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Research on Potential Factors Influencing the Development of New Energy Vehicles

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Abstract: This study constructs double Analytic Hierarchy Process of the potential influencing factors on the development of new energy vehicles, mainly divided into government support and the attractiveness of new energy vehicles to customers. Based on the social survey results on customer attractiveness, a judgment matrix is established and evaluated through consistency testing. The results indicate that the factors with significant impact on the industry's development are the safety and range of new energy electric vehicles, as well as the government's subsidy policies for new energy vehicles. A multiple regression equation is established to predict the future development of the new energy vehicle industry by considering variables such as new energy vehicle sales volume, range of new energy electric vehicles, and the Multiple regression. The results suggest that the new energy vehicle industry will continue to thrive in the next decade. At the same time, the relationship between factors affecting the development of new energy electric vehicles and factors affecting traditional energy vehicles was studied, and two sets of typical correlation analysis variables were constructed. It was found that there was a partial inverse relationship between these two sets of variables. According to the analysis results, the development of new energy electric vehicles has a certain inhibitory effect on the global development of traditional energy vehicles.

Keywords: New energy vehicles, Analytic Hierarchy Process, Multiple Regression, Trade Canonical Correlation Gravity Model.

1. Introduction

The In recent years, with the rapid development of the economy, the demand for cars has been increasing. However, traditional cars produce a large amount of exhaust emissions during use, which causes serious pollution to the environment. In 2020, the total emissions of four pollutants from motor vehicles in China reached 15.577 million tons, resulting in severe pollution[1]. In response to this problem, some domestic companies in China, such as BYD, Great Wall Motors, and Changan Automobile, have shifted their focus to the production of new energy vehicles, ceasing the sale of traditional fuel vehicles and increasing their efforts in the development of new energy vehicles. In China has listed new energy vehicles as one of the strategic emerging industries. New energy vehicles, based on advanced principles and utilizing cutting-edge technologies, are designed with new structures. Currently, new energy vehicles can be categorized into four major types. Taking new energy electric vehicles as an example, they have the advantages of low pollution, low energy consumption, and peak shaving capabilities compared to traditional conventional vehicles.

The development of new energy vehicles, including electric vehicles, is regarded as a strategic initiative for China to transition from a large automobile country to an automobile power, as well as an important measure to address climate change and promote green development[1]. Since the release of the "Energy-saving and New Energy Vehicle Industry Development Plan (2012-2020)" by the State Council, China has adhered to a pure electric-driven strategy, and the new energy vehicle industry has achieved tremendous success, becoming one of the significant driving forces for the transformation of the global automobile industry[2].

In the past few years, new energy vehicles have continuously improved their advantages and functionality, and their sales have steadily increased. However, China's new energy vehicle development also faces challenges such as weak innovation capabilities in core technologies, the need for improvement in quality assurance systems, lagging infrastructure construction, an incomplete industrial ecosystem, and increasingly fierce market competition.

Therefore, new energy electric vehicles are favored by more and more consumers and receive strong support from government policies.

2. Analysis of the main factors affecting new energy electric vehicles

2.1. Data processing

Before analyzing the main factors affecting new energy electric vehicles, data collection and data search, as well as data processing and analysis, were conducted. In this question, the paper have analyzed the main factors affecting new energy vehicles. The factors influencing new energy vehicles include policy, market, and technology[3]. Assuming that other factors remain constant, the main factors influencing new energy vehicles are government support and the attractiveness of new energy electric vehicles themselves. We need to use the Analytic Hierarchy Process to analyze tax reduction policies, charging fee discounts, purchase quota restrictions, electric vehicle prices, driving range, the number of charging stations, charging time, and vehicle safety. Data source: Reference[4].

Based on the above introduction, this article constructs decision matrices for various factors, as shown in Tables 1-3.

Tables 1 Supportive policies foctor

	Supportive policies	Intrinsic attractiveness
Supportive policies	1	1/4
Intrinsic attractiveness	4	1

Tables 2 Tax reduction policy influence

	Tax reduction policy	Charging fee discounts	Vehicle quota restrictions
Tax reduction policy	1	5	3
Charging fee discounts	1/5	1	1/2
Vehicle quota restrictions	1/3	2	1

Tables 3 Proportion of five influencing factors

	Price	Battery range	Number of public charging stations	Charging time	Vehicle safety
Price	1	1/5	1/3	3	1/5
Battery range	5	1	4	6	1/3
Number of public charging stations	3	1/4	1	4	1/4
Charging time	1/4	1/6	1/3	1	1/7
Vehicle safety	5	3	4	7	1

Square root method for weight determination

$$\overline{w_i} = \sqrt[m]{\prod_{j=1}^{m} aij} \tag{1}$$

$$w_i = \frac{\overline{w_i}}{\sum_{j=1}^{m} \overline{w_j}} \tag{2}$$

Obtain the weight table 4 for each factor:

Table 4 Weight of policy support

	Tax reduction policy	Charging fee discounts	Vehicle quota restrictions
Weight	64.912	12.203	22.881

Based on the weights shown in the table 4, it can be inferred that tax reduction policies have a relatively high impact on new energy electric vehicles in China, followed by vehicle purchase restrictions and then charging fee incentives. This reflects that favorable policies play a significant guiding role in the future development of new energy electric vehicles, which will further drive the growth of new energy electric vehicles in China.

Table 5 Weight of advantages for new energy vehicles

	Price	Battery range	Intrinsic attractiveness	Charging time	Vehicle safety
Weight	8.861	28.712	12.865	4.209	45.361

According to the weights in the table 5, it can be observed that tax reduction policies have a relatively higher proportion of influence on new energy electric vehicles in China, followed by vehicle purchase restrictions, and finally charging fee incentives. This reflects that favorable policies play a significant guiding role in the future development of new energy electric vehicles, and these policies will also promote the growth of new energy electric vehicles in China.

Solving for the maximum eigenvalue of a matrix：

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^{n} \frac{(AW)_i}{W_i} \tag{3}$$

Evaluating the consistency index：

$$CI = \frac{\lambda \max - n}{n-1} \tag{4}$$

Computing the Consistency Ratio (CR) to assess the consistency test：

$$CR = \frac{CI}{RI} \tag{5}$$

Tables 6 supportive policiescon of sistency test

	CR	The result of consistency test
Supportive policies	0.094	Passed
Intrinsic attractiveness	0.004	Passed

According to Table 6, the establishment of the above model is based on data processing and analysis, closely related to logical thinking, and conforms to real-world logic. Through the established model, the following analysis can be obtained:

In terms of government support for new energy vehicle policies, tax reduction policies have a greater impact and a higher weight of 64.912%. The purchase quota restrictions also have a relatively high weight. The discount on charging fees also has a promoting effect on the development of new energy electric vehicles.

In terms of attractiveness to users, the weight of vehicle safety is the highest, reaching 45.361%, indicating that users attach greater importance to the safety of the vehicle. The weight of driving range and the number of charging stations is also relatively high, highlighting the significant advantages of new energy electric vehicles. In comparison, the weights of price and charging time are relatively small, indicating that consumers do not attach high importance to these factors.

3. Statistical analysis of new energy vehicles based on linear regression equation

3.1. Build model algorithm

(1)Linear Regression Equation

Linear regression is a statistical analysis method in mathematical statistics used to determine the quantitative relationship that may exist between two or more variables. In this question, we establish a multiple linear regression equation based on the statistical data of China's new energy electric vehicle industry's development.

(2)Least Squares Method

In a linear regression model, the least squares method is used to estimate the regression equation. It can find the best-fitting function for a set of data by analyzing the minimization of the sum of squares between predicted values and actual values[5]. In this question, we utilize the least squares method to find the multiple regression equation by examining whether the random errors of observations follow a normal distribution and applying calculus to find extrema.

Define the annual sales volume of new energy vehicles as variable Y_i, the annual quantity of public charging stations as variable Z_i,the annual battery range as variable L_i,and the year as variable N_i, Construct the following linear regression equation:

$$L_i = a_1 Ni + b_1 \tag{6}$$

$$Z_i = a_2 Ni + b_2 \tag{7}$$

where L_i and Z_i are dependent variables, N_i is an independent variable, and $a_1\ a_2\ b_1\ b_2$ represents the regression parameters. With the above equations, a multiple regression model is constructed:

$$Y = a + b_3 L + b_4 Z + \varepsilon \tag{8}$$

where Y_i is dependent variables, L_i and Z_i are independent variables, $a\ b_3\ b_4$ represents the regression parameters. ε represents random disturbance. The dependent variable and all independent variables are observed n times, resulting in a sample data set:

$$(Y_i, L_i, Z_i), i = 2012 \cdots\cdots 2022 \tag{9}$$

Assuming that the random error of the i-th observation is ε_i,and ε_i follows a normal distribution $N(0,\sigma^2)$,, $E(\varepsilon_i \varepsilon_j) = 0(i \neq j)$:

$$Y_i = a + b_3 L_i + b_4 Z_i + \varepsilon_i, \tag{10}$$

$$i = 2012, 2013, \cdots, 2022, \varepsilon_1, \cdots, \varepsilon_n \ iid\ N(0,\sigma^2) \tag{11}$$

The empirical regression equation is obtained through the method of least squares using calculus to find the extremum for multiple variables:

$$Y_i = -0.8212 + 0.994 * (-52599.116 + 26.113\,Xi) + (-83472.566 + 41.512\,Xi) \tag{12}$$

According to the regression equation, the projected sales volume of new energy vehicles in the next decade is shown in the following table 7:

Tables 7 Ten year sales forecast for new energy vehicles

Time	2023	2024	2025	2026	2027
Sales volume of new energy vehicles	422.01	422.68	423.36	424.03	424.71
Time	2028	2029	2030	2031	2032
Sales volume of new energy vehicles	425.39	426.06	426.74	427.42	428.09

Significance testing of the regression equation:

$$SSR = \sum_{i=1}^{n} \left(\hat{Y} - \overline{Y} \right)^2 \tag{13}$$

$$SSE = \sum_{i=1}^{n} \left(Yi - \overline{Y} \right)^2 \tag{14}$$

$$F = \frac{SSR}{SSE\ /(n-2)} \sim F(1, n-2) \tag{15}$$

where SSR is the sum of squares of regression and SSE is the sum of squared residuals, the combined formula yields: $F = 191.053$, $F > F(k, n-k-1)$. Therefore, at the significance level of c, the model assumption holds. The establishment of the above model is based on linear regression predictions conducted on the development data of China's new energy electric vehicle industry.

The establishment of the aforementioned model is based on the linear regression prediction conducted on the development data of China’s new energy electric vehicle industry. According to the results generated by the model, it indicates a favorable development of new energy electric vehicles in the next decade. This result and trend are also supported by the conducted verification.

3.2. Analysis of New Energy Electric Vehicles and Traditional Energy Vehicles

The paper establish a typical and relevant model. The typical correlation model can be achieved by finding the maximum correlation coefficient between two sets of variables, along with the linear combinations associated with it.

Assuming two sets of variables represent new energy electric vehicles and traditional energy vehicles.

$$X = \begin{pmatrix} X_1 \\ X_2 \end{pmatrix}, Y = \begin{pmatrix} Y_1 \\ Y_2 \\ Y_3 \\ Y_4 \end{pmatrix} \tag{16}$$

Define two sets of linear relationships, U and V.

Calculate the variances of U_i and V_i.

$$\mathrm{var}(U_i) = \sum_{k=1}^{p} \sum_{l=1}^{p} a_{ik} a_{ik} \mathrm{cov}(X_k, X_l) \tag{17}$$

$$\mathrm{var}(V_j) = \sum_{k=1}^{p} \sum_{l=1}^{q} b_{jk} b_{jl} \mathrm{cov}(Y_K, Y_L) \tag{18}$$

Calculate the correlation coefficient：

$$\rho_i^* = \frac{\mathrm{cov}(U_i, V_i)}{\sqrt{\mathrm{var}(U_i)\mathrm{var}(V_i)}} \tag{19}$$

Our goal is to maximize ρ_i^*.

The paper will establish evaluation criteria through a mind map. Among the eight criteria, the restricted use policy can be assigned a value of 0 or 1. For the vehicle purchase subsidy, we can refer to the subsidy policy data to determine the specific subsidy amount. Similarly, for the electricity subsidy, we can refer to the policy to determine the specific subsidy value[6]. The fuel consumption difference can be defined as the annual gasoline cost divided by the annual charging cost, represented as numerical values. The difference in maintenance costs can also be represented by numerical values. The change in stock value can be measured by selecting representative changes in stock market values for three major automobile industry companies. The patent quantity can be classified into electric vehicles and traditional fuel-powered vehicles, represented as numerical values. The same approach can be applied to subsequent criteria as shown in Figure 1~2.



Figure 1. Electric vehicles and traditional fuel-powered vehicles evaluation criteria

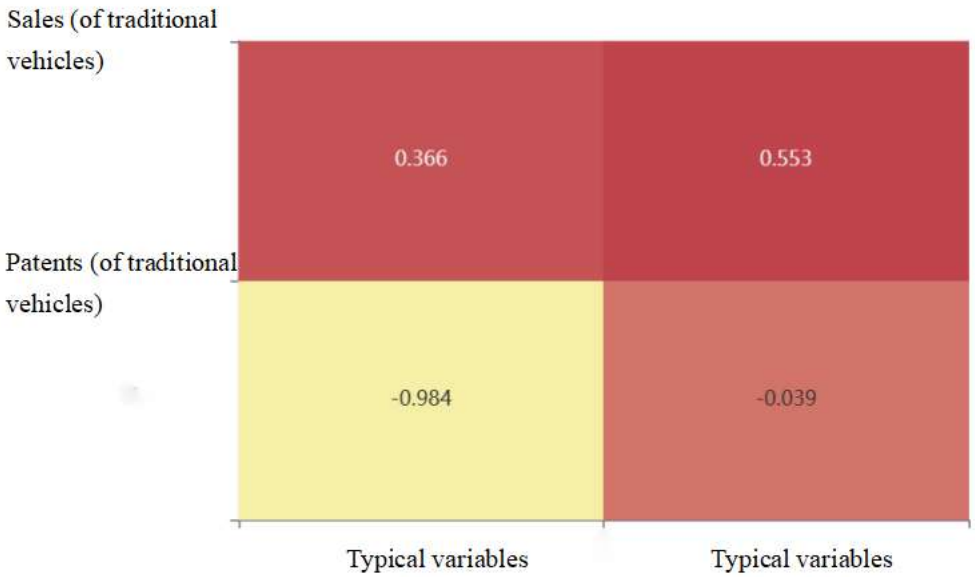


Figure 2. Electric vehicles and traditional fuel-powered vehicles index

In conclusion, the paper will establish a model that considers factors such as restricted use policies, purchase subsidies, electricity subsidies, fuel consumption differences, maintenance cost differences, stock value changes, patent quantities, and future developments in the respective industries.

3.3. Principle hypothesis

Data statistics and analysis were conducted based on the stock of new energy electric vehicles and CO2 emissions in China.

According to Chinese news reports in 2022, the current stock of new energy vehicles in China exceeds 7.8 million, resulting in a reduction of approximately 15 million tons of carbon emissions per year[7]. Each vehicle contributes to an average annual reduction of around 2 tons of carbon emissions, thereby mitigating greenhouse effects. The national stock of new energy vehicles in 2022 accounted for 4.10% of the total, with 41,000 vehicles in cities with a population of 1 million[8,9]. Compared to an all-conventional fuel vehicle scenario, this resulted in a reduction of approximately 82,000 tons of carbon emissions annually. With the gradual increase in the adoption of new energy vehicles during the electrification process, the carbon emissions reduction also increases[10]. The growth rate of new energy electric vehicles in 2022 was 0.96. Therefore, the carbon emissions reduction for that year amounted to:

$$C_q = (1+q)C_l \tag{20}$$

where C_l represents the carbon emission reduction in the previous year.

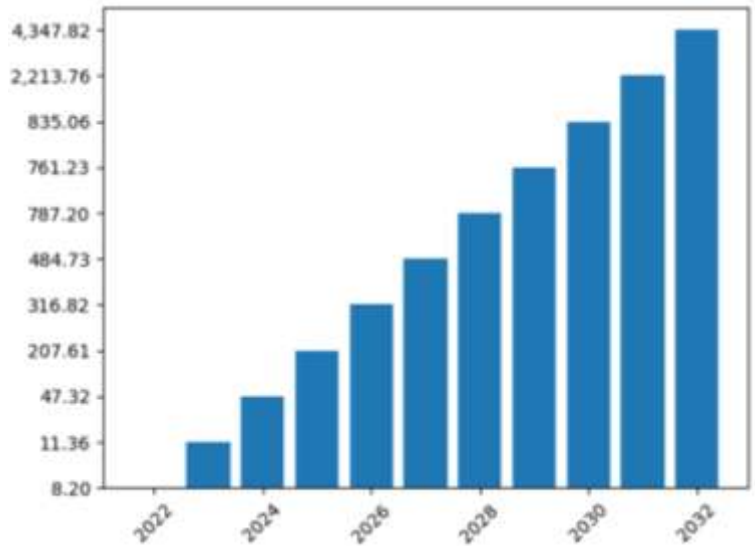


Figure 3. Predict trend of CO2 reduction in new energy electric vehicle electrification

As shown in Figure 3, indicates the amount of CO2 emissions reduction in the electrification process of new energy electric vehicles as the years progress. The graph reflects the prediction that CO2 emissions will exceed 20 million tons in the next decade, which can have a positive impact on the ecological environment and play an active role in carbon peaking and carbon neutrality.

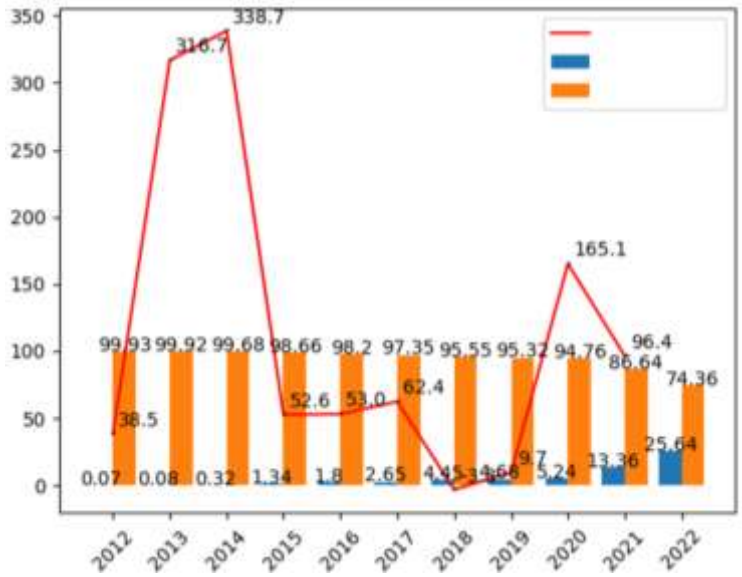


Figure 4. Ten years new energy electric vehicles and conventional vehicles in terms of ownership

As shown in Figure 4 illustrates the data on the number of new energy electric vehicles and conventional vehicles in terms of ownership. From the data collected between 2012 and 2022, it can be observed that the proportion of new energy vehicles has been increasing year by year. Additionally, by examining the indicator of CO2 in the air, it can be inferred that as the number and proportion of new energy electric vehicles continue to rise, there is an overall decreasing trend in CO2 emissions, although there was some fluctuation in 2020. This demonstrates the clear positive impact of new energy electric vehicles on urban areas.

4. Conclusions

This article conducts weighted evaluation and comparison: Typicality analysis allows simultaneous analysis of the correlation between two groups of variables, revealing the underlying relationship between the two. This article is able to describe the relationship between export trade flow and economic, geographic, and demographic factors among countries. It relies on subjective judgments of experts, which may introduce subjective biases and inconsistencies. In the case of multicollinearity among independent variables, the model results may be unstable and have poor explanatory power.

In addation, this article analyzes the main factors that affect new energy vehicles. The factors that affect new energy vehicles include policies, markets, and technologies. The main factors affecting new energy vehicles are government support and the attractiveness of new energy vehicles themselves. We need to use Analytic Hierarchy Process to analyze factors such as tax reduction policies, charging fee discounts, purchase quota restrictions, electric vehicle prices, range, number of charging stations, charging time, and vehicle safety. Among them, government oriented policies are an important factor affecting social development, which is related to the development trend of new energy electric vehicles and people's concerns about car prices, charging costs, purchase restrictions, etc.

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