Research on Sales Forecasting of New Energy Passenger Vehicles in Beijing-Tianjin-Hebei City Cluster based on Grey Prediction GM(1,1) Model

Ying Li

liying12108@163.com

Beijing Jiaotong University, Beijing, China

Abstract: In recent years, the international community has paid more and more attention to carbon emissions, and China's Double-Carbon Policy is also being steadily implemented. As a key industry in carbon emissions, the transportation industry has become the focus of achieving carbon reduction goals by promoting the development of new energy vehicles. The Beijing-Tianjin-Hebei city group is the closest city group to the political center in China, and its development trend is of great significance to other city groups in China due to the radiation of policy speed. Based on this, this paper uses GM (1,1) model to forecast the sales volume of new energy passenger vehicles in this city group. It is found that the change of future sales volume in this city group presents an exponential upward trend. In view of this trend, this paper puts forward corresponding policy suggestions to lay a theoretical foundation for formulating specific policy measures.

Keywords: Grey prediction GM(1,1) model; Beijing-Tianjin-Hebei city cluster; New energy passenger vehicles; Sales forecast

1 Introduction

In recent years, the contradiction between traditional energy and the ecological environment has become increasingly intensified, the global consensus on carbon reduction and the national forward-looking policy guidance, the steady advancement of the China's Double-Carbon Policy and the collective follow-up of enterprises to carry out technology research and development innovation have promoted the rapid development of the new energy automobile industry, which has formed a first-mover advantage. From the perspective of automobile market performance, China's new energy vehicle sales and market penetration rate are rising, and the penetration rate of new energy vehicles in China has reached 25.6% in 2022. At the same time, the sales volume of new energy passenger vehicles in China was 6,535,500, accounting for 94.90% of the sales volume of new energy vehicles. It has contributed an important force to the sustainable development of China's industrial economy and the stable growth of macro-economy, and its market size is expected to continue to expand in the future.

The sales and development of new energy vehicles are greatly affected by policies, and the Beijing-Tianjin-Hebei city group is the city group closest to the political center in China and one of the most economically developed regions in China. The change trend of the sales volume of this city group has a great reference for other city groups in the country. Therefore, it is of

ICEMME 2023, November 17-19, Beijing, People's Republic of China

DOI 10.4108/eai.17-11-2023.2342718

great research significance to predict the future sales of new energy passenger vehicles in the Beijing-Tianjin-Hebei city cluster.

At present, many scholars have done research in this direction of new energy vehicle prediction. Thomas A. Becker[1] uses A network externality model to project the market adoption rate of electric vehicles in the United States through 2030 and analyzes the impact of electric vehicle deployment on other related industries. Liu Yingqi et al.[2] constructed the Bass prediction model to predict the overall trend of China's new energy vehicle industry and the future market performance of typical models such as pure electric vehicles. Koohfar Sahar[3] uses a time series approach to forecast EV charging demand, providing a basis for long-term EV investment planning and resource allocation. Zhu Manyu and Zhang Zheng[4] forecast the sales volume of new energy vehicles in China based on GM(1,1) model. The research results show that the sales volume of new energy vehicles shows an obvious upward trend, and the model presents a good fitting accuracy. However, the current research mainly focuses on the overall prediction of new energy vehicles, and there are few prediction studies on passenger cars and commercial vehicles. For most consumers in China, passenger cars are more closely related to them, so it is of great significance to take passenger cars as the research object.

Based on this, this paper will use the GM(1,1) model to forecast the sales volume of new energy passenger vehicles in the Beijing-Tianjin-Hebei city cluster, and strive to present a better prediction accuracy in the case of few data, small samples and lack of information. Then, the next trend of new energy passenger vehicle sales in the Beijing-Tianjin-Hebei city cluster is reasonably deduced, and finally policy suggestions are put forward to promote the steady development of the new energy passenger automobile industry, laying a theoretical foundation for the formulation of specific policy measures.

2 Researching Method

Grey prediction model is a forecasting method which builds a mathematical model to make prediction through a small amount of incomplete information. It is based on the past and present development laws of objective things, with the help of scientific methods to describe and analyze the future development trend, and form scientific assumptions and judgments[5]. Through reading the existing literature, it is found that the model is widely used in the field of new energy vehicle prediction.

2.1 Data source

This paper is based on the sales volume of new energy passenger vehicles in the Beijing-Tianjin-Hebei region from 2016 to 2019. Due to the impact of the novel coronavirus epidemic in 2020-2022, the data is not scientific, so it is not adopted. The sales data of new energy passenger vehicles come from the third-party data platform of Che Zhixing. After data processing, the sales data of new energy passenger vehicles in the Beijing-Tianjin-Hebei city cluster is shown in Table 1:

Table 1. Sales Volume of new energy passenger vehicles in Beijing-Tianjin-Hebei City Cluster from 2016 to 2019 (Unit: vehicle)

Year	Total value	Beijing	Tianjin	Hebei Province
2016	84368	63210	20114	1044
2017	101401	56245	31077	14079
2018	156898	73536	47506	35856
2019	144426	80294	30102	34030

2.2 Model building

The GM(1,1) model approximates the time with the solution of the first order linear differential equation by using the random original time series, and then adds up the new time series[6]. This model is suitable for single sequence modeling prediction. In this paper, only time series variables are used, so we choose to use this model to forecast sales.

The model building is mainly divided into the following steps:

First, to use GM(1,1) for modeling, first of all, it is necessary to test the level ratio of the original series X0={x0（1），x0（2），…，x0（N）} and calculate the level ratio of the series according to formula (1) :

$$a(k) = \frac{x^0(k-1)}{x^0 k}, \text{ k=2,3,...,n} \quad \text{.......(1)}$$

If all the stage ratios are in the interval (e^(-2/n+1), e^(2/n+1)), then gray prediction can be made..

Second, you need to enumerate a primitive sequence, as shown in formula (2) :

$$X^0=\{x^0(1), x^0(2), \cdots, x^0(N)\} \quad \text{.......(2)}$$

Then, the cumulative generation method (AGO) is used to generate the first-order cumulative generation module to obtain the formula (3) :

$$X^1=\{x^1(1), x^1(2), \ldots, x^1(N)\} \quad \text{.......(3)}$$

Third, by defining grey derivatives, generating series, defining grey differential equation model and other processes, it is listed according to matrix method, as shown in formula (4)[7] :

$$b = \begin{bmatrix} a \\ b \end{bmatrix}$$

$$Y = \begin{bmatrix} X^0(2) \\ X^0(3) \\ X^0(4) \\ \cdots \\ X^0(n) \end{bmatrix}$$

$$B = \begin{bmatrix} -z^1(2) & 1 \\ -z^1(3) & 1 \\ -z^1(4) & 1 \\ \cdots\cdots & \cdots \\ -z^1(n) & 1 \end{bmatrix} \quad \text{.....(4)}$$

Finally, the whitening equation of the gray differential equation is established, and then the parameters a and b are solved by the least square method, and then the time response series is replaced by the formula (5) :

$$x^1(k+1) = \left(x^0(1) - \frac{b}{a}\right)e^{-ak} + \frac{b}{a}, \text{ k=1,2...,n-1.....(5)}$$

2.3 Data verification

According to formula (1), the stage ratio test is carried out on the data. If the stage ratio range is within the interval (0.6703, 1.4918), it indicates that the data passes the test and the grey prediction model can be constructed. The settlement results are shown in Table 2:

Table 2. Raw data level ratio test results

Year	Total value	Stage ratio
2016	84368	
2017	101401	0.8320
2018	156898	0.6462
2019	144426	1.0864

It can be seen that most of the stage ratios are within the prescribed range. Among them, the 2018 grade ratio is very close to 0.6703. Based on this, the model can be constructed and predicted through the stage ratio test.

2.4 Data prediction

According to the original sales data of new energy passenger vehicles in Beijing-Tianjin-Hebei City cluster from 2016 to 2019, EXCEL software was used to calculate various matrices or data required for GM(1,1) prediction model, and the parameters were solved by least square method, a=-0.14725, b=94279.94209. Then, the sales data of the next six years are calculated by substituting formula (5), as shown in Figure 1:

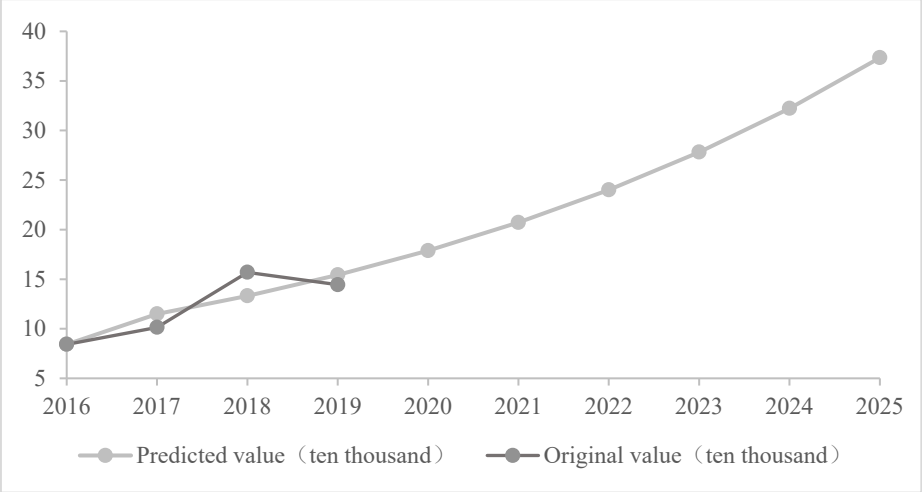

Fig. 1. 2016-2025 sales data of new energy passenger vehicles.

In order to ensure the validity and scientificity of the predicted data, the accuracy of the constructed GM(1.1) model was tested, and the fitting value, relative error, C and P were calculated using EXCEL software. The results are shown in Table 3:

Table 3. Testing of GM(1,1) model

Year	Original value	Fitted value	Relative error
2016	84368	84368	0.00%
2017	101401	114959	13.37%
2018	156898	133197	15.11%
2019	144426	154328	6.86%
C	0.4867	0.35＜C≤0.50	Pass
P	0.8822	0.80≤ P＜0.95	Pass

According to the analysis of the results in Table 3, the relative error of data fitting is within the acceptable range, and P is within the range of [0.8,0.95], and C is within the range of [0.35,0.5], indicating that the accuracy of the model reaches the qualified level, and the gray prediction results can be adopted. The sales data of new energy passenger vehicles in the Beijing-Tianjin-Hebei City cluster from 2020 to 2025 predicted by the model are shown in Table 4:

Table 4. Forecast Value of new energy passenger Vehicles in the Beijing-Tianjin-Hebei City Cluster in 2020-2025 (Unit: vehicle)

Year	2020	2021	2022	2023	2024	2025
Sales volume	178811	207178	240046	278127	322250	373373

3 Discussion

According to the research results, the sales volume of new energy passenger vehicles in the Beijing-Tianjin-Hebei city cluster has shown exponential growth and will exceed 350,000 units by 2025. In addition, if the impact of the COVID-19 epidemic is excluded, the number should exceed 200,000 in 2021. This shows that new energy passenger vehicles are being accepted by consumers, and it's market penetration is gradually increasing. Next, this paper discusses from two aspects.

3.1 Development trend Policy suggestion

Through the study and judgment of the data, we can also analyze that consumers' current acceptance of new energy passenger vehicles has increased, making the market penetration of new energy passenger vehicles also increased. At the same time, the relevant supporting facilities of new energy vehicles will continue to improve, according to the current development plan of the country, the development scale of charging piles and other types of replenishment facilities and the matching new energy vehicle development scale linkage, and eventually achieve a balanced state of matching.

At the same time, the development trend of the Beijing-Tianjin-Hebei city cluster, as an important region in China's economic and political development, has an important reference for other city cluster in China. Therefore, according to this development trend, other city cluster should keep up with the pace of reform and development as soon as possible, actively improve infrastructure construction, and provide support and help for the development of new energy passenger vehicles.

3.2 Policy suggestion

According to the above data, although they are in the same city cluster, the sales volume of Tianjin and Hebei Province is much lower than that of Beijing. However, Tianjin and Hebei Province, as important areas of industrial development, should pay more attention to the development of overall carbon reduction. Therefore, these two regions should strengthen infrastructure construction and formulate some preferential policies modeled on Beijing, so as to promote the increase of sales volume of new energy passenger vehicles.

At the same time, according to the change of consumer consumption preferences, current consumers began to pursue more "fashion and technology" in addition to cost-effective. Different from traditional cars that simply meet the driving experience, current cars pursue the application of new technologies to meet the growing new consumer needs of young groups. Therefore, the local government should promote the development of patented technologies for new energy passenger vehicles, improve consumers' sense of experience for new energy passenger vehicles from the perspective of technological progress, and thus increase sales.

4 Conclusions

Based on the GM(1,1) model of grey prediction, this paper scientifically forecasts the sales volume of new energy passenger vehicles in the Beijing-Tianjin-Hebei city cluster from 2020

to 2025 based on the sales data of new energy passenger vehicles in the Beijing-Tianjin-Hebei city cluster from 2016 to 2019. According to the forecast results, the number of sales in the city cluster will continue to show exponential growth until 2025, and will exceed 350,000 vehicles in 2025.

According to the predicted results and research conclusions, relevant departments and new energy passenger vehicle enterprises in China can take the following two aspects of countermeasures: (1) Pay attention to the overall harmonious development of city clusters, and regions with low sales volume should learn from some favorable policies of regions with high sales volume to bridge the sales gap. (2) To meet consumer demand and strengthen technical support for new energy passenger vehicles, some favorable policies can be issued to promote their technological progress, so as to enhance the vitality and competitiveness of the city cluster market and the national market.

Reference

[1] Thomas A. Becker, Electric vehicles in the US: a new model with forecasts to 2030 [R]. Center for Entrepreneurship & Technology (CET), 2009, 2009.1.v.2.0

[2] Liu Yingqi, Wang Meng, Wang Jingyu. Research on China's new energy vehicle market forecast [J]. Economic and Management Research,2016,37(04):86-91.

[3] Koohfar Sahar, Prediction of Electric Vehicles Charging Demand: A Transformer-Based Deep Learning Approach[J].Sustainability,2023,3(15): 2105-2105.

[4] Zhu Manyu, Zhang Zheng. Research on sales forecasting of new energy vehicles based on GM(1,1) model [J]. Logistics Engineering and Management,2023,45(02):138-141.

[5] Tian Guiping. Logistics Economics [M]. Beijing: China Machine Press,2007.

[6] Li Gongwei. Application of GM(1,1) Grey prediction Model in Dynamic construction cost management of high-speed railway projects [J]. Value Engineering,2019,38(12):30-32.

[7] Liu Yaodi, Xiao Yuhui, Zhan Jingjing. Research on market ownership prediction of new energy vehicles in Yangtze River Delta based on Grey prediction model [J]. Internal Combustion Engines and Accessories,2023(12):107-109.