Prediction Of the Future Development of New Energy Vehicles in China Based on Grey Model and Times Series

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Abstract. Energy shortages have led countries to promote the new energy vehicle industry for sustainable development goals. Establish the grey model and exponential smoothing-based time series model to predict the future development of new energy vehicles in China. And concluded that compared to 2022, imports of new energy vehicles are projected to decrease by 77% in 2032, exports and infrastructure are projected to increase by 1.5 times, the cruising capacity of new energy vehicles is projected to triple, and the new energy vehicle industry will increase its market share by 12% in China.

Keywords: Grey model; Exponential smoothing-based time series model; New energy vehicles in China.

1. Introduction

The contradiction between the global energy shortage problem and the growing sales volume of the automobile market is becoming increasingly prominent, the traditional fuel vehicles have been unable to meet the environmental requirements[1-2]. The new energy automobile industry, the strategic emerging industry, has achieved rapid development in recent years due to its properties of low energy consumption, low pollution and so on[3].

Previous scholars have studied many factors affecting new energy vehicle sales. The research on new energy vehicle sales includes demand analysis based on the comprehensive model of Motivation–Intention–Context–Behavior[1], the influence of personal emotion based on the partial least squares structural equation model[5], and the impact of government subsidies[6]. Previous research methods are based on different single factors to research new energy vehicle sales. However, the single influencing factor may produce many errors, resulting in inaccurate prediction results.

This paper takes into account several influencing elements and forecasts the future development of the new energy automotive sector using the gray model and the exponential smoothing-based time series model. It would be crucial to support the global energy transition, lower carbon emissions, and achieve sustainable development, according to our research and prediction.

2. Grey model and exponential smoothing-based time series model.

According to research already conducted, the new energy vehicle industry's market share, core technology, import and export volume, and supporting infrastructure will all have an impact on how the sector develops in the future. Therefore, we quantitatively predict the future development of new energy vehicles in the above five aspects.[7-8]

Among them, we quantify the supporting facilities of new energy vehicles through the number of existing public charging piles in China. And the core technology is quantified by the cruising ability of new energy vehicles.

2.1. Grey model

The grey model was established to predict the indicators of affecting its future development[9-10].

Firstly, assume that the original sequence passes the grade ratio test, and it can establish the gray model successfully:

$$X^{(0)}(k)+aZ^{(1)}(k)=b \tag{1}$$

Estimate the value of a and b by regression analysis. The corresponding whitening differential equation and its solution :

$$\frac{dx^{(1)}(t)}{dt}+ax^{(1)}(t)=b \tag{2}$$

$$x^{(1)}(t)=(x^{(0)}(1)-\frac{b}{a})e^{-a(t-1)}+\frac{b}{a} \tag{3}$$

So, the predicted value can be calculated:

$$x^{(1)}(k+1)=(x^{(0)}(1)-\frac{b}{a})e^{-ak}+\frac{b}{a},k=1,2,...n-1, \tag{4}$$

And the predicted value of the original sequence:

$$x^{(0)}(k+1)=x^{(1)}(k+1)-x^{(1)}(k),k=1,2,...n-1, \tag{5}$$

However, the forecasting data of import and market share had a low fit to real value. So, for these two indicators, the exponential smoothing-based time series model.

2.2. Exponential smoothing-based time series model.

The prediction method of third exponential smoothing is based on the value of second exponential smoothing. It is mainly based on the initial mean, the relevant feature results are calculated according to three specific formulas, and the next data is recursively derived[11-12].

For the three exponential smoothing values

$$S_t^{(n)}=\alpha y_t+(1-\alpha)S_{t-1}^{(n)}(n=1,2,3) \tag{6}$$

Finally, the model can be written:

$$y_{t+m}=a_t+b_tm+C_tm^2,m=1,2,... \tag{7}$$

Among the above equation:

$$a_t=3S_t^{(1)}-3S_t^{(2)}+S_t^{(3)} \tag{8}$$

$$b_t=\frac{\alpha}{2(1-\alpha)^2}[(6-5\alpha)S_t^{(1)}-2(5-4\alpha)S_t^{(2)}+(4-3\alpha)S_t^{(3)}] \tag{9}$$

$$c_t=\frac{\alpha}{2(1-\alpha)^2}[S_t^{(1)}-2S_t^{(2)}+S_t^{(3)}] \tag{10}$$

3. Results

The acquired and processed data were individually entered into the time series model based on exponential smoothing and the grey model. Get the predicted results and plot the figures.

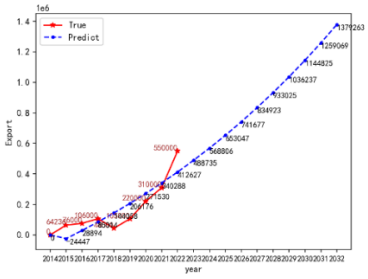

Fig. 1 Export volume predicted by grey model

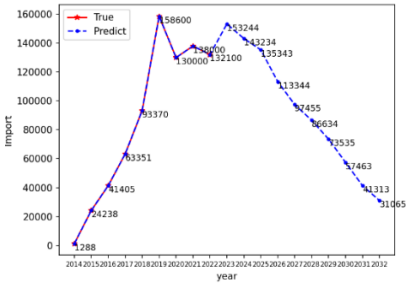

Fig. 2 Import volume predicted by time series model.

In Fig.1, the number of China's new energy vehicle exports continues to increase, and the growth rate remains stable in the forecast for the next ten years, and the number of exports continues to increase, and the growth rate remains stable. in 2032, the annual exports are projected to reach about 1.38 million vehicles.

Fig.2 shows China's imports of new energy vehicles show an overall decreasing trend in the forecast for the next decade. From 2022 to 2023 the number of export increases, reaching a maximum of more than 150,000 units; from 2023 to 2032 the number of vehicles continues to decrease and the decreasing trend remains steady. In 2032, the annual exports are expected to decrease to about 30,000 units.

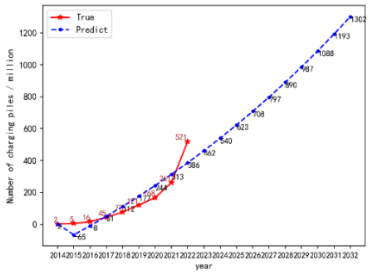

Fig. 3 Charging piles predicted by grey model

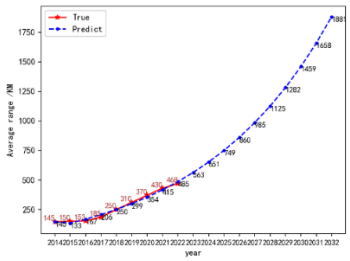

Fig. 4 Cruising Ability predicted by grey model.

As can be seen in Fig.3, the number of charging piles in China will continue to increase and the rate of increase will continue to increase by a small margin over the next decade. This indicates that new energy automobile industry supporting facilities will continue to improve in the future in China.

Fig.4 shows that China's new energy vehicles will continue to increase in range and growth rate over the next decade. This indicates that the range of China's new energy vehicles is constantly improving, and the core technology is constantly being revolutionized.

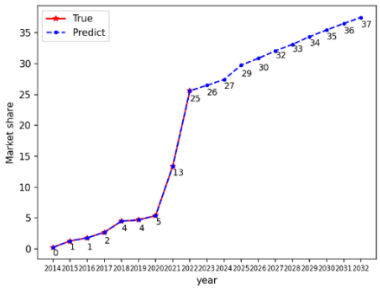

Fig. 5 Market Share predicted by time series model.

As can be seen from Fig.5, market share in the future in the next 10 years continues to increase, of which the fastest rate of increase in 2022-2023, the rate of increase in 2023-2032 slowed down. It is expected that the market share of new energy automobile industry in 2032 is 37%.

Through the projected data, we find that in the future, China's exports of new energy vehicles continue to increase because of the development of its own core technology, thus reducing the demand for import. The industry's market share is growing as a result of the optimization of new energy

vehicles' basic technologies. The demand for new energy vehicles and the advancement of public facilities in China is driven by the people's confidence in domestic new energy vehicles.

4. Conclusion

This paper introduces a hybrid model combining a gray model and a time series model, leveraging their complementary nature to enhance prediction accuracy. By integrating multiple dimensions, it offers a more comprehensive and precise depiction of China's new energy vehicle industry development. Predictions suggest a significant decline in new energy vehicle imports by 77% in 2032, alongside a 1.5-fold increase in exports and infrastructure, a tripling of new energy vehicle cruising capacity, and a 12% expansion in market share within China. The method exhibits strong predictability and robustness, offering a data-driven foundation for decision-making and facilitating a clearer understanding of the industry's trajectory.

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