

China's New Energy Electric Vehicle Industry: Multifaceted Analysis and Future Outlook

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Abstract: This paper comprehensively analyzes the development of China's new energy electric vehicle industry using multiple models. It constructs a new Porter's diamond model to identify influencing factors, develops time-series and polynomial fitting models for industry development prediction, applies the Lotka-Volterra model to explore the competition between new and traditional energy vehicles, uses ridge regression to assess the impact of foreign policies, and builds a mechanism model for urban electrification analysis. The models are tested, evaluated, and suggestions for improvement and promotion are provided.

Keywords: New energy electric vehicles; Panel model; Lotka-Volterra model; Ridge regression; Mechanism model.

1. Introduction

1.1. Background

In the era of escalating environmental concerns and the pressing pursuit of sustainable development, new energy electric vehicles (NEVs) have emerged as a pivotal solution. Since 2011, China has been actively fostering the growth of its NEV industry. The Chinese government has implemented a series of far-reaching supportive policies, such as R & D subsidies, purchase incentives, and infrastructure-building initiatives. These efforts have not only propelled the domestic NEV industry to thrive but also made it a new symbol of China, paralleling the success of the "Chinese high-speed railway".

Against this backdrop, this research focuses on two core issues. The first is to comprehensively understand the complex ecosystem of China's NEV industry. This involves identifying and analyzing the main factors influencing its development, including technological breakthroughs, economic incentives, policy landscapes, and market dynamics. It also requires establishing a model that can accurately describe the current state of the industry and forecast its future trends, considering the interplay of these factors. The second core issue is to assess the broader impact of China's NEV development, both globally and environmentally. This includes exploring how China's NEVs are reshaping the global traditional energy vehicle industry in terms of market share and technological innovation, evaluating the influence of foreign policies on China's NEV development, analyzing the ecological benefits of urban NEV electrification, and finally, promoting the wider adoption of NEVs among the public through an open letter, highlighting their advantages and the significance of embracing this green transportation option.

2. Methodology

2.1. Data Sources

The data for this study is gathered from multiple authoritative sources. The 2018-2022 Statistical Yearbook of the Automobile Industry and Yearbook of Energy Saving and New Energy Vehicles offer industry-specific data on

production, sales and vehicle types. The State Intellectual Property Office provides information on patents. The China Association of Automobile Manufacturers supplies data on market share. The First Electric Vehicle Network gives real-time insights. Provincial statistical yearbooks and bulletins contribute regional data, ensuring a comprehensive and accurate analysis of China's new energy electric vehicle development.

2.2. Model Assumptions

In the context of this research on China's new energy electric vehicle (NEV) industry, several key assumptions are made. Firstly, we focus solely on the market-driven effects of NEVs, deliberately excluding the impact of administrative measures. This simplifies the analysis, allowing us to isolate and understand the pure market forces at play.

Secondly, we assume a linear relationship between the development of the NEV industry and its influencing factors. Although the real-world situation may be more complex, this assumption enables us to build initial models and analyze the basic trends. It serves as a starting point for further exploration.

Thirdly, we presume that the relevant data adheres to the time-series law. This implies that historical data can be effectively utilized to predict future trends through appropriate models, facilitating the industry's development forecasting.

Finally, in a market with full competition, we assume that traditional and new energy vehicles have a competitive relationship. This assumption helps us understand the market dynamics and the potential substitution effect between the two types of vehicles, which is crucial for analyzing the industry's development and future trends.

3. Model Building and Results

3.1. Analysis of Influencing Factors

A new Porter's diamond model is constructed by introducing government policy factors. Four dimensions and 14 indicators are selected to establish an evaluation index system. A panel model is used to calculate indicator weights. The results show that charging infrastructure, the number of automobile manufacturing industries, and road mileage

significantly impact the development of new energy electric vehicles.

Table 1. Evaluation index system of factors influencing the development of new energy vehicles in China

Level one indicators	Secondary indicators	
Factors of production	Number of automobile manufacturing industries (units)	X1
	Employees in related industries (ten thousand)	X2
	Public charging (exchange) stations and piles (seats)	X3
Domestic demand	Resident population (ten thousand)	X4
	Per capita disposable income (yuan)	X5
	Per capita GDP (yuan)	X6
	Private car ownership (10,000)	X7
	Highway mileage (10,000 kilometres)	X8
Relevant supportive factors	Employees in the Transport Industry	X9
	Relevant technology turnover (billion yuan)	X10
	Electricity consumption (kWh)	X11
Policy factors	Relevant capital investment (million yuan)	X12

3.2. Industry Development Prediction

Based on time - series analysis of sales data from 2011 - 2021, the sales of new energy electric vehicles grew slowly

before 2020 and rapidly after. A quadratic polynomial fitting model with a higher R - square is chosen to predict the industry's development in the next ten years.

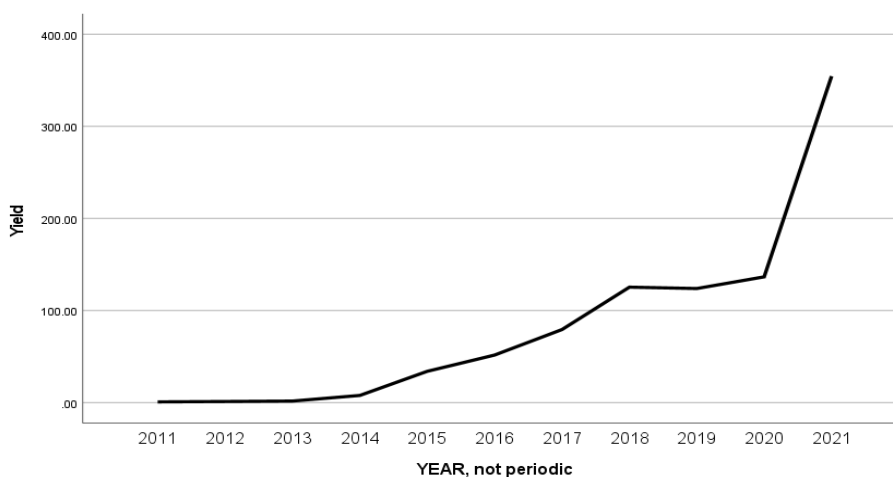


Figure 1. Line graph of China's new energy electric vehicle sales in the past ten years

Through the line graph of the sales of new energy electric vehicles in China in the past ten years, it can be clearly found that the sales of new energy electric vehicles show a slow growth trend before 2020, and a sudden increase after 2020.

Through the SPSS software, the expert modeller is used to make a preliminary prediction of the sales of new energy electric vehicles in China in the next ten years, and the specific results are as follows:

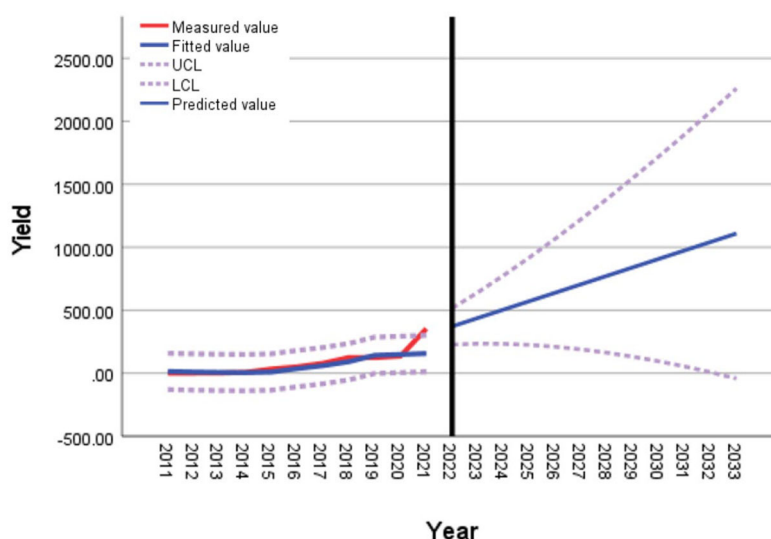


Figure 2. China's new energy electric vehicle sales in the next ten years

Table 2. Approximate sales of new energy electric vehicles in China in the next ten years

Year	Predicted value	Confidence interval	
2023	439.41	235.41	643.41
2024	506.44	234.10	778.78
2025	573.47	225.54	921.40
2026	640.50	210.51	1070.48
2027	707.53	189.58	1225.47
2028	774.55	163.16	1385.95
2029	841.58	131.58	1551.59
2030	908.61	95.12	1722.11
2031	975.64	54.00	1897.29
2032	1042.67	8.42	2076.93
2033	1109.70	-41.44	2260.84

3.3. Competition between New and Traditional Energy Vehicles

The Spearman correlation coefficient is used to confirm the negative correlation between the sales of new energy and traditional energy vehicles. A Lotka - Volterra population competition model is established. The model is validated using data from 2015 - 2022 and predicts that new energy electric vehicles will gradually replace traditional ones, but the latter will not disappear rapidly.

In order to test the accuracy of the model, it is tested based on known data from 2015-2022. The sales growth rates of new energy electric vehicles and traditional energy vehicles, r_1 and r_2 , are preset as 0.63 and 0.1; the global automotive market size M is preset as the past peak of 9500; at present, the cost of new energy electric vehicles driving 100 kilometres is about one-third of that of traditional energy vehicles, and together with the subsidies and tax cuts for new energy vehicles, it can be about one-quarter, so s_1 is taken to be 1/4, and s_2 is taken to be 4. In summary, the model is set as follows:

Table 3. Model validation parameter settings

Parameter	Value	Parameter	Value
X0	39	M	9500
Y0	8929	s_1	1/4
r_1	0.63	s_2	4
R2	0.1		

The final plot of the predicted and actual values is shown below, and it can be observed that the predicted line and the

actual line basically coincide, indicating that the prediction accuracy of this model is good.

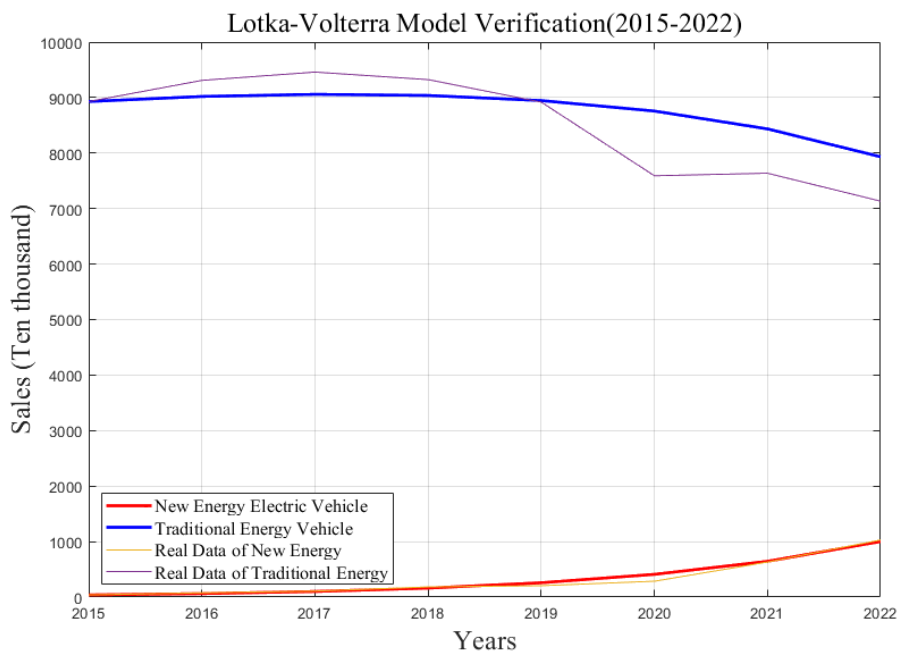


Figure 3. Lotka Volterra Model Verification

Through the graph analysis found that the hindering effect of new energy electric vehicles on traditional energy vehicles

is directly proportional to the sales of new energy electric vehicles, that is, the more sales of new energy electric vehicles, the more obvious the effect of hindering effect on traditional energy vehicles.

By searching the official government websites of various countries, we collect and organise the targeted policies that have been made public on the development of new energy electric vehicles in China, and get some typical policies as follows.

4. Impact of Foreign Policies

4.1. Policy sources and evaluation

(1) Extracting Policy Keywords

Table 3. Selected policies of other countries that restrict the development of new energy electric vehicles in China

Policy	Content	Influence
European Union anti-subsidy investigation	Through the sampling method to determine BYD, SAIC Motor and GEELY Auto three Chinese companies officially launched anti-subsidy investigation	Administrative intervention
USA Inflation Reduction Act 2022	We will increase support and subsidies for the US new energy vehicle industry. Subsidized NEVs must be assembled in North America, and battery materials and "critical minerals" must come from the United States or from a country with which the United States has a free trade agreement (FTA)	Local subsidy
Regulation (EU) 2023/1542 of the European parliament and of the council	Power and energy storage batteries are required to be sold in Europe, recycled in Europe, and manufactured in Europe	Access restriction
European Union anti-dumping investigation	Impose additional tariffs on Chinese cars that Europe says are being sold at unfairly low prices	Tariff barrier

The Index of Economic Freedom ranking published by The Heritage Foundation evaluates all countries in the world on 12 indicators from four perspectives: rule of law, government size, regulatory efficiency, and open market.

The rule of law can reflect unfair practices like unfair adjudication and government intervention. Government size involves financial support to local industries. Regulatory efficiency reflects policies beneficial to the local business environment. The open market includes tariff barriers and other trade - related measures, and also encompasses anti -

free trade policies, all as exemplified in the table.

(2) Selection of Target Data

The United States, Germany and Japan are selected as the three major auto industry countries, representing the responses of North America, Europe and East Asia to China's new energy electric vehicle industry, and the Index of Economic Freedom scores are used to represent the changes in the governmental qualities and policy tendencies of the United States, Germany and Japan, so as to quantitatively analyse the policies.

Table 4. 2018-2022 USA Germany Japan Score Table

Nation	Index	Variable	2018	2019	2020	2021	2022
USA	RL	U_RL	76.03	78.43	80.90	76.30	83.10
	GS	U_GS	58.80	61.77	61.80	57.70	43.47
	RE	U_RE	84.23	83.27	82.23	83.57	81.87
	OM	U_OM	83.90	83.87	81.60	81.80	80.07
Germany	RL	G_RL	78.10	78.87	79.20	76.70	93.47
	GS	G_GS	64.47	64.97	65.33	64.50	61.60
	RE	G_RE	75.20	71.33	70.83	70.87	73.00
	OM	G_OM	78.97	78.67	78.80	78.00	76.40
Japan	RL	J_RL	79.47	76.87	79.50	81.77	90.43
	GS	J_GS	56.93	59.63	62.03	64.37	46.53
	RE	J_RE	82.10	81.80	81.50	83.33	77.33
	OM	J_OM	70.77	70.00	70.00	66.80	65.13

In terms of the development of new energy electric vehicles in China, domestic sales and export sales data are selected to explore the impact of restrictive policies in other countries on

the scale, development speed, and internal and external tendencies of China's new energy electric vehicle industry.

Table 5. Domestic Sales and Export Volume of New Energy Electric Vehicles in China, 2018-2022

Index	2018	2019	2020	2021	2022
Domestic sales	123.99	120.4	136.7	352.1	524.88
Export volume	1.02	3.7	7	31	67.9

4.2. Construction of the ridge regression model

(1) Reasons for selection

Ridge Regression (Ridge Regression) is a biased estimation regression method dedicated to the analysis of covariate data, which is essentially a kind of improved least squares estimation method, by abandoning the unbiasedness of the least squares method, and obtaining the regression coefficients more in line with the reality and more reliable regression method at the cost of losing part of the information and reducing the precision.

Due to the small amount of data for each sample, only a 5-year time period. The samples, in turn, are complex, with up to 12 independent variables. Macroeconomics is inherently chaotic, and a country's economic freedom is influenced by the overall national context, and its policies are more similar in all aspects of its tendencies, making it prone to multicollinearity in the independent variables. The partial regression coefficients estimated by the ridge regression model tend to be close to the real situation, which can deal with this kind of multicollinearity, and have a better effect on the repair and fitting of pathological data.

(2) Modelling

The ridge regression model is a biased estimation regression method dedicated to the analysis of covariate data, which in essence is a modified least squares estimation method. The multiple linear regression formula is as follows:

$$Y = X\beta + \varepsilon$$

The results of the ordinary least squares estimation method are as follows:

$$\beta = (X'X)^{-1}X'Y$$

However, when the independent variables have strong correlation and covariance, the correlation coefficient between the independent variables is close to 1. At this time, when using the above equation to solve the model parameters, the problem of being unable to solve or estimating the variance is too large will inevitably occur, in order to solve the problem, it is necessary to add a normal matrix, thus reducing the effect of multiple covariance between the independent variables, and obtaining the ridge regression model:

$$\beta(K) = (X'X + kI)^{-1}X'Y$$

(3) Solving the ridge regression model

The four aspects of economic freedom scores of the United States, Germany, and Japan are used as independent variables, and the domestic sales and export sales of China's new energy electric vehicles are used as independent variables, respectively, to construct two ridge regression models. Firstly, the ridge trace plot with the residual sum-of-squares plot under different K-values is plotted to determine the K-value of the ridge regression model.

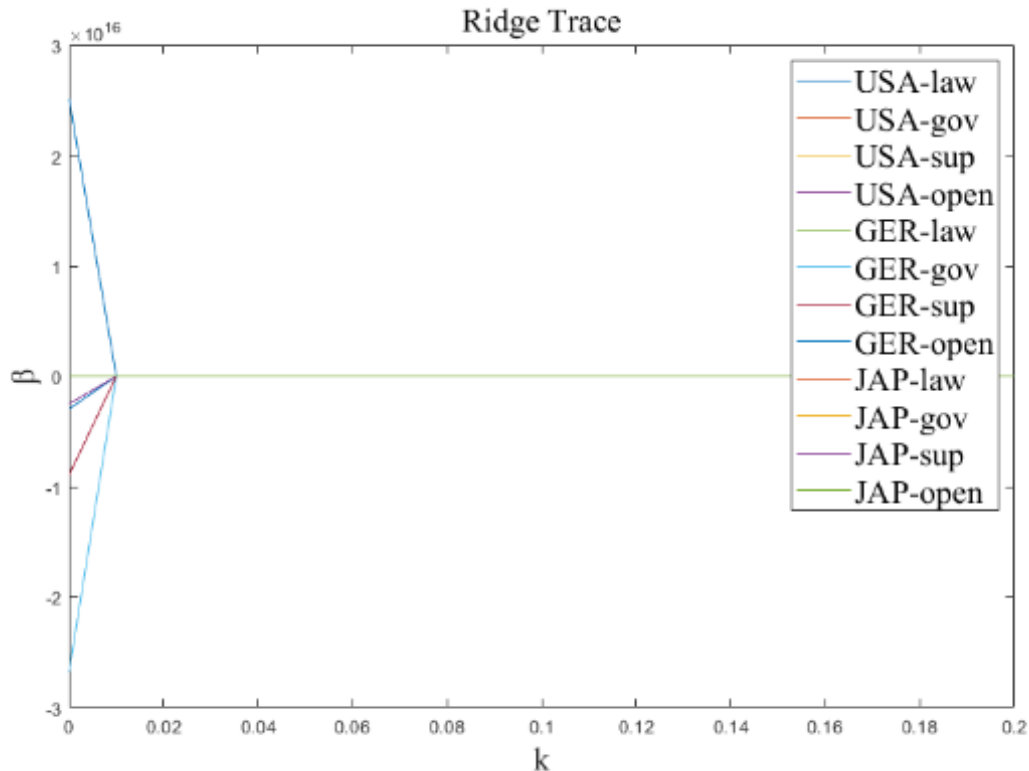


Figure 4. Ridge trace plot

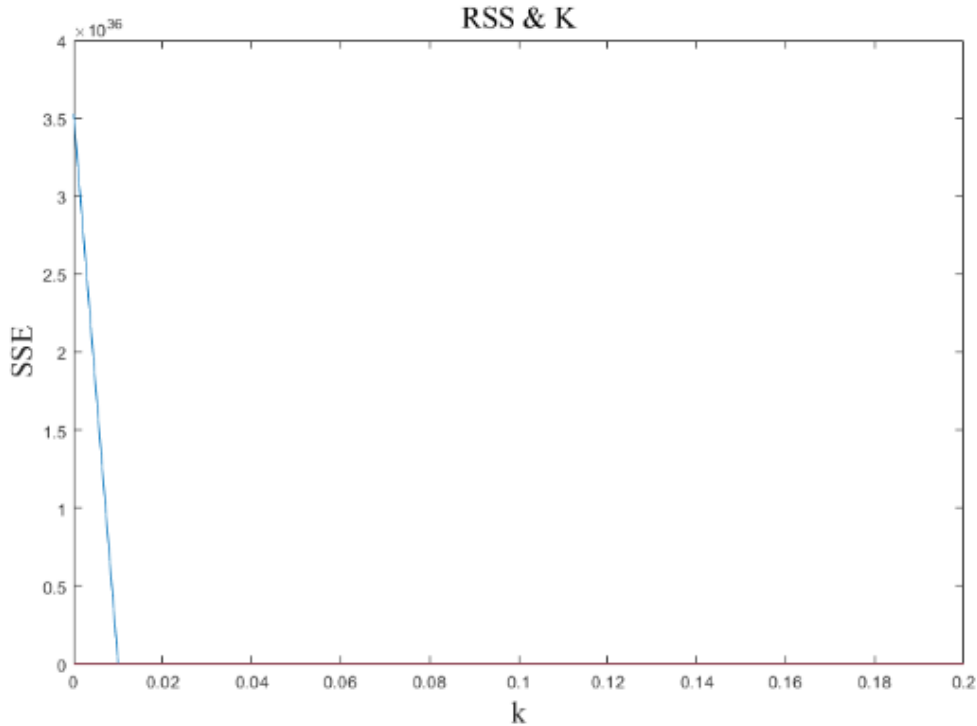


Figure 5. RSS plots at different values of K

Finally, based on the variance expansion factor method, determine $K = 0.098$. respectively, construct the independent variable for domestic sales and export sales of the ridge regression model, the test, the two models of the goodness-of-fit R^2 were 0.998 and 0.999; and then draw the ridge regression fitting results of the map is as follows, observation of the image, the predicted value and the true value of the basic consistency, which can be proved that the ridge regression model fitting effect is very good.

Analysis of the results of the ridge regression model

The coefficients of the respective variables in the regression model can reflect their relationship with the development of new energy electric vehicles in China, and a positive coefficient represents that the corresponding aspects of the country are beneficial to the development of China's new energy automobile industry, while a negative coefficient represents that the corresponding aspects of the country hinder the development of China's new energy automobile industry. The table is as follows.

Table 6. Impact of U.S., Germany, and Japan on Domestic Sales Volume

Nation	RL	GS	RE	OM
USA	-0.1086	-0.1608	0.0624	-0.1545
Germany	0.0259	-0.1470	-0.0789	-0.2129
Japan	0.1775	0.0271	0.0480	-0.3091

Table 7. Impact of U.S., Germany, and Japan on Export Volumes

Nation	RL	GS	RE	OM
USA	-0.0480	-0.1463	0.0172	-0.1229
Germany	0.0564	-0.1401	-0.0821	-0.1964
Japan	0.1491	-0.0114	-0.0004	-0.2598

The table reveals several key findings. Japan is more favorable to China's new energy electric vehicle development, having the most positive coefficients and smaller negative -coefficient absolute values, likely due to geographical and economic - cultural similarities. The US, unlike Germany and Japan, tends to intervene administratively, as shown by its negative Rule of Law coefficient, which may be related to its strategies against China's rise. Globally, despite an overall trend towards economic globalization, the negative Open market coefficient indicates that countries increase tariffs to hinder China's new energy vehicle development, especially in the context of a sluggish global economy and trade protectionism.

5. Conclusion

This study comprehensively analyzes China's new energy electric vehicle industry from multiple aspects. The models used provide valuable insights into the industry's development, influencing factors, and future trends. However, there is still room for improvement in the models. Future research can focus on refining the models, incorporating more complex real - world factors, and further exploring the long - term development of the new energy electric vehicle industry.

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