Analysis of the development factors of new energy electric vehicles

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Abstract. New energy electric vehicles are developing rapidly, so the analysis of the key factors in the development of new energy electric vehicles is also crucial. Analysing the key factors influencing the development of China, employing an Analytic Hierarchy Process (AHP) model. The model passed CI and CR checks, highlighting the significant impact of Economic and Policy considerations on the industry's development.

Keywords: Development factors; Analytic Hierarchy Process; CI and CR checks.

1 Introduction

In recent years, there has been an increasing global concern about environmental issues, and with vehicle emissions being one of the main sources of pollution, the shift to cleaner energy vehicles has become a trend. With energy security and sustainable development, new energy electric vehicles use electricity that is more renewable and sustainable. The development of new energy electric vehicles is gradually and rapidly developing. With increased environmental awareness and government support for clean energy, more and more automakers are investing in the electric vehicle market. Technological advances, lower battery costs and improving charging infrastructure have all contributed to the development of electric vehicles[1].

As one of the world's largest markets for new energy electric vehicles, China has a large consumer base and rapidly growing demand. This market size has also attracted investment and competition from both domestic and foreign companies. China is actively promoting the development of this sector by improving the new energy electric vehicle industry chain and carrying out a great deal of technological R&D and innovation. The Chinese government has actively promoted the rise of new energy electric vehicles through a series of preferential policies, considering it a pivotal direction for future transportation development[2]. The aim of this study is to use the hierarchical analysis method (AHP) to deeply analyse the key factors affecting the development of new energy electric vehicles in China. And by establishing a mathematical model, it predicts that its future development trend is positive and good.

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2 Problem Restatement and Analysis

2.1 Problem Restatement

Factors Analysis. Conduct an in-depth examination of the core factors influencing the development of new energy electric vehicles in China. Establish a mathematical model and elaborate on how these factors specifically affect the integration of new energy electric vehicles into urban environments in China.

2.2 Analysis of Question

Analysing the main factors affecting the development of new energy electric vehicles in China requires a thorough examination and data search. existing literature and studies to identify these factors. Through extensive literature review, a series of indicator factors are selected and organized into primary and secondary levels. To structure the analysis, an Analytic Hierarchy Process (AHP) model is established, defining both primary and secondary indicators[3]. The results of the model are then validated using the Consistency Index (CI) and Consistency Ratio (CR). This rigorous approach ensures a systematic evaluation of the factors affecting the development of new energy electric vehicles in China, providing a solid foundation for strategic decision-making in the field.

3 General Assumptions Notations

3.1 Assumptions

To simplify the model and facilitate its formulation and computation, we have made the following assumptions: Considering that the gathered data may not fully account for the influence of information openness.The reliability of the preprocessed data is assumed, ignoring errors or inaccuracies that may have been introduced during the preprocessing phase.Presuming the absolute dependability of the established big data model, founded on existing data for tasks such as prediction and assessment. Non-quantifiable elements like political maneuvering between governments that could impact data acquisition are not taken into account.

3.2 Notations

Furthermore, we have presented the essential symbols defined during the modeling process, as delineated in Table 1.

Table 1. Notations.

Symbol	Description
TWF_{i}	Average weight of i-the factor
$\boldsymbol{D}$	The level of development
$C^{*}(x)$	The Random Fores

Symbol	Description
OOB_k	"Out-Of-Bag" for the k-the tree
$\delta(\cdot)$	The indicator function
$imp\left(x^{(j)}\right)$	Feature Importance
W	Test Statistic
ρ	Correlation Coefficient

4 Model and Solution of Question

The evolution of China's new energy electric vehicle sector is intricately shaped by the confluence of policy, technology, economy, environmental resources, and societal factors. These elements potentially exert a direct influence on the overall developmental trajectory of the new energy vehicle industry. This inference comes from a meticulous and comprehensive collection of data from different online sources.In order to examine the relative importance of these factors in more depth, we decided to develop a systematic mathematical model using a hierarchical analysis.

After an extensive review of information and literature, we have compiled the tangible indicators of the influence factor, as illustrated in Figure 1 below:

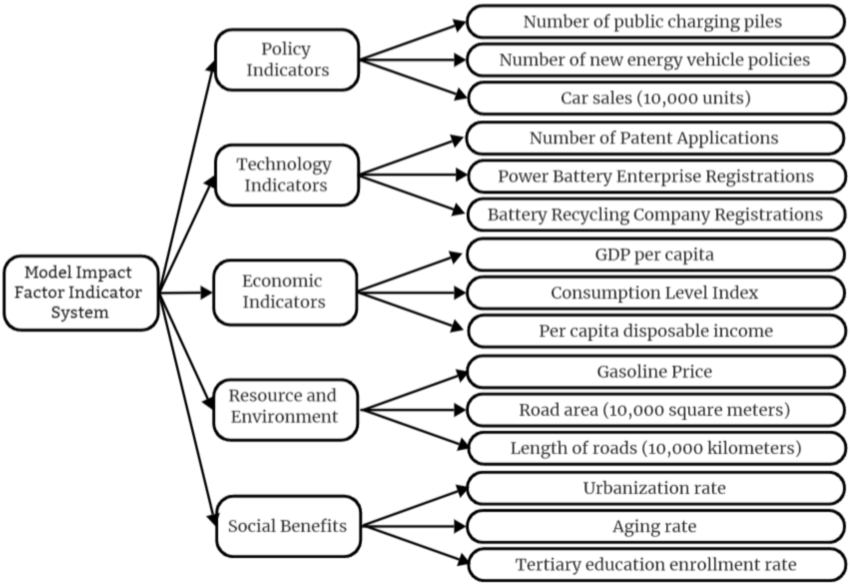

Fig. 1. Model impact factor.

4.1 Model Establishment

*Step one: P*airwise Comparison Matrices Construction.

New energy vehicles' development is influenced by multiple factors such as policy, technology, market, and social aspects. To systematically analyze these factors.

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \tag{1}$$

Expert scoring is employed to construct pairwise comparison matrices for each key factor. As an illustration, the policy matrix. A is constructed, where each element a_{ij} denotes the relative importance of factor i compared to factor j.

Step two: Eigenvalues and Eigenvectors.

$$\lambda_{max} = max(\lambda_1, \lambda_2, \lambda_3, \dots, \lambda_n)$$

$$\boldsymbol{v}_{max} = CE\ \lambda_{max} \tag{2}$$

Eigenvalues λ and eigenvectors $\mathbf{v}$ of the policy matrix are calculated to obtain weight information. The maximum eigenvalue $\lambda_{\max}$ and its corresponding eigenvector $\mathbf{v}_{\max}$ represent the relative weights of each factor. CE is corresponding eigenvector of.

Step three: Consistency Check.

$$CI = \frac{\lambda_{\max} - n}{n-1}$$

$$CR = \frac{CI}{RI}\ \lambda_{\max} \tag{3}$$

To ensure coherence in expert ratings, the Consistency Index (CI) and Consistency Ratio (CR) are introduced. A CR value below 0.1 indicates a successful consistency check, affirming the rationality of matrix construction.

Step four: Weight Calculation.

$$\begin{aligned} \boldsymbol{W}^A &= \frac{1}{n}\sum_{j=1}^{n} a_{ij} \\ \boldsymbol{W}^G &= \left(\prod_{j=1}^{n} a_{ij}\right)^{\frac{1}{n}} \\ \boldsymbol{W}^E &= \frac{v_{max}}{\sum_{i=1}^{n} v_{max}} \end{aligned} \tag{4}$$

Various methods, including the arithmetic mean, geometric mean, and eigenvector methods, are employed to calculate factor weights. A is Arithmetic, G is Geometric, E is Eigenvalue.

Step five: Hierarchical Total Weight.

$$TWF_{\ i} = \frac{1}{m}\sum_{j=1}^{m} w_j TWSF_{\ i} \tag{5}$$

Considering the hierarchical structure of AHP, the hierarchical total weight is introduced, indicating the weight of each factor in the overall decision, TWF $_i$ is the average weight of i-the factor relative to factor i, TWSF $_i$ is Total Weight Subfactor, w_j represents the weight of j-the subfactor relative to factor i.

Step Six: Comprehensive Model.

The final comprehensive model is formulated as:

$$D = \prod_{i=1}^{n} Total\ Weight_{\ Factor_i} \tag{6}$$

The product of the total weights of each factor, providing an overall assessment of the NEV development level. D is the level of development.

4.2 Problem Solving

Initially, we establish several parameters for the AHP algorithm model, encompassing the decision matrix, matrix dimensions, RI list, eigenvalues, and eigenvectors. Specifically, we specify the RI list as [0, 0, 0.52, 0.89, 1.12, 1.26, 1.36, 1.41, 1.46, 1.49, 1.52, 1.54, 1.56, 1.58, 1.59]. After exhaustive relevant literature and in-depth investigation, we define the eigenvector matrix of each influencing factor and perform the corresponding matrix calculation.

We chose to apply three different matrix weighting methods: mean, geometric mean and eigenvector to calculate the weights. Subsequently, we determine the average of these three weights. In addition, after the calculation of the second tier indicators and the definition of the first tier indicators, we proceeded to determine the weights of the first tier indicators based on their influencing factors.

This strategic approach ensures a comprehensive understanding of the AHP model attributes, aligning with rigorous literature reviews and meticulous studies. The incorporation of diverse matrix weighting methods enhances the model's robustness, contributing to its applicability in various contexts.

Solution Step 1: Weight Calculation.

We have obtained the results as presented in Table 2.

Table 2. Influencing Factors.

Research target	Primary Indicator	Weight1	Secondary indicators	Weight2
Influencing Factors of New Energy Vehicle Development	Policy Indicators	0.20270	Number of public charging piles	0.30598
			New energy vehicle policies	0.32459
			Car sales (10,000 units)	0.36943
	Technology Indicators	0.19583	Number of Patent Applications	0.34954
			Power Battery Enterprise	0.32617
			Registrations Battery Recycling	0.32429
	Economic Indicators	0.20671	GDP per capital	0.36251
			Consumption Level Index	0.33213
			Per capital disposable income	0.30537
	Resource and Environment	0.18346	Gasoline Price	0.32633
			Road area(10,000 square meters)	0.32718
			Length of roads(10,000 kilometers)	0.34649
	Social Benefits	0.20081	Urbanization rate	0.33557
			Aging rate	0.33406
			Tertiary education enrollment rate	0.33036

The displayed values above represent the average weights derived from three different weighting methods. We regard this average weight as the degree of influence, signifying the magnitude of impact on the development of new energy vehicles (NEVs). Within the secondary indicators, car sales emerge as the most influential factor within policy impact, with a weight of 0.36943. In the technological aspect of NEVs, the number of patent applications stands out as the predominant factor, with a weight of 0.34954. Among the economic factors, the most significant influencers in terms of per capital GDP is the number of patent applications, carrying a weight of 0.36251. In the environmental impact category, road length holds an influence factor of 0.34649. Notably, there is no significant distinction among the three factors in the social benefit methodology.

Concerning primary impact indicators, Economic metrics and NEV Policy indicators exhibit substantial influences, with weights of 0.20671 and 0.20270, respectively. It is evident that the influencing factors for China's new energy vehicles primarily lie in the country's social economy conditions and associated policies promoting NEVs.

Solution *Step 2*: Consistency Check

To validate the rationality of the AHP model, we conducted a rigorous consistency test. This involved calculating the coefficients of RI and CR, and the results are summarized in the following Table 3.

Table 3. Consistency Check.

	Policy Indicators	**Technology Indicators**	**Economic Indicators**	**Resource Environment**	**Social Benefits**	**Research target**
RI	5e-05+0j	0j	0.01364+0j	0.00694+0j	0.00453	0.00118+0j
CR	0.0001+0j	0j	0.02623+0j	0.01335+0j	0.00871	0.00097+0j

Upon careful examination, it is evident that both RI and CR values are exceptionally small. Each CR is less than 0.1, a pattern observed consistently across both primary indicators and research subjects. This attests to the successful completion of the consistency test using the Analytic Hierarchy Process, validating its applicability at both the primary indicator and research object levels.

The minuscule values of RI and CR underscore the robustness of the AHP algorithm model, affirming its efficacy within the specific context of this study. This confirmation of a high degree of consistency in the decision-making process further strengthens confidence in the soundness of the hierarchical approach to methodology and adds depth to its application in the research field.

5 Model Evaluation and Further Discussion

5.1 Strengths

The complexity of this problem is larger, with more influencing factors, and the use of AHP analysis can improve the transparency and rationality of decision-making for the solution of complex problems. And this model uses three kinds of weights to solve the problem and passes the consistency test.

In the process of solving problems using the established mathematical models, rigorous examinations and validations were conducted. The models successfully passed the verification and validation processes, affirming the robustness of the proposed methodology in this paper.

5.2 Weaknesses

The results of AHP rely heavily on subjective judgment. To a certain extent, there is a shortage of large errors, and this thesis deals with more problematic factors, more workload, and lower applicability.

5.3 Further Discussion

This study provides valuable insights for future research by using different models and methods to analyse and predict the global nuclear weapons problem. However, there are opportunities for improvement to deepen our understanding of new energy electric vehicles (NEV) and their global impact[4].

Concerning the AHP model, it is acknowledged that outcomes depend on subjective judgment. Future research could explore ways to reduce this impact by incorporating more objective data and methodologies, such as broader surveys and authentic feedback, to enhance the model's reliability.

6 Conclusion

6.1 Summary

This study aims to analyse in depth the core factors affecting the development of new energy electric vehicles in China and to predict its development trend in the next decade by establishing a mathematical model.

We selected five first-level indicators, including economic factors and policy factors, with corresponding second-level indicators. The hierarchical analysis method (AHP) model is used to analyse the key factors affecting the development of new energy electric vehicles in China. The model has passed CI and CR inspection, highlighting the significant impact of economic and policy considerations on the development of the industry.

6.2 Vision of the Future

I think the global development prospects of new energy vehicles are very optimistic.

First, market growth. It is expected that the new energy vehicle market will continue to grow in the future. Driven by multiple factors such as environmental protection, government policy support and technological progress, more and more consumers will choose to buy new energy vehicles.

Second, technological innovation. With the continuous progress of technology, battery technology, electric drive technology, intelligent interconnection technology, etc. will continue to be developed and improved to improve the performance, range and user experience of new energy vehicles.

Third, the cost decreases. With the scale effect and technological progress, the manufacturing cost of new energy vehicles will gradually decrease, so that the price difference between new energy vehicles and traditional fuel vehicles will gradually narrow, thus promoting the popularization and development of the market.

Fourth, global competition. Automobile manufacturers in various countries will increase investment and R&D in the field of new energy vehicles, and the competition will be more fierce, which will promote the continuous innovation of new energy vehicle technology and the continuous progress of the market.

Fifth, energy transformation. New energy vehicles will become an important part of energy transformation, playing an important role in reducing carbon emissions, reducing energy consumption, improving air quality and protecting the environment[5].

Generally speaking, new energy vehicles will become one of the leading trends in the global automobile industry in the future, making important contributions to the construction of a clean, low-carbon and sustainable transportation system[6].

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