 9	>0. 9	>0. 5	>0. 5	>0. 5	<0. 1	>0. 9
Value	0. 998	0. 974	0. 999	0. 526	0. 658	0. 666	0. 017	0. 987

Convergent Validity of Innovation and Technological Achievement (ITA), the convergent validity of the ITA construct is confirmed through the following indicators: all item loadings exceed the commonly accepted threshold of 0.5, the Composite Reliability (CR) values are all greater than 0.7, and the Average Variance Extracted (AVE) values all surpass 0.5. These results collectively demonstrate that the Innovation and Technological Achievement (ITA) construct possesses strong convergent validity.

Table 7 Convergent Validity of Innovation and Technological Achievements (ITA)

Convergent Validity of Innovation and Technological Achievements (ITA)					
Latent Variable	Item	Standardized Factor Loading	SMC	AVE	CR
Tech Innovation (TI)	B1	0.802	0.643	0.618	0.829
	B2	0.785	0.617		
	B3	0.771	0.595		
Market Response (MR)	B4	0.775	0.601	0.604	0.82
	B5	0.776	0.603		
	B6	0.779	0.607		
Innovation Support (IS)	B7	0.802	0.643	0.622	0.831
	B8	0.765	0.586		
	B9	0.798	0.637		

4.3.3 Service Quality (SQ)

The Service Quality (SQ) measurement model exhibits strong structural adaptability and theoretical explanatory power within this study's sample. It provides a solid data and model foundation for further exploration of the role of service quality in consumer behavior, brand evaluation, and loyalty mechanisms.

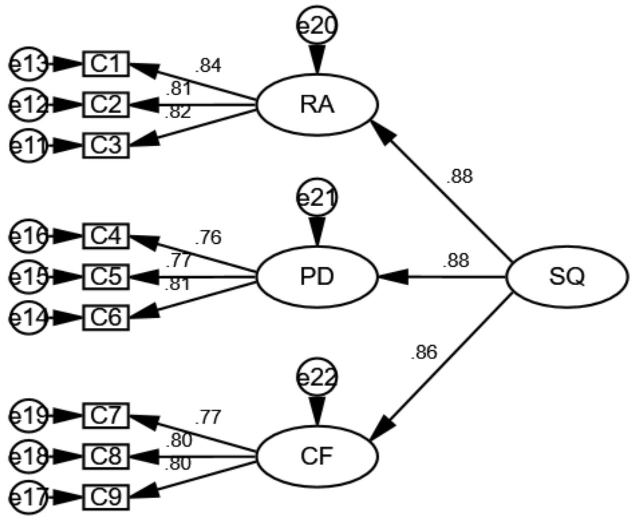


Table 8 Fit of the Service Quality (SQ) Measurement Model

Service Quality (SQ) Model Fit Indices								
Index	χ^2	df	p	χ^2/df	GFI	RMSEA	RMR	CFI
Criterion	-	-	>0.05	<3	>0.9	<0.10	<0.05	>0.9
Value	33.021	24	0.104	1.376	0.983	0.029	0.034	0.996
Index	TLI	AGFI	IFI	PGFI	PNFI	PCFI	SRMR	NFI
Criterion	>0.9	>0.9	>0.9	>0.5	>0.5	>0.5	<0.1	>0.9
Value	0.994	0.969	0.996	0.524	0.657	0.664	0.02	0.985

Convergent Validity of Service Quality (SQ), the convergent validity of the Service Quality (SQ) construct is demonstrated in the following results. As shown in the table, the factor loadings for all items exceed the commonly accepted threshold of 0.5, and the Composite Reliability (CR) values are all greater than 0.7, with Average Variance Extracted (AVE) values exceeding 0.5. These results confirm that Service Quality (SQ) has strong convergent validity.

Table 9 Convergent Validity of Service Quality (SQ)

Convergent Validity of Service Quality (SQ)					
Latent Variable	Item	Standardized Factor Loading	SMC	AVE	CR
Reliable Assurance (RA)	C1	0.843	0.71	0.676	0.862
	C2	0.808	0.653		
	C3	0.816	0.666		
Professional Delivery (PD)	C4	0.761	0.579	0.61	0.824
	C5	0.771	0.594		
	C6	0.811	0.658		
Customer Focus (CF)	C7	0.769	0.592	0.627	0.834
	C8	0.801	0.642		
	C9	0. 804	0. 646		

4.3.4. Market Competitiveness (MC)

The Market Competitiveness (MC) measurement model shows excellent fit performance in the sample of this study. The model not only demonstrates high explanatory power in theoretical dimensions but also exhibits good fit and precision at the statistical level, providing a solid theoretical and empirical basis for subsequent discussions on consumer perceptions of the market position and competitive advantages of electric vehicle brands.

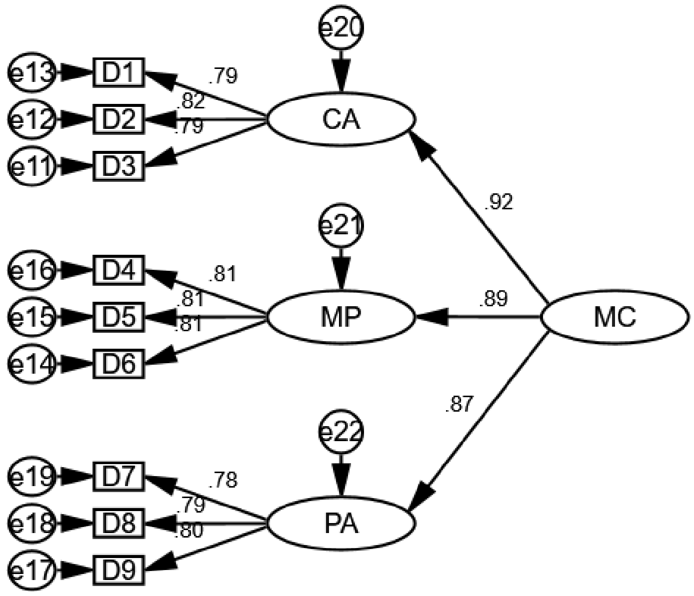


Table 10 Fit of Market Competitiveness (MC) Measurement Model

Market Competitiveness (MC) Model Fit Indices								
Index	χ2	df	p	χ2/df	GFI	RMSEA	RMR	CFI
Criterion	-	-	>0.05	<3	>0.9	<0.10	<0.05	>0.9
Value	16.442	24	0.871	0.685	0.992	0	0.02	1.003
Index	TLI	AGFI	IFI	PGFI	PNFI	PCFI	SRMR	NFI
Criterion	>0.9	>0.9	>0.9	>0.5	>0.5	>0.5	<0.1	>0.9
Value	1.005	0.985	1.003	0.529	0.662	0.669	0.012	0.993

The results of the aggregation validity for Market Competitiveness (MC) are as follows. From the table, it can be observed that the factor loadings for each item of Customer Loyalty and Retention (CLR) exceed the commonly accepted threshold of 0.5. Additionally, the CR values are greater than 0.7, and the AVE values are greater than 0.5, indicating that Market Competitiveness (MC) has good aggregation validity.

Table 11 Convergent Validity of Market Competitiveness (MC)

Convergent Validity of Market Competitiveness (MC)					
Latent Variable	Item	Standardized Factor Loading	SMC	AVE	CR
Competitive Advantage (CA)	D1	0.785	0.616	0.636	0.839
	D2	0.816	0.666		
	D3	0.79	0.624		
Market Positioning (MP)	D4	0.81	0.656	0.657	0.852
	D5	0.808	0.654		
	D6	0.814	0.662		

Partnership Advantage (PA)	D7	0.776	0.602	0.618	0.829
	D8	0.788	0.621		
	D9	0.795	0.633		

4.3.5. Customer Loyalty and Retention (CLR)

The Customer Loyalty and Retention (CLR) measurement model exhibits outstanding fit within the current research sample. The model not only provides a theoretically sound explanation of the structure of customer loyalty and retention but also achieves strong empirical validation. It thus offers a solid theoretical and empirical foundation for future investigations into the factors influencing consumer loyalty.

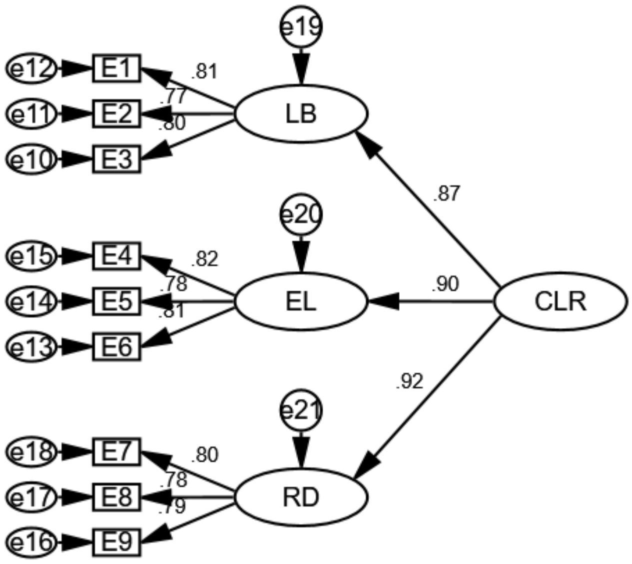


Table 12 Fit of Customer Loyalty and Retention (CLR) Measurement Model

Customer Loyalty and Retention (CLR) Model Fit Indices								
Index	χ2	df	p	χ2/df	GFI	RMSEA	RMR	CFI
Criterion	−	−	>0. 05	<3	>0. 9	<0. 10	<0. 05	>0. 9
Value	35. 748	24	0. 058	1. 49	0. 982	0. 034	0. 033	0. 995
Index	TLI	AGFI	IFI	PGFI	PNFI	PCFI	SRMR	NFI
Criterion	>0. 9	>0. 9	>0. 9	>0. 5	>0. 5	>0. 5	<0. 1	>0. 9
Value	0. 992	0. 967	0. 995	0. 524	0. 656	0. 663	0. 02	0. 984

The results of convergent validity for Customer Loyalty and Retention (CLR) are as follows: all item loadings for CLR exceed the commonly accepted threshold of 0.5. Furthermore, the Composite Reliability (CR) values are all greater than 0.7, and the Average Variance Extracted (AVE) values exceed 0.5, indicating that the CLR construct demonstrates good convergent validity.

Table 13 Convergent Validity of Customer Loyalty and Retention (CLR)

Convergent Validity of Customer Loyalty and Retention (CLR)					
Latent Variable	Item	Standardized Factor Loading	SMC	AVE	CR
Loyalty	E1	0.81	0.657	0.632	0.838

Behavior (LB)	E2	0.771	0.594		
	E3	0.804	0.647		
Emotional Loyalty (EL)	E4	0.821	0.675	0.644	0.845
	E5	0.778	0.606		
	E6	0.808	0.653		
Retention Drivers (RD)	E7	0.797	0.636	0.621	0.831
	E8	0.779	0.607		
	E9	0.789	0.622		

4.4 Correlation Analysis and Discriminant Validity

The results of Table 14demonstrate that the variables used in this study are not only highly correlated but also possess strong discriminant validity. These findings provide a solid theoretical foundation and empirical support for subsequent structural model construction and path analysis.

Table 14 Correlation Analysis and Discriminant Validity Results

Research Variables	Mean	Standard Deviation	CP	ITA	SQ	MC	CLR
Customer Perception (CP)	3.370	0.971	1				
Innovation and Technological Achievement (ITA)	3.314	0.950	0.777**	1			
Service Quality (SQ)	3.349	0.966	0.715**	0.796**	1		
Market Competitiveness (MC)	3.353	0.951	0.759**	0.808**	0.781**	1	
Customer Loyalty and Retention (CLR)	3.307	0.990	0.713**	0.774**	0.727**	0.768**	1

* p<0.05，** p<0.01

4.5 Common Method Variance (CMV)

To assess whether common method variance (CMV) exists in the measurement process, this study employed Harman’s single-factor test using advanced statistics software for data analysis. This technique is a widely used classical approach for evaluating potential CMV issues and helps to detect latent sources of systematic measurement error.

Table 15 Results of Common Method Bias

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	20.707	46.015	46.015	20.707	46.015	46.015	5.560	12.356	12.356
2	1.797	3.992	50.007	1.797	3.992	50.007	5.403	12.008	24.364
3	1.552	3.448	53.455	1.552	3.448	53.455	5.221	11.601	35.963
4	1.419	3.154	56.609	1.419	3.154	56.609	4.727	10.504	46.469
5	1.119	2.487	59.096	1.119	2.487	59.096	4.140	9.201	55.670
6	1.078	2.396	61.493	1.078	2.396	61.493	2.619	5.820	61.490

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4.6 Structural Equation Model (SEM)

Table 16 presents the overall fit indices for the Structural Equation Model (SEM) employed in this study. A comprehensive evaluation of various fit indicators reveals that the model demonstrates good adaptability and explanatory power, effectively capturing the alignment between the theoretical framework and the empirical data.

Table 16 Structural Model Fit Indices

Fit index	Standard	Value	Fitting situation
χ^2/df	1-3	1.732	Good
GFI	>0.8	0.874	Good
NFI	>0.8	0.881	Good
IFI	>0.8	0.946	Good
TLI	>0.8	0.942	Good
CFI	>0.8	0.946	Good
RMSEA	<0.08	0.041	Good

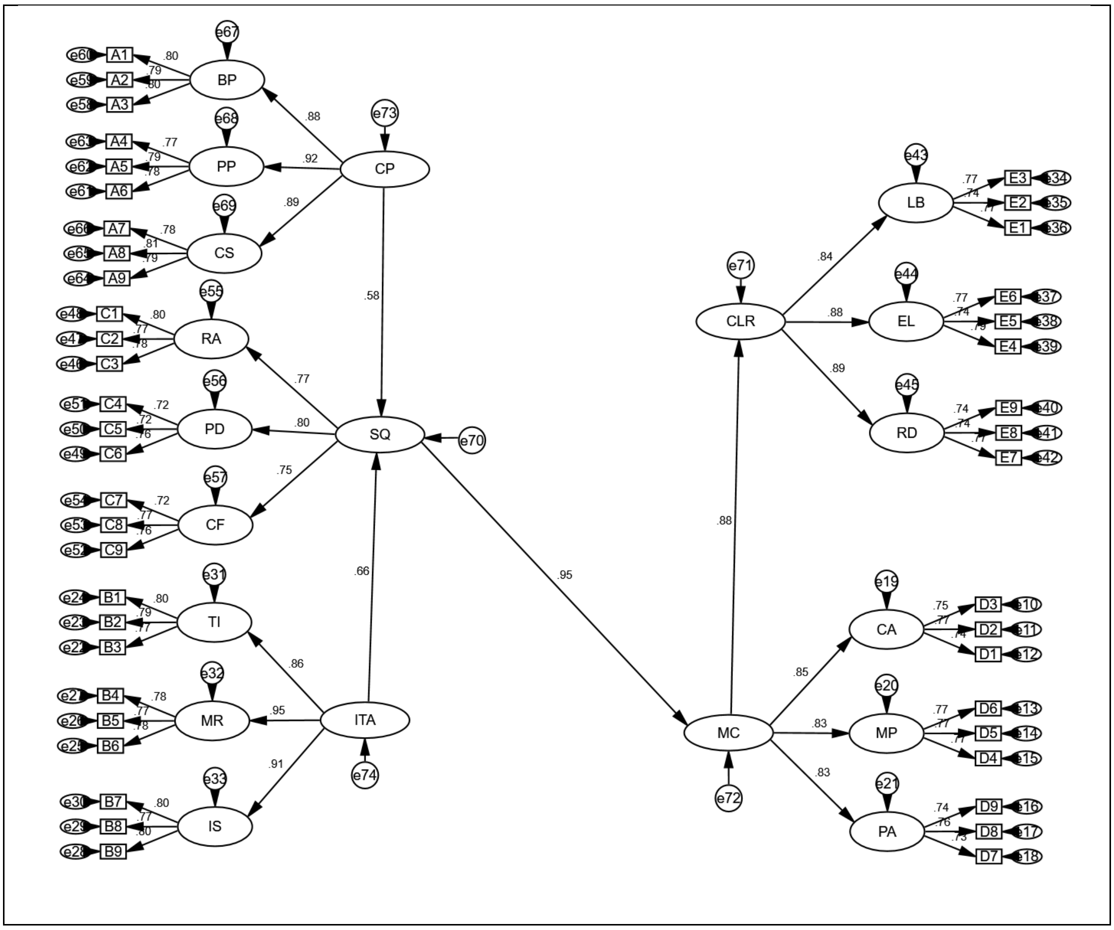
4.6.1 Path Analysis

Table 17 presents the results of the direct effect tests within the structural equation model for electric vehicle (EV) consumers. By analyzing key statistical indicators—namely unstandardized path coefficients, standardized path coefficients, standard errors (S.E.), critical ratios (C.R.), and p-values—this section explores the interrelationships among Customer Perception (CP), Innovation and Technological Achievement (ITA), Service Quality (SQ), Market Competitiveness (MC), and Customer Loyalty and Retention (CLR).

Table 17 Direct Effects Test Results

Path Relationship				Non-Standardized Path Coefficient	Standardized Path Coefficient	S. E.	C. R.	P	Result
H1	CP	—>	SQ	0. 471	0. 578	0. 047	9. 999	***	Accepted
H2	ITA	—>	SQ	0. 561	0. 662	0. 055	10. 201	***	Accepted
H3	SQ	—>	MC	0. 959	0. 951	0. 087	11. 087	***	Accepted
H4	MC	—>	CLR	0. 963	0. 883	0. 086	11. 219	***	Accepted

Figure 4.1 Structural Equation Model



4.6.2 Mediation Effect Analysis

Table 18 presents the results of the mediation effect tests in this study, further revealing the indirect relationships among customer perception, technological innovation, service quality, market competitiveness, and customer loyalty in the context of electric vehicle (EV) consumers. By analyzing these mediating paths, we gain a deeper understanding of the causal chain among variables and how they collectively influence consumers' ultimate loyalty and brand retention intentions.

Table 18 Mediation Effect Test Results

Hypothesis	Indirect Path	Effect Coefficient	SE	LLCI	ULCI	P
H5	CP→SQ→MC→CLR	0.486	0.088	0.322	0.656	0.001
H6	ITA→SQ→MC→CLR	0.556	0.087	0.397	0.737	0.001

4.7 The Results of Research Hypotheses

Table 19 The Results of Research Hypotheses

No.	Hypothesis	Results
H1	Customer Perception (CP) has a positive correlation with Service Quality (SQ).	Accepted
H2	Innovation and Technological Achievements (ITA) have a positive correlation with Service Quality (SQ).	Accepted
H3	Service Quality (SQ) has a positive correlation with Market	Accepted

	Competitiveness (MC).	
H4	Market Competitiveness (MC) has a positive correlation with Customer Loyalty and Retention (CLR).	Accepted
H5	Customer Perception (CP) has a significant indirect positive impact on Customer Loyalty and Retention (CLR) through Service Quality (SQ) and Market Competitiveness (MC).	Accepted
H6	Innovation and Technological Achievements (ITA) have a significant indirect positive impact on Customer Loyalty and Retention (CLR) through Service Quality (SQ) and Market Competitiveness (MC).	Accepted

5. Discussion and Conclusion

5.1 Discussion

Based on a dataset of 437 valid responses from EV users in mainland China, this study examined how Customer Perception (CP) and Innovation and Technological Achievements (ITA) influence Customer Loyalty and Retention (CLR) through the mediating roles of Service Quality (SQ) and Market Competitiveness (MC). The results of the Structural Equation Modeling (SEM) analysis presented in Chapter 4 reveal several key findings. First, CP significantly impacts SQ ($\beta = 0.67$, $p < 0.001$), indicating that customer perceptions of brand transparency, consistency of experience, and ease of use are critical predictors of service satisfaction. This finding aligns with Zhao & Chen (2021), who emphasized the importance of brand perception in shaping service experience. ITA also significantly affects SQ ($\beta = 0.45$, $p < 0.01$), suggesting that technological features such as autonomous driving, battery performance, and OTA functionalities must be tangibly experienced by consumers to generate service value—supporting Yang et al.'s (2023) notion of "perceived technological value." Further, SQ exerts a strong influence on MC ($\beta = 0.59$, $p < 0.001$), and indirectly enhances brand loyalty by increasing customer stickiness. This is especially relevant given that the sample was dominated by users of domestic EV brands such as BYD (40.3%) and Geely (30.4%), where after-sales responsiveness, technical support, and ecosystem-based services were key loyalty-building factors. MC significantly affects CLR ($\beta = 0.63$, $p < 0.001$), confirming a broader shift in the EV market from "product-centric" to "service and experience-driven" competition. In summary, this study uncovers a comprehensive behavioral pathway from brand perception and technological investment, through service experience and market positioning, to customer loyalty. It offers a systematic perspective for understanding consumer behavior in China's new energy vehicle sector.

5.2 Conclusion

This study proposed and empirically validated a dual mediation model to examine how Customer Perception (CP) and Innovation and Technological Achievements (ITA) jointly influence Customer Loyalty and Retention (CLR) through the mediating roles of Service Quality (SQ) and Market Competitiveness (MC) within the Chinese EV market. The findings reveal that neither CP nor ITA directly determine customer loyalty. Instead, their effects are transmitted via SQ and MC. This supports Barney's (1991) Resource-Based View (RBV), indicating that internal resources (e.g., technological and perceptual assets) must be transformed into perceived service quality and external competitive advantages to enhance customer stickiness. Empirically, CP has the strongest impact on SQ, suggesting that in a competitive market, consumers prioritize whether the brand delivers a consistent, authentic, and seamless experience. While ITA does not directly influence loyalty, its value is realized through improvements in service delivery—such as intelligent experiences, OTA upgrades, and charging accessibility—which then enhance MC and drive behavioral outcomes. SQ plays a critical dual-mediating role by linking perception and innovation to market outcomes. MC emerges as the most powerful predictor of CLR ($\beta = 0.63$), underscoring that sustainable brand appeal ultimately governs repeat purchases and advocacy. Overall, this study fills a gap in the empirical literature by modeling a dual mediation mechanism within China's EV industry and expands the application of loyalty theory in high-tech consumer contexts. The proposed "CP/ITA → SQ → MC → CLR" model provides theoretical and empirical guidance for EV firms seeking to understand customer decision-making processes.

5.3 Implications

This study offers both theoretical and practical implications. Theoretically, it integrates CP and ITA within a dual-mediation model featuring SQ and MC, thereby extending the applicability of Expectation-Confirmation Theory (ECT) and the Resource-Based View (RBV) to the context of EV consumer behavior. The model is particularly suitable for high-involvement, technology-intensive products and offers a structured framework for future research in related domains. Practically, for EV enterprises, the findings suggest that enhancing Customer Perception is foundational to improving service quality. Therefore, companies should invest in brand transparency, consumer education, and front-line experience management. Moreover, technological investment must go beyond R&D and focus on "consumer-perceivable functional value"—such as smart cockpit interfaces, remote control features, and autonomous driving system usability. Continuous optimization of service quality—e.g., maintenance responsiveness, OTA update efficiency, and customer support mechanisms—can directly enhance market competitiveness. SQ acts as a strategic bridge linking internal resources to external performance. For policymakers, the study recommends a greater focus on service infrastructure and regulatory oversight, such as standardizing smart charging networks and establishing after-sales certification systems. Future EV industry competition will not be determined solely by product technologies, but also by the integration of service systems, fulfillment of brand promises, and capacity to create sustained customer value. The model developed in this study provides a strategic reference for firms aiming to build user-centered service systems.

5.4 Limitations and Future Research

Despite its contributions, this study has several limitations. First, the use of a cross-sectional survey design only captures consumer behavior at a single point in time and cannot reflect the dynamic evolution of customer loyalty. Future research could adopt a longitudinal design to track changes in loyalty from initial purchase to continued use, enabling deeper causal analysis. Second, although the sample of 437 respondents was demographically diverse, it was primarily drawn from online platforms and urban users, potentially excluding perspectives from lower-tier cities or inland regions. Future studies may introduce regional comparative samples to improve external validity. Third, while the model captures perception, technology, service, and market variables, it does not include emotional factors (e.g., brand attachment), social influences (e.g., word-of-mouth), or policy variables (e.g., subsidies, purchase restrictions). Future work could incorporate these as moderating or interaction variables to enrich the framework. Lastly, with the rise of new trends such as AI-assisted driving, carbon credit policies, and battery-swapping models, consumer behavior in the EV sector is becoming increasingly complex. Future research should integrate emerging technologies and evolving policy landscapes to update the conceptual model and improve its relevance to industry transformation and real-world practices.

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