Explore the Economic and Policy Factors Behind the Development of New Energy Vehicles

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Abstract. As one of China's strategic emerging industries, China's new energy vehicle industry has developed rapidly in terms of industrial scale and technological level. It is meaningful to study the development factors of new energy electric vehicles in China, predict future development trends, and promote new energy vehicles. This paper analyzes the development and main influencing factors of new energy electric vehicles in the past ten years and speculates on the future development trend of new energy vehicles by using different models, like EWM-GRA model, gray prediction model and DID method.

Keywords: New Energy Vehicles; the EWM-GRA Model; the Metabolic GM (1,1); DID method.

1 Introduction

As one of China's strategic emerging industries, China's new energy vehicle industry has developed rapidly in terms of industrial scale and technological level (Wu et al., 2020[1]). Since its production and sales volume ranked first in the world in 2015, it has ranked first in the world for three consecutive years. As of the end of 2017, China The number of new energy vehicles in existence has exceeded 1.6 million, accounting for 50% of the total number of new energy vehicles in the world (Zhao et al., 2022[2]).

Overall, the development situation of China's new energy vehicles is good, with production and sales volume continuing to expand, and technology levels also improving. However, compared with foreign industrial frontiers, my country's industrial scale, technological level, infrastructure construction and other aspects still have considerable room for development (Wen et al., 2022[3]). Considering the economic and energy-saving benefits of new energy electric vehicles, it is meaningful to study the development factors of new energy electric vehicles in China, predict future development trends, and promote new energy vehicles.

This paper analyzes the development and main influencing factors of new energy electric vehicles in the past ten years, and speculates on the future development trend of new energy vehicles and the possible impacts. First, we introduce the EWM-GRA

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model, and applied the entropy weighting method to the indicators of production volume, sales volume, market share, and market penetration rate to get the development index of the industry and assess the EV charging cost, number of industry patents and other indicators on the development index with the gray correlation. Second, we choose the gray prediction model because of its small and exponentially growing data volume. By using this model, we can obtain the development curve of the industry with an upward trend in the next ten years. Finally, we use the double-difference method to study the policy effect, i.e., the export volume of Tesla's new energy vehicles as the control group, and the export volume of SAIC's and BYD's new energy vehicles as the control group, to verify its feasibility through the parallel trend test, and to conclude that the boycott policy of some countries will have a negative effect on China's new energy electric vehicle development.

2 Research Design

2.1 The Establishment of EWM-GRA Model

We determine the annual production volume, sales volume, market share and penetration rate of China's new energy electric vehicles (EVs) as the indicators describing the development level , construct the development index evaluation model, solve the respective weights of the two indicators through the entropy weighting method, and then calculate the scores by applying the gray correlation evaluation method, according to which the correlation degree of the indicators affecting China's new energy EV development index is inferred, and the higher the scores are, the higher is the degree of importance of the index. The greater the score, the higher the importance.

The basic idea of the entropy weight method is to determine the objective weights based on the magnitude of indicator variability (Zhu et al., 2020[4]; Chen, 2021[5]). Generally speaking, if the information entropy of an indicator is smaller, it indicates that the indicator deserves a greater degree of variability, provides more information, and plays a greater role in the comprehensive evaluation, and its weight will be larger. On the contrary, the larger the information entropy of an indicator, the smaller the degree of variability of the indicator, the smaller the amount of information provided. The smaller the role played in the comprehensive evaluation, and the smaller its weight.

The gray correlation model is used to determine whether the correlations between sequences are strong or not by the similarity of the geometrical shapes of the curves of the sequences ([6] Barroso et al., 2020[6]). The more similar the geometrical shapes of the curves are, the greater the degree of correlation between the related sequences, and vice versa, the smaller the degree of correlation. In this problem, there may be correlations between independent variables such as consumption index, number of patents, services, etc., which respond synergistically to each other and are filled with many uncertainties. Therefore, it can be considered that there is a gray correlation relationship between the factors of the whole system, then, the use of gray correlation model can make a better explanation. The specific steps are shown in equation below.

2.2 The Establishment of Metabolic GM(1,1)

This paper has a small amount of sample data and the observed data shows an upward trend over time similar to an exponential image, so a gray prediction model can be used. The metabolic GM(1,1) model has higher superiority in small sample long-term prediction due to the continuous supplementation of the most recent information in the prediction process and the removal of old information, so that the predicted values are generated in the dynamic process (Bekiaris & Klamt, 2020[7]; Zimmermann et al., 2021[8]).

2.3 The Establishment of DID Model

To address the question of the impact of other countries' policies to resist China's new energy development on the development of new energy vehicles in China, we have adopted the double-difference-in-differences (DID) method, which is widely used in econometrics, to study the impact of the policies on the development situation. he double-difference method is a statistical method widely used in fields such as economics, social sciences and public health to estimate the impact of a policy, intervention or event on one or more groups. It estimates policy effects by comparing differences before and after the implementation of the policy and between groups affected and unaffected by the policy (Sant'Anna & Zhao, 2020[9]; Arkhangelsky et al, 2021[10]).

2.4 Data Sources

This paper selects the information data of China's new energy electric vehicle industry from 2013 to 2022 as shown in Table 1 and seven related factors affecting the development of the industry, chooses the production volume, sales volume, market share and market penetration as the indicators to measure the level of development of the industry, selects the oil price and the consumption index of the population as the economic indicators, uses the number of patents, the charging cost and the energy efficiency of the vehicle as the technical indicators, the number of charging piles as the service indicators, and the amount of government subsidies for new energy vehicles as policy indicators.

Table 1. Data sources

Database Name	Website
CEIC Data	https://insights.ceicdata.com.cn/
Qianzhan Network	https://www.qianzhan.com/
International Metal Processing Network	https://www.mmsonline.com.cn/info/331001.shtml

3 Results

3.1 Comprehensive Evaluation Results

First, the data were imported into Matlab, the indicators were standardized, the entropy value of the standardized indicators was calculated, and then the coefficient of variation of each indicator was calculated, and the weights were calculated for the four indicators of new energy electric vehicles, namely, market sales volume, production volume, market share, and market penetration, and the weights were obtained to be 0.3708, 0.2780, 0.2006, and 0.1506, respectively. Then, the normalized data were multiplied by the weights, respectively, and the normalized results of market sales volume, production volume, market share, and market penetration were sequentially weighted, thus obtaining an index representing the development level of new energy electric vehicles in China, i.e., the development index as table 2.

Table 2. Development indicators and their measurement

	2013	2014	2015	2016	2017
Production	0.089306	0.012475	0.018403	0.031124	0.041591
Sales	0.009013	0.013327	0.019705	0.031132	0.047703
Market Share	0.084935	0.091001	0.097068	0.103135	0.109202
Market Penetration Rate	0.01649	0.027484	0.038478	0.054968	0.065962
Development Index	0.030857	0.013428	0.024434	0.035926	0.054021
	2018	2019	2020	2021	2022
Production	0.071186	0.063513	0.08032	0.204668	0.387414
Sales	0.077441	0.074865	0.082187	0.21782	0.426808
Market Share	0.115268	0.121335	0.127402	0.133469	0.139535
Market Penetration Rate	0.076956	0.087949	0.098943	0.109937	0.12093
Development Index	0.082456	0.090492	0.106564	0.199511	0.362211

Second, The gray correlation image of each influencing factor with the development index as the parent series was plotted using Excel as shown as figure 1.

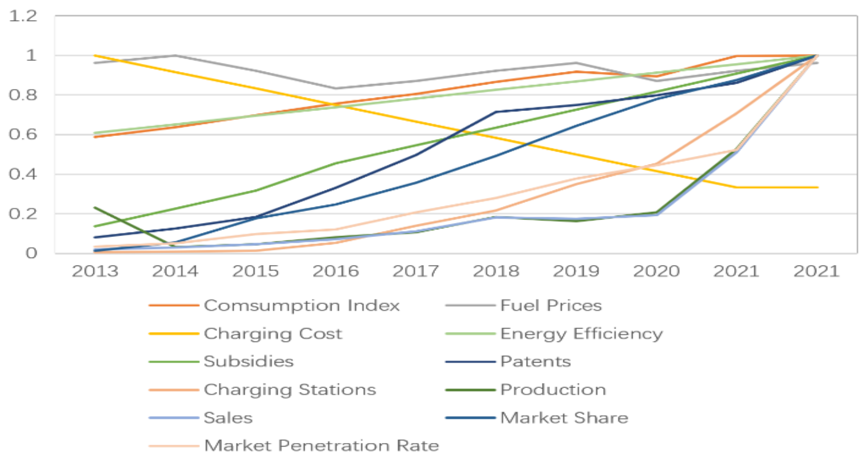


Fig. 1. The gray correlation image of each influencing factor with the development index

As can be seen through the image, the consumer index and oil price index are relatively stable, while the indexes reflecting the level of development, such as sales volume, production ratio and market share, show an upward trend, reflecting the process of the development of new energy electric vehicle market, which was initially accumulated slowly, and then the speed of development has been significantly improved after a period of time.

Taking the development index as the parent series, the correlation value was obtained by using weighting of the correlation coefficients, and the gray correlation was solved as shown in Table 3 below.

Table 3. The Degree of Correlation

Index	The Degree of Correlation
Charging Stations	0.8752
Patents	0.8004
Subsidies	0.7931
Comsumption Index	0.7542
Energy Efficiency	0.753
Fuel Prices	0.7229
Charging Cost	0.6564

From the analysis of the above table, it can be seen that since the value of the correlation lies in the interval [0, 1], and the larger the value of the correlation indicates the stronger the correlation with the parent series (i.e., the development index), the higher the correlation means that the correlation between the sub-series and the parent series is higher, and vice versa, the lower the correlation is. It can be seen that for the development index: for the seven evaluation items affecting the development index of China's new energy electric vehicles, the correlation of the number of charging piles is the highest 0.8752, i.e. the highest evaluation, while the correlation of the charging cost is the lowest 0.6564, i.e. the lowest evaluation.

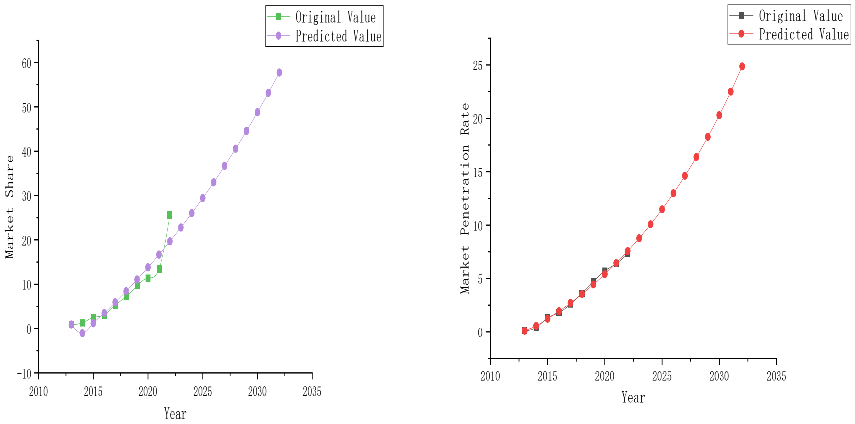
3.2 Future Development Forecast Results

Using Matlab, the Metabolic GM(1,1) model was constructed to calculate the development coefficient as well as the gray role quantity. The development coefficient a=0.29152 and the gray role quantity b=245777.5294 can be obtained by calculating the model, thus obtaining the prediction model for the first period. The data of 2020 predicted by GM(1,1) modeling based on the data of 2013-2019 was taken as new data, while the data of 2013 was removed, keeping the data isodimensional, building the original series of the Metabolic GM(1,1) model and repeating the above steps, and finally obtaining the prediction results of the experimental group and the table of errors.

Table 4. The forecast of China's new energy electric vehicle development index

Year	Forecast Value	True Value	Forecast Value
2020	974890.00	856828.56	-0.13778887
2021	1054370.00	1020900.15	-0.03278464
2022	2030290.00	2068815.63	0.018622072
$R2$		0.952153	

As can be seen from the figure 2 and table 4, the R-Square of metabolic GM(1,1) is large enough, 0.952153, which indicates that it has a good prediction effect. We applied the metabolic GM(1,1) model and solved it separately to obtain the development index for the next ten years for each of the four indicators measuring the level of development.



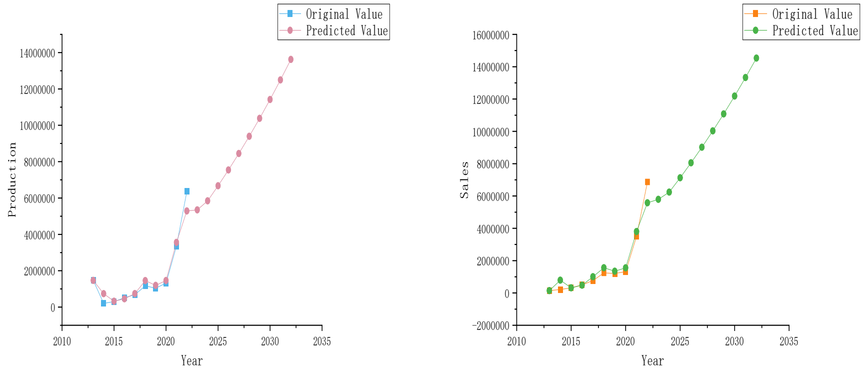


Fig. 2. Trends in the four development indicators over the next decade

Utilizing the entropy weight method, the four indicators were combined to obtain the development index for the next ten years as shown in the table 5.

Table 5. The development index for the next ten years

Year	Predicted Value	Year	Predicted Value
2023	2291292.4496	2028	8321937.3315
2024	2937127.4199	2029	10745782.0654
2025	3761892.2254	2030	13680669.7475
2026	4847032.3727	2031	17127507.1770
2027	6253270.0610	2032	22173529.1326

3.3 Policy Evaluation Results

Double difference method (DID) is the experimental group and the control group of the amount of policy intervention is subtracted to assess the policy effect, as can be seen from the table 6, the significance of the P-value of 0.000***, the level of the level of the presentation of significance, the rejection of the original hypothesis, the coefficient of -89987.563, it can be assumed that the U.S. boycott of the development of China's new energy vehicles policy intervention is effective, for the negative direction.

Table 6. The result of DID (2018)

Result		Coefficient	Standard error	t	P
	Control	34973.5			
Before	Treated	8962.875			
	Diff(T-C)	-26010.625	15010.055	-1.733	0.099*
	Control	225869.25			
After	Treated	109871.063			
	Diff(T-C)	-115998.188	9191.744	-12.62	0.000***
Diff-in-Diff		-89987.563	10613.712	-8.478	0.000***

Note:****,***,*represent1%,5%,10%significancelevelsrespectively.

The result of DID shows that the P value is 0.003 * * * , which is significant on the level, and the coefficient is -159813.9, which can be considered as effective and negative.

4 Conclusions

By utilizing various statistical and economic models such as the EWM-GRA model, gray prediction model, and DID method, this study first constructs an index to explore the key factors influencing the development of China's new energy electric vehicles (NEEVs) and explains how these factors impact the growth of NEEVs in China. Secondly, this study collects industry development data on China's NEEVs and predicts their future development over the next 10 years. Lastly, this study analyzes the impact of policies implemented by certain countries to resist China's NEEVs on the development of new energy electric vehicles. This research can provide some guidance for the future industry development of new energy vehicles in China and the formulation of supporting policies.

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