Advances in Consumer Research
https://acr-journal.com/
Volume-01 | Issue-1 | Jan - Dec 2024

Original Researcher Article *DOI: xxxxxxxxxxxxxxxxx*

Research on the Factors Influencing Consumer Purchase Intentions for New Energy Vehicles Using the DEMATEL-ANP Method

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Received: 03 Oct 2024
Revised: 16 Oct 2024
Accepted: 31 Oct 2024
Published: 16 Nov 2024

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Abstract

In recent years, the market for new energy vehicles has garnered significant attention and has experienced rapid development on a global scale, particularly in China. However, the escalation of market competition and shifts in consumer demand have substantially influenced the sales and sustainable growth of new energy vehicles. Consequently, this study aims to investigate the key factors impacting consumers' decisions to purchase new energy vehicles from a consumer-centric perspective by employing a multi-attribute decision-making methodology. To this end, we develop a set of 19 criteria encompassing four dimensions: social, technological, economic, and regional geographic factors. Utilizing data obtained from 138 valid questionnaires conducted in Northeast China, we analyzed the causal relationships and influence weights of each criterion through the Decision-making Trial and Evaluation Laboratory (DEMATEL) and Analytic Network Process (ANP) models. The findings indicate that economic considerations, including vehicle prices, maintenance costs and government subsidies are the predominant factors influencing consumers' purchasing decisions regarding new energy vehicles. Additionally, consumers' perceptions and values play a pivotal role in shaping their purchasing decisions and are crucial to market advancement. Intriguingly, technological aspects do not appear to be a significant concern in consumer purchasing behavior. This research enriches the understanding of consumer decision-making processes in the context of new energy vehicle sales and provides valuable insights for the strategic development of the new energy vehicle industry.

Keywords: New energy vehicle, Consumer behavior decision, Decision-making Trial and Evaluation Laboratory (DEMATEL), Analytic Network Process (ANP), Empirical research.

INTRODUCTION

In recent years, the automotive industry has experienced a rapid proliferation of new energy vehicles. This surge, particularly catalyzed by companies such as Tesla, BYD, and Xiaomi, has led to a diverse array of electric and hybrid electric vehicles that now command a substantial share of the Chinese market (Chen et al., 2024). This transformation has significantly altered the landscape, which was previously dominated by traditional fuel vehicles. Characterized by new energy efficiency and environmental sustainability, new energy vehicles resonate with the burgeoning concept of green travel, thereby attracting considerable consumer interest (Lin & Shi, 2022a). In contrast to conventional automobiles, new energy vehicles typically feature high- performance battery systems and incorporate advanced technologies, including intelligent driving and vehicle networking, appealing to consumers who prioritize innovation (Wang & Han, 2024). Furthermore, many consumers express appreciation for the quiet and efficient driving experience offered by these vehicles, which is often highlighted during test drives. The lower operating costs associated with new energy vehicles also play a crucial role in influencing purchasing decisions. Collectively, these factors have significantly contributed to the rapid advancement of new energy vehicles (Zhao et al., 2024).

However, the swift increase in new energy vehicle market share has prompted traditional fuel vehicle manufacturers to adopt aggressive pricing strategies to sustain their competitive edge (Zhao et al., 2024). Notably, esteemed brands such as Volkswagen, BMW, and Audi have implemented steep reductions in the prices of select fuel models, with discounts exceeding 30% in some cases. Concurrently, media coverage has frequently highlighted safety concerns related to new energy vehicles, including issues such as spontaneous combustion, failures in intelligent driving systems, and malfunctions at high speeds, exacerbating consumer apprehensions regarding safety

(Zhang et al., 2023). Moreover, challenges such as charging accessibility, battery life anxiety, and diminished battery performance at low temperatures continue to hinder consumer purchase intentions (Sun et al., 2023). In this context, consumer preferences in the automotive purchase decision-making process have undergone significant transformations compared with the era of traditional fuel vehicles (Nigam et al., 2024). Nonetheless, a comprehensive understanding of consumer consumption preferences related to the emerging business model associated with new energy vehicle sales and the underlying mechanisms influencing these preferences remains limited. This knowledge gap presents new challenges to the sustainable development of the new energy vehicle industry.

With the growing public awareness of environmental protection and the proactive promotion of relevant government policies, the market demand for new energy vehicles continues to rise, drawing significant attention from the academic community (Zhao et al., 2024). Research on consumer decision making in the context of new energy vehicle selection has primarily focused on various factors such as brand cognition, technology acceptance and innovation diffusion, environmental awareness and social impact, economic considerations, product attributes and performance, consumer psychological factors, policy environment, and dealer reputation (Chen et al., 2024; Kim & Cho, 2024; Li et al., 2016; Lin & Shi, 2022a; Nigam et al., 2024; Sun et al., 2023; Zhang et al., 2023; Zhao et al., 2024). However, existing studies often lack an in-depth exploration of the specific characteristics of the emerging new energy vehicle market, particularly regarding the identification of specific factors that influence consumer choices and the interrelations among these factors. Furthermore, previous investigations of automobile consumer behavior have predominantly employed qualitative analyses, case studies, and macro- level data analyses, with insufficient attention given to the collection of frontline data. This oversight limits the understanding of potential consumer behaviors and their influencing factors within the burgeoning new energy vehicle market. Consequently, there is a pressing need to conduct systematic and detailed research to elucidate the key factors and internal influencing mechanisms relevant to consumers' choices regarding new energy vehicles.

Multi-attribute decision-making methods are widely employed in the domain of decision analysis to analyze and resolve complex decision-making challenges (Liu et al., 2024). Consumers of new energy vehicles encounter a multitude of influencing factors throughout their selection and purchasing processes, making it imperative to utilize multi-attribute methods that can evaluate various attributes and feasible alternatives from multiple perspectives (Kim & Cho, 2024; Pamidimukkala et al., 2024). In contrast to traditional statistical models, the multi-attribute decision-making approach requires fewer samples and can generate more effective research outcomes with smaller sample sizes, thereby highlighting its unique advantages in the study of new energy vehicle sales. Thus, this study aims to employ a multi-attribute decision-making framework to conduct a comprehensive analysis of consumer demand for new energy vehicles and the factors influencing this demand. To accomplish this objective, the study began with face-to-face surveys involving both vehicle sales representatives and potential consumers, enabling a thorough investigation of the key determinants that drive consumer choice regarding new energy vehicles. Through consultations with industry experts, this research identifies the principal factors influencing consumer decision- making and establishes a robust framework for decision criteria and evaluation dimensions. Following this, the Decision Testing and Evaluation Laboratory (DEMATEL) and Analytical Network Process (ANP) methodologies were employed to analyze the data derived from the questionnaires. This quantitative approach aims to elucidate the relative significance of various influencing factors and to explore the causal relationships among them, thereby facilitating the prioritization and assessment of factors that impact consumer purchase behavior within the context of new energy vehicles.

The objective of this study is to identify the key factors influencing consumers' choices of new energy vehicles and to elucidate the causal relationships among these factors. The specific components of this study are as follows:

1) To investigate the critical factors affecting consumers' willingness to purchase new energy vehicles and to develop corresponding evaluation criteria.
2) To employ the DEMATEL methodology to analyze the causal relationships among influencing factors, assess their degrees of influence, and establish priorities from the consumers' perspective.
3) The ANP method was used to evaluate the weights of various factors, thereby identifying the significant variables that influence consumers' choices regarding new energy vehicles.

Through a systematic analysis of these relationships, this research provides valuable theoretical insights to support the sustainable development of the new energy vehicle industry and offers practical guidance for the formulation and implementation of relevant policies.

The main structure of this paper is delineated as follows: Chapter Two introduces the research methodology and procedures, Chapter Three discusses and analyzes the results, and Chapter Four summarizes the research conclusions.

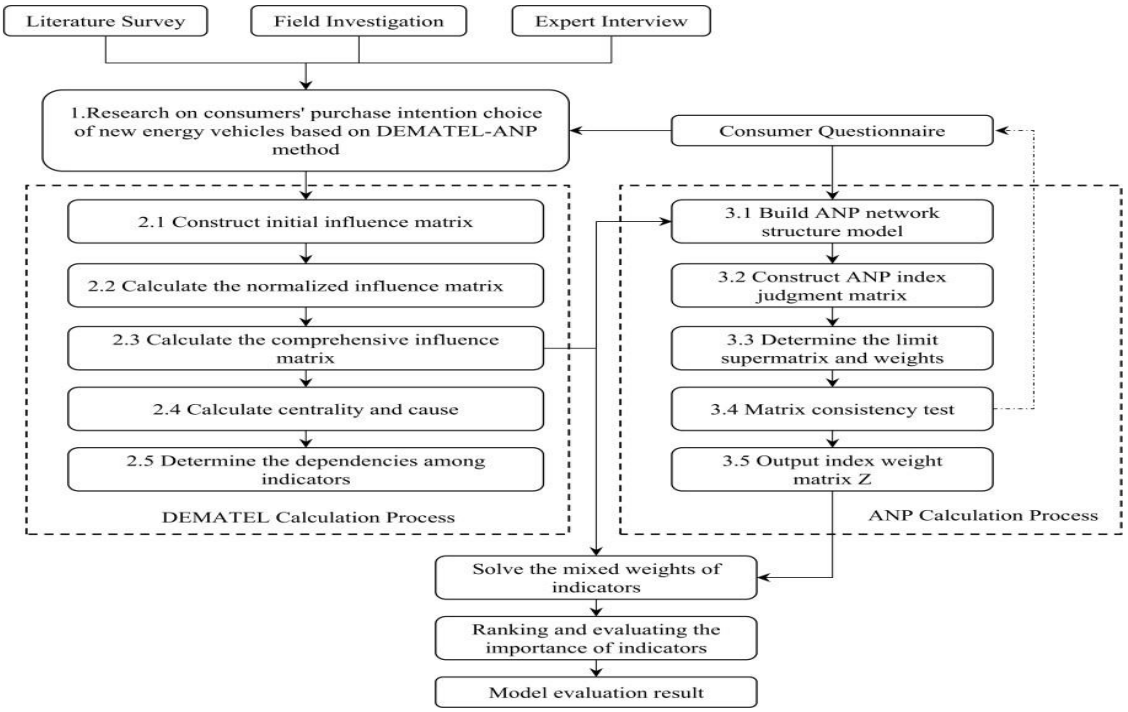
METHODOLOGY

3.1. Research Methods

Numerous elements may exhibit direct or indirect relationships in complex decision-making scenarios. In such contexts, many conventional index weight assignment methods, including the analytic hierarchy process and entropy method, typically assume that indicators are independent of one another, thereby overlooking interactions between dimensions. The DEMATEL method serves as a modeling approach that utilizes graph theory and matrix analysis to examine the relationships among factors in complex problems. By constructing an influence relationship-directed graph and a comprehensive influence matrix, DEMATEL calculates the degree of
influence each indicator exerts on others, and subsequently determines the centrality and causative degree of each indicator to reflect its relative importance. This method has been extensively applied in enterprise operation decision-making and environmental assessments (Büyüközkan & Güleryüz, 2016; Wang et al., 2024).

The ANP method, on the other hand, is an extension of the analytic hierarchy process and is primarily employed to address complex decision models characterized by interdependence and feedback. Compared with traditional analytic hierarchy process, ANP provides a more precise calculation of priorities, effectively manages problems that cannot be structured hierarchically, and allows for a comprehensive analysis of multiple indicators that exhibit interdependencies and interactive effects. This capability facilitates a more scientific and accurate evaluation process, making ANP widely applicable to complex multi-criteria decision-making challenges (Saaty, 2013; Taherdoost & Madanchian, 2023).
Considering the interactive influences and complex interconnections among various factors affecting consumers' purchase intentions regarding new energy vehicles, this study establishes an evaluation model using DEMATEL-ANP methodology. Specifically, following the establishment of the evaluation framework and index system, the DEMATEL method was employed to elucidate the interrelationships among the key factors and quantify the intensity of these influences. Building upon this analysis, the ANP method was utilized to assess the relative importance of indicators across different dimensions, enabling a more nuanced understanding of the intricate relationships among clusters of related factors through a synthesis of subjective and objective weighting. This approach underscores the scientific rigor and objectivity of evaluation results. This research focuses on potential consumers, service personnel, and experts involved in the sales of new energy vehicles in Liaoning, China. Through a combination of a literature review, field investigations, and expert consultations, a comprehensive research design was formulated. Subsequently, a DEMATEL questionnaire was developed, and the collected data were analyzed using both DEMATEL and ANP methodologies. The research design is illustrated in Figure 1.

Figure 1. Schematic diagram of the research design



3.2. Dimensions and criteria

Drawing on findings from the literature, field investigations, and the requirements of the DEMATEL methodology, an initial criterion list consisting of 15 items across five dimensions was established. The preliminary survey involved 268

participants, including 35 sales personnel in new energy vehicles, 155 customers, and 8 experts in related fields. The respondents were encouraged to provide suggestions based on their industry insights. Following a thorough review and filtering process, adjustments were made to the dimensions and criteria and additional elements were incorporated into the list. Ultimately, a comprehensive set of 19 criteria was finalized, encompassing four dimensions, as detailed in Table 1.

Table 1Decision dimension index framework

Target layer	Primary index layer	Secondary index layer	Secondary index number
		Brand image	U1
		Social perception and public opinion	U2
	Social Factors (K1)		
		Opinion leaders and consumer trends	U3
		Government policy	U4
		Appearance	U5
		Security	U6
	Technical Factors (K2)	Cruising property	U7
Factors influencing consumers' purchase intention choice of new energy vehicles		Advanced disposition	U8
		durability	U9
		Vehicle price	U10
		Operating cost	U11
	Economic factors (K3)	Service life	U12
		Hedging ratio	U13
		Consumption concept	U14
		Climatic condition	U15
		Topographic condition	U16
	Regional and Geographical Factors (K4)	Regional economic level	U17
		Regional cultural atmosphere	U18
		Urban planning and transportation systems	U19

3.2.1 Social Factors

The social factors dimension encompasses several critical aspects that significantly influence consumer behavior in the context of new energy vehicles.

Brand Image Brand image embodies the overall perceptions and evaluations consumers associate with a particular brand. In the realm of new energy vehicles, brand image is typically linked with attributes such as technological innovation, environmental sustainability, reliability, and performance. Existing research indicates a notable trend in China, where consumer awareness of brand distinctions has gradually diminished. Independent brands, characterized by cost-effectiveness, advanced technology, and a robust reputation, are gaining favor; in 2023, sales of independent brand new energy vehicles constituted 84.64% of the market (J. Zhang et al., 2024; Zhu et al., 2023). This shift suggests a changing landscape in consumer preferences, wherein individuals increasingly gravitate towards independent brands that blend affordability with innovation and trustworthiness.

- Social perceptions and public opinionSocial perception and public opinion encompass the collective attitudes and views of the population regarding new energy vehicles. These perceptions are instrumental in shaping consumer purchasing behavior. Prior studies underscore the critical impact of public sentiment on consumer decision-making: favorable public opinion fosters positive consumer attitudes, whereas negative sentiments can engender resistance to purchasing (Wu et al., 2023; Zhao et al., 2024). In the digital age, consumers' evaluations of product value are heavily mediated by social media platforms, which significantly influences their decision-making processes.
- Opinion Leaders and Consumer TrendsOpinion leaders wield considerable influence within specific domains, impacting the consumption choices of those around them. Consumer trends refer to the evolving preferences of

the general public over time. Research reveals that for consumers lacking prior purchase experience, the opinions and behaviors of their social circles heavily influence their intention to purchase new energy vehicles (Lin & Shi, 2022b; Lv et al., 2024). This underscores the significance of opinion leaders and prevailing consumption trends in shaping consumer intentions regarding new energy vehicles; their influence can either facilitate or alter public consumption behavior.

- Government Policy

  Government policies play a pivotal role in shaping consumers' intentions toward new energy vehicles. Through fiscal subsidies, tax incentives, and other mechanisms, governmental initiatives aim to encourage consumer adoption of new energy vehicles. Scholarly studies have demonstrated that fiscal subsidy policies are particularly effective in influencing purchase intentions, and as governments implement more substantial preferential measures, they exhibit a greater likelihood of opting for new energy vehicles (Tian et al., 2024; Xu & Mo, 2024). Moreover, the Chinese government has enacted incentives, such as purchase subsidies and tax exemptions, to further stimulate consumer uptake of new energy vehicles, highlighting the crucial intersection between public policy and market dynamics in the promotion of sustainable transportation solutions.

3.2.2 Technical Factors

The survey results indicate that technical factors constitute a critical dimension in examining factors that influence consumers' purchase intentions regarding new
energy vehicles. These factors can be categorized as follows:

(a) Appearance

Appearance represents the initial impression that consumers form about new energy vehicles and encompasses visual elements, such as design, shape, and color. An aesthetically appealing appearance can significantly enhance consumer goodwill and willingness to purchase new energy vehicles. Previous studies suggest that consumers assess various external characteristics of new energy vehicles, including interior aesthetics, style, and model, indicating that appearance is a vital technical factor that influences purchase intentions (Chen et al., 2023).

(b) Safety

Safety pertains to the capability of new energy vehicles to ensure the well-being of occupants while driving, encompassing both active and passive safety technologies. Consumers have high expectations regarding the safety features of these vehicles, as safety is intrinsically linked to the protection of lives and property. Research indicates that safety is an important factor for consumers when considering the purchase of new energy vehicles (Jing et al., 2025; Li et al., 2024).

(c) Cruising Range

Cruising range refers to the distance that new energy vehicles can travel on a single charge, a technical parameter of paramount importance to consumers. A longer driving range typically correlates with higher consumer satisfaction and increased willingness to purchase new energy vehicles. Prior studies have identified insufficient range as a major deterrent for consumers when opting against new energy vehicles (Chen et al., 2024)

(d) Advanced Features

Advanced features include the incorporation of intelligent and connected technologies in new energy vehicles, such as advanced driver-assistance systems, intelligent connectivity, and integrated infotainment systems. These technological enhancements can significantly improve driving experience and boost the appeal of new energy vehicles. Research has shown that technological advancements impact not only ownership costs and resale value but also overarching purchase intentions among consumers (Zhu et al., 2024).

(e) Durability

Durability is related to the longevity and reliability of new energy vehicles, specifically battery life and motor endurance. Vehicles exhibiting high durability can mitigate maintenance costs and prolong service life, thereby enhancing consumers' willingness to purchase. Studies have highlighted that limitations in battery lifespan and the associated high costs of battery replacement are critical drawbacks that influence consumer purchase intentions (Alganad et al., 2023; Bag et al., 2019).

3.1.1 Economic factors

Economic factors encompass several key aspects that consumers consider when considering the purchase of new energy vehicles:

(a) Vehicle Price

The price of a vehicle is the most significant economic factor influencing consumer decisions regarding the purchase of new energy vehicles. Previous studies indicate that the foremost determinant of whether consumers invest in these vehicles is their purchasing power (Sun et al., 2023). The relatively high initial costs associated with owning new energy vehicles can render consumers' purchasing capacities inadequate, thereby adversely affecting their purchase intentions. Furthermore, higher prices increase consumer expectations regarding a vehicle's technical specifications. When consumer expectations do not align with price, there is a marked decrease in the purchase intention.

(b) Operating Costs

Operating costs encompass regular expenses associated with the use of new energy vehicles, including charging and maintenance costs. Research has shown that daily ownership costs are directly correlated with the income generated by these vehicles (Du et al., 2024). As automotive technologies continue to advance, operating costs will be reduced, further impacting consumers' purchase intentions.

(c) Service Life

The expected service life of new energy vehicles is a crucial factor in the total cost of ownership over a specific period (Liu & Wang, 2024). As consumers tend to focus on the long-term performance and durability of these vehicles while seeking to minimize the total cost of ownership. Advances in technology and the maturation of the industry have contributed to the increasing lifespan of new energy vehicles, which has not only bolstered consumer confidence but also facilitated their widespread adoption.

(d) Depreciation Rate

The depreciation rate refers to the proportionate decrease in the value of a new energy vehicle compared to its original purchase price after a certain period of usage. Research suggests that depreciation rate is a significant consideration for consumers (Schloter, 2022). Despite the increase in warranty rates for new energy vehicles, the three- year warranty coverage remains below 50%, which is significantly lower than that of conventional fuel vehicles. The level of depreciation directly impacts the potential economic loss that consumers may incur when selling or replacing vehicles, thereby influencing their purchase intentions.

(e) Consumer Attitudes

Consumer attitudes encompass the values and behaviors associated with purchasing, particularly in relation to environmental protection, energy conservation, and acceptance of new technologies. As technological advancements continue and fuel costs rise, consumer demand for new energy vehicles has steadily increased, which has spurred manufacturers to enhance their products and contribute to a surge in new energy vehicle sales (Alganad et al., 2023). Moreover, heightened awareness of environmental issues and the growing acceptance of new energy technologies have led consumers to favor new energy vehicles, directly influencing their purchase intentions.

3.1.1 Regional and Geographical Factors

The influence of regional and geographical factors on purchase intention of new energy vehicles encompasses several key dimensions.

(a) Climatic Conditions

Climatic conditions have a significant impact on the utilization and performance of new energy vehicles. For instance, extreme temperatures, either high or low, can adversely affect battery efficiency and driving range. Given the variance in climate across different regions, consumer expectations and requirements regarding the endurance and adaptability of new energy vehicles are likely to differ. Research indicates that climatic factors play a critical role in shaping the new energy vehicles market, particularly under extreme weather conditions, where the performance and reliability of these vehicles are tested (Khanna et al., 2025).

b) Topographic Conditions

Topographic factors including elevation, slope, and relief variations significantly influence the experience and suitability of new energy vehicles. In mountainous regions or areas characterized by significant terrain fluctuations,

consumers may prioritize a vehicle's power performance and climbing capabilities. The diversity and complexity of the terrain, including features such as basins, hills, and mountains, can present ecological challenges while simultaneously impacting the operational feasibility of new energy vehicles (Papa et al., 2022).

c) Regional Economic Levels

The economic status of a region directly affects consumer purchasing power and overall demand for new energy vehicles. Consumers residing in economically developed regions are typically more inclined to invest in new energy vehicles, as these populations often have higher disposable income. According to research, the promotion of new energy vehicles has yielded notable success in first-tier cities, which are generally characterized by robust regional economic conditions (Q. Zhang et al., 2024).

Regional Cultural Atmosphere The cultural atmosphere of a region, encompassing the values, lifestyles, and environmental awareness of local residents, significantly influences their acceptance of new energy vehicles. In regions with a strong emphasis on environmental sustainability, new energy vehicles are likely to be more popular, as they are perceived as essential for reducing pollution and achieving sustainable development objectives. As societies progress both economically and socially, there is an increasing focus on ecological preservation and the pursuit of greener lifestyles.

d) Urban Planning and Transportation Systems

Effective urban planning and transportation infrastructure are crucial to the widespread adoption and utilization of new energy vehicles. A well-designed urban environment can facilitate the availability of charging facilities and create convenient transportation networks, thereby encouraging consumers to invest in and use new energy vehicles (Yan et al., 2024).

e) Research instruments

In this study, we employed a questionnaire based on the DEMATEL methodology to gather data and explore consumers' purchase intentions for new energy vehicles. The first step involved developing a preliminary evaluation framework and criteria through a comprehensive literature review, field investigations, and consultations with sales personnel and potential customers of new energy vehicle enterprises. Subsequently, we invited eight experts in the field of consumer behavior to assess these criteria and made the necessary adjustments based on their feedback. Following the establishment of the final criteria, a questionnaire was designed.

To measure the interactions among the dimensions, we utilized a five-point Likert scale, where 0 represents "no impact," 1 indicates "low impact," 2 signifies "medium impact," 3 denotes "strong impact," and 4 reflects "very high impact." This questionnaire was then used to conduct a practical survey targeting consumers who expressed their intention to purchase new energy vehicles. Participants were asked to evaluate the extent to which each dimension (criterion) influenced their overall purchase intention. The subsequent sections provide a detailed overview of the questionnaire format, sampling method, and data-collection procedure. The structure of the questionnaire is outlined as follows.

a. Introduction: This section includes a greeting for participants, a concise introduction outlining the purpose of the study, and information about the research team.
b. Purchase intention for new energy vehicles: Participants were asked about their past purchases or future intentions regarding new energy vehicles.
c. Basic Personal Information: This segment collected demographic information anonymously, encompassing participants' gender, age, education level, marital status, occupation, monthly income, residential area, and other pertinent details.
d. DEMATEL Questionnaire: This section features the evaluation scale, dimensions, and criteria used for assessment.
e. Conclusion: In this final section, we extend our gratitude to the participants for their involvement and encourage them to review their responses to ensure that all questions have been addressed.
f. It is essential to note that the study adhered to ethical guidelines, ensuring that all participants were at least 18 years of age and were informed about the study's purpose and procedures

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3.4. DEMATEL

The following steps were performed during the DEMATEL analysis conducted in this study (Qin et al., 2022; Wang et al., 2024).

1. Establishing the Direct Influence Matrix: Utilizing the results obtained from the questionnaire, we constructed a direct influence matrix based on the interrelationships among the various factors. This matrix was then normalized to produce the normalized direct influence matrix, designated as M .
2. Calculating the Comprehensive Influence Matrix: Leveraging the normalized direct influence matrix, we computed the comprehensive influence matrix T using the appropriate formula.

T □ lim (M □ M² □ … □ Mⁿ) □ M(E □ M)□¹ (1)

n□□

3. Extracting a Reasonable Threshold: This study disregards relationships characterized by minimal impact among indicators within the evaluation framework for purchase intentions regarding new energy vehicles. A reasonable threshold value □ was selected, which is critical for excluding the less significant decision criteria presentin the comprehensive impact matrix

T□ . This process further simplifies the

comprehensive impact matrix by filtering out relationships that exhibit minimal influence. Consequently, a simplified comprehensive impact matrix was derived through computational simplification of the truncated set matrix H .
T□ □ □t□ □

, H □ □□0, if tij □ □ (2)

n□n □□tij , if tij □ □

4. Calculating Centrality and Original Degree: Based on the results derived from previous calculations, we computed the cause degree and centrality of the target matrix by summing and averaging the horizontal and vertical values of the matrix. The calculation formula is as follows:

Di □ □tij , Rj
j □1

□ □tij (3)

i□1

Here, Rj

denotes the degree to which a standard is directly or indirectly influenced
by other standards, whereas Di
represents the extent to which a particular standard
directly or indirectly affects other standards.

5. Determining Dependencies Between Indicators: The final step involves establishing dependencies among the identified indicators.

3.5. ANP

We adhered to the standard ANP calculation procedure, which consists of the following steps (Büyüközkan & Güleryüz, 2016; Saaty, 2013; Tian et al., 2023).

1. Constructing the Network Structure: First, we establish the network structure through pairwise interactions among factors within the same target layer, as well as between different target layer index factors.
2. Constructing the Judgment Matrix: Utilizing the nine-level scale provided by the analytic hierarchy process, we assign priority metrics and conduct pairwise comparisons of the factors within the index layer. The index elements of criterion layer i are defined as sub-criteria. We then compare the influence of indicators in criterion

layer j against those in criterion layer i, resulting in a judgment matrix w , from which

a normalized feature vector matrix is constructed.

w □ □W (j)

W (j)
W (j) □T (4)

□ i1 i 2 ini □

3. Constructing an Unweighted Supermatrix: The ANP model employs a supermatrix to represent the degree of influence between the elements derived from comparisons
among the elements. By integrating the judgment matrix, we can construct the unweighted supermatrix (Wij □ 0), which is formed when the pairwise elements exhibit no influence on one another.

$$W \square \begin{bmatrix} W_{11} & W_{12} & \cdots & W_{1N} \\ W_{21} & W & \cdots & W_{2N} \\ \vdots & \vdots & & \vdots \\ W_{N1} & W_{N2} & \cdots & W_{NN} \end{bmatrix} \quad (5)$$

4. Constructing a Weighted Supermatrix: If the unweighted supermatrix fails to meet normalization criteria, each column of the unweighted matrix must be normalized. We subsequently weight the influence between different indicator layers, resulting in the weighted matrix A .

$$A \square \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1N} \\ a_{21} & a & \cdots & a_{2N} \\ \vdots & \vdots & & \vdots \\ a_{N1} & a_{N2} & \cdots & a \end{bmatrix} \quad (6)$$

5 Constructing the Limit Matrix: To accurately represent the complex indirect relationships among the index factors, we process the stability of the weighted supermatrix. This step yields the final weights for the selected factors and results in the limit matrix W□ . The limit value of the supermatrix raised to the k power approaches infinity, allowing for the calculation of the comprehensive weights of the indices using the SD software. The limit matrix is obtained.

W□ □ lim Wk (7)

k □□

RESULTS

The survey was conducted between April 20 and October 20, 2024. Among the 155 questionnaires distributed, the effective response rate was 89.03% and 138 valid questionnaires were recovered. The validity of the questionnaire was proven to be satisfactory.

3.3. Correlation impact analysis

Table 2Combined impact matrix for level 1 indicators

	Social Factors (K1)	Technical Factors (K2)	Economic factors (K3)	Regional and Geographical Factors (K4)

Social Factors (K1)	0.2367	0.0425	0.3037	0.0610
Technical Factors (K2)	0.4826	0.0956	0.6100	0.1439
Economic factors (K3)	0.4901	0.0842	0.4733	0.1515
Regional and Geographical Factors (K4)	0.4612	0.1986	0.6430	0.2401

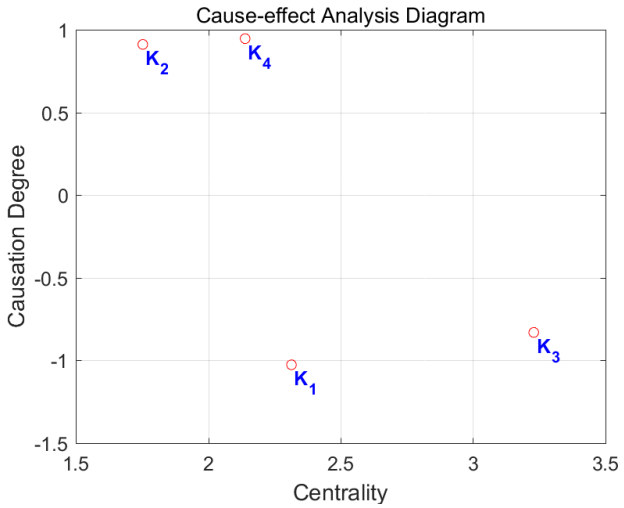

Figure 2. Cause degree and relationship degree of primary index

From the solution of the initial relationship matrix, we can derive a comprehensive influence matrix that delineates the interactions among indicators across all levels, as illustrated in Table 2. Building on these results, we calculated the degrees of centrality and causation, as shown in Figure 2. The structural framework of the first-level index network for the evaluation model is illustrated in Figure 3.

The analysis presented in Table 2 and Figure 2 reveals that the degrees of causation of the technical and regional factors are positive, highlighting their role as primary drivers of system change. This finding suggests that policy formulation and system optimization should prioritize these two dimensions, promoting systemic advancement by enhancing technical capabilities and refining regional layouts. By contrast, the negative causation degrees associated with social and economic factors imply that these indicators are more susceptible to external influences rather than serving as active agents of change. Therefore, it is imperative to implement more proactive interventions for these indicators to mitigate their adverse impacts and convert them into constructive
influences within the system.

In our examination of consumers' willingness to adopt new energy vehicles, we discovered that economic factors are the predominant determinants of consumer decisions. This trend may stem from consumers' initial assessments of their economic conditions when considering the purchase of new energy vehicles, which includes consideration of vehicle prices, charging expenses, government incentives, as well as the total cost of ownership and the value proposition of electric vehicles. The pronounced impact of economic factors underscores consumers' sensitivity to prices, highlighting the centrality of cost-effectiveness in their purchasing decisions. Following economic considerations, social factors—encompassing aspects such as social status, cultural background, and group dynamics—also play a significant role in shaping consumer values and spending patterns, thereby influencing purchase choices. For instance, peer influence may prompt consumers to select new energy vehicles that align with their perceived social standing, or they may be guided by advertising and social marketing towards models branded as "environmentally friendly" or "high-tech." Furthermore, regional and geographical factors deserve attention, as they encompass the availability of new energy vehicles, local consumption habits, climate conditions, etc.. Consumer preferences for new energy vehicles can vary significantly across regions due to these contextual variables. For instance, urban areas

grappling with severe air pollution may exhibit a higher propensity for consumers to choose zero- emission electric vehicles, whereas regions with abundant sunlight may be more interested in solar-powered electric vehicles.

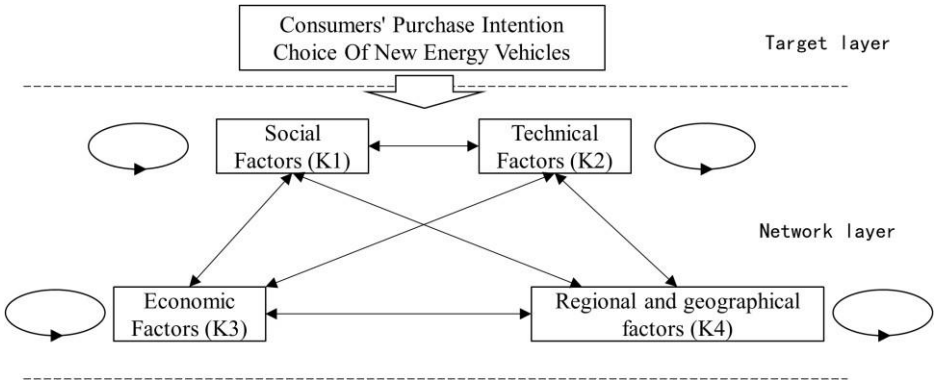

Figure 3. Evaluation model level indicator network structure

Table 3.Centrality and cause degree of each secondary indicator

Secondary index	Influence degree	Affected degree	Centrality	Causation degree	Indicator attribute
U1	0.5961	1.6950	2.2911	-1.0990	Outcome indicator
U2	0.5065	1.5179	2.0244	-1.0113	Outcome indicator
U3	0.4630	1.4118	1.8747	-0.9488	Outcome indicator
U4	0.5462	0.7055	1.2517	-0.1593	Outcome indicator
U5	0.5880	0.4449	1.0329	0.1431	Cause-type indicator
U6	0.8916	0.2487	1.1403	0.6430	Cause-type indicator
U7	0.7514	0.1361	0.8875	0.6153	Cause-type indicator
U8	1.2158	0.1026	1.3184	1.1131	Cause-type indicator
U9	0.8687	0.3857	1.2544	0.4830	Cause-type indicator
U10	0.8846	1.2514	2.1360	-0.3668	Outcome indicator
U11	0.8351	1.2656	2.1007	-0.4305	Outcome indicator
U12	0.7006	0.9890	1.6897	-0.2884	Outcome indicator
U13	0.5686	1.7265	2.2951	-1.1579	Outcome indicator
U14	0.8674	1.5349	2.4024	-0.6675	Outcome indicator
U15	1.7210	0.0145	1.7355	1.7065	Cause-type indicator
U16	0.7377	0.0286	0.7663	0.7091	Cause-type indicator
U17	1.0360	0.1294	1.1654	0.9066	Cause-type indicator
U18	0.9356	0.6195	1.5551	0.3161	Cause-type indicator
U19	0.4388	0.9453	1.3841	-0.5064	Outcome indicator

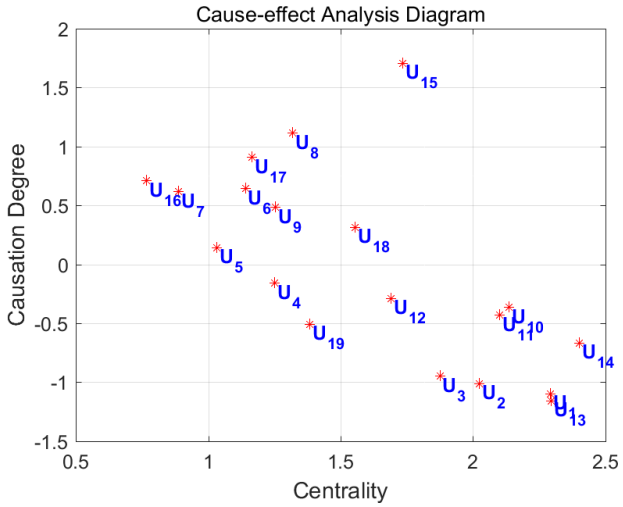

Figure 4. Centrality and cause degree of secondary indicators

By calculating the direct influence matrix for each secondary index, we derived the centrality and causation degrees of these indices, as shown in Table 3 and Figure 4. The analysis reveals that consumers' consumption concepts (U14) exhibit the highest degree of centrality, indicating that due to the heterogeneous nature of goods, consumers' personal beliefs and values play a pivotal role in shaping their purchasing decisions. Conversely, the topographic factor within the regional and geographical dimensions yields the lowest value, suggesting that while mountainous and hilly terrain may lead to differentiated consumption choices among local consumers, this phenomenon does not have a significant impact on a broader scale.

Examining the sub-dimensions, we found that (1) brand image holds a dominant position within the social elements affecting consumers. This aligns with real-world scenarios where reputable brands such as Tesla and BYD experience heightened market demand because of their reliable brand images. (2) Regarding technical factors, durability has emerged as a primary concern for consumers. The perception of
durability implies that a product can maintain its functionality and appearance over time, thereby reducing the need for frequent replacement, which is a key consideration for consumers. (3) Consumer consumption concepts are overwhelmingly influential in the realm of economic factors. (4) Finally, within the regional and geographical contexts, local identification with specific vehicle brands plays a critical role. This phenomenon is easily illustrated by the popularity of various Wuling brand electric vehicles in regions near the Wuling factory, as well as the prevalence of red-flag energy vehicles observed throughout the Chinese city of Changchun.

Table 3 and Figure 4 provide detailed insights into the causative and resultant attributes of each secondary indicator. Notably, climatic conditions have emerged as a significant representative factor, with a profound influence on consumer behavioral decisions. For instance, in regions such as Heilongjiang, where winter temperatures plummet, the sales of pure electric vehicles are typically low, whereas plug-in hybrid vehicles, which can operate on both electricity and gasoline, tend to sell well, an outcome attributable to prevailing climatic conditions. When considering the key outcome indicators, it is evident that the hedging ratio result from the interplay between multiple factors, with this particular indicator demonstrating a notably significant passive influence attribute.

3.4. Evaluation results

Building on these factors and their interrelations, we constructed an evaluation network using the ANP method. The resolution of this model yields the weights of various indices that influence consumers' intention to purchase automobiles, as shown in Table 4. The results indicate that economic factors have a consistent influence on the purchase intentions of new energy vehicle consumers. This dominance can be attributed to the direct impact of economic considerations, including the purchase cost of new energy vehicles, operating expenses, government subsidies, and fuel prices, on consumer decision-making. Consumers typically opt for models that minimize their long-term expenditure, thereby cementing the preeminence of economic factors.

In the realm of social elements, consumer behavior is shaped by social and cultural backgrounds as well as societal perceptions. As environmental awareness and the concept of sustainable development gain traction, consumer acceptance of new energy vehicles has increased correspondingly. In this context, social recognition and public opinion emerged as significant influencing factors. Additionally, regional development and geographical considerations are fundamental, as varying levels of infrastructure development, policy support, and market maturity across regions can

substantially affect consumers' willingness to purchase. For instance, the distribution of charging stations is contingent on regional factors, which in turn influence consumer decisions regarding the acquisition of new energy vehicles.

Interestingly, the technical elements ranked last among the four dimensions assessed. This phenomenon can be understood in light of the current state of new energy vehicle technology, where many manufacturers have reached relatively advanced and mature levels of technological proficiency. Reliability, quality, and overall technological configurations have become well established. As a result, consumers have developed a high degree of trust in technology, rendering them less sensitive to this dimension in their purchasing decisions

Table 4Calculation results of indicator weights

Primary index			Secondary index				
Item	Weight	sorting	Subproject	Intra-group weight	Intra-group weight sorting	Global weight	Global weight sorting
K1	0.2456	2	U1	0.3079	1	0.0756	3
			U2	0.2720	2	0.0668	6
			U3	0.2519	3	0.0619	7
			U4	0.1682	4	0.0413	14
K2	0.1859	4	U5	0.1833	4	0.0341	17
			U6	0.2024	3	0.0376	16
			U7	0.1575	5	0.0293	18
			U8	0.2340	1	0.0435	12
			U9	0.2227	2	0.0414	13
K3	0.3506	1	U10	0.2011	3	0.0705	4
			U11	0.1977	4	0.0693	5
			U12	0.1590	5	0.0558	9
			U13	0.2160	2	0.0757	2
			U14	0.2261	1	0.0793	1
K4	0.2180	3	U15	0.2627	1	0.0573	8
			U16	0.1160	5	0.0253	19
			U17	0.1764	4	0.0385	15
			U18	0.2354	2	0.0513	10
			U19	0.2095	3	0.0457	11

CONCLUSION

From the perspective of consumer behavior research, this study employs field investigations and questionnaire surveys to explore the sales landscape of new energy vehicles in Northeast China. It examines the key factors influencing consumers' decisions to purchase new energy vehicles and develops a survey framework to evaluate consumers' willingness to buy these vehicles. Subsequently, by integrating the DEMATEL-ANP methodology, the study investigates the critical factors affecting consumer behavior and their interrelationships, followed by a detailed analysis of the

findings. The study culminates in several significant conclusions: This study highlights the crucial role of economic factors in consumers' decisions to purchase new energy vehicles, focusing on key economic indicators such as acquisition costs, operating expenses, warranty rates, and total cost of ownership. Additionally, regional and geographic

variables—such as climate, topography, and the level of economic development—also significantly influence consumer purchasing behavior. Therefore, it is essential to take these factors into account when formulating relevant policies or optimizing the market system to foster the healthy development of the new energy vehicle market. Moreover, consumer values and personal beliefs are pivotal in shaping car purchase decisions, emphasizing the need to understand and influence consumer perceptions to boost sales. However, the study found that technical factors did not have a significant impact on consumers' purchasing decisions, a point that should be considered in policy-making and marketing strategies.

Although this study offers valuable insights, it also acknowledges certain limitations. These shortcomings may include the geographical constraints of the sample, the timeframe during which the data were collected, and potential methodological limitations. To enhance the comprehensiveness and accuracy of future research, the following recommendations are proposed: (a) Expanding the Sample Scope: Increasing the diversity of the sample by including consumers from various regions and economic backgrounds can yield a broader range of data. (b) Long-term Tracking Research: Conducting longitudinal studies to monitor changes in consumers' purchasing behaviors and attitudes over time will provide a deeper understanding of the dynamic factors influencing their decisions. (c) Consideration of Policy and Market Changes: As policies evolve and markets develop, it is essential to regularly update research to reflect on the latest influencing factors. By implementing these strategies, we can further enhance our understanding of the purchasing behavior of new energy vehicle consumers and offer more targeted guidance for policymakers and automakers.

Declarations

Ethical Approval: We confirm that the study meets ethical requirements and ensures informed consent of participants.

Consent to participate: Not Applicable

Consent for publication: Not applicable

Availability of data and materials: All data generated or analysed during this study are included in this published article.

Competing interests

The authors declare that they have no competing interests.

Funding

Authors declare that they can afford the payment for the article publication fee at the payment time.(Self-sponsor)

Authors' contributions

Jie Leng was responsible for conceptualization of the research, methodology development, formal analysis, writing the original draft, and organizing the overall manuscript structure. Daoqing Hao supervised the research, designed and administered the questionnaire research, reviewed and edited the manuscript, and provided critical feedback on the methodology and results. Mingyang Guo contributed to the software implementation of the DEMATEL-ANP method, data processing, and visualization of the results. Additionally, assisted with the technical aspects of the statistical analysis. Xiaoxiao Liu contributed to data collection, validation of research findings. Additionally, assisted with literature review and manuscript editing.

Acknowledgments: Not applicable

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