Dynamic Analysis of the new Energy Vehicle Industry

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Abstract. In the context of the rapid development of China's new energy vehicle industry, the research aims to deeply analyze the trend and interrelationship of key indicators, and explore their impact on sales. The XGBoost model reveals the key characteristics of market acceptance and sales growth rate, and the GA-LSTM model predicts the future development trend. The research aims to provide strategic reference for the government and enterprises and promote the sustainable development of the new energy vehicle industry.

Keywords: XGBoost Model;GA-LSTM model;new energy vehicle industry;trend research

1. Introduction

1.1 Research Purpose and train of thought

This paper aims to deeply study the key factors to promote the development of new energy electric vehicles in China, and establish a mathematical model to quantify its impact on the development of new energy electric vehicles. The first research content is to ensure the comprehensiveness of the system by building a comprehensive index system such as infrastructure, market acceptance and industry scale with the help of expert consultation. At the same time, through the analysis of the current situation of the indicators, and the use of the relevant analysis model and xgboots-sample model, an in-depth understanding of the impact of various factors on the sales of new energy vehicles. In the second study content, the time series model and GA-LSTM method were adopted by collecting industry data. Through this research idea, this paper aims to provide scientific basis for deepening people's understanding of the development of new energy electric vehicles in China, provide support for government and industrial decision-making, and promote the sustainable development of new energy electric vehicle industry.

1.2 The Significance of the development of new energy vehicles

The development of new energy vehicles is of great significance. First, they reduce their dependence on limited fossil fuels, reduce greenhouse gas emissions and help combat climate change. Secondly, promoting the development of the new energy vehicle industry has promoted scientific and technological innovation and improved the competitiveness of the industry. At the same time, the popularization of new energy vehicles has promoted the application of clean energy and promoted the development of renewable energy. In addition, the construction of the new energy vehicle industry chain has created employment

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opportunities and promoted economic growth. Therefore, the development of new energy vehicles is of profound significance to the environment, science and technology and economy.

2. Model preparation

2.1 Indicator construction process

This study adopts the method of literature research and expert questionnaire survey to construct the index system of new energy power development in China. Through three rounds of expert consultation from Delphi method, the first and second level indicators of infrastructure and operation situation, [1]market acceptance, industry scale and development trend have been preliminarily determined. In the second round of consultation, indicators such as low ratings such as the average service life of new energy vehicles and the number of related patent applications were removed. On this basis, the third round of consultation was carried out, and the final index system covering the number of charging piles, sales growth rate, quantity, ownership and other aspects was finally formed. The whole process, after several rounds of expert consultation and careful adjustment, ensures the accuracy and practicability of the index system, and provides a scientific basis for the follow-up analysis and modeling of the new energy electric vehicle industry.[2]

2.2 Index system determination

The final indicators are as follows Table 1:

Table 1. List of the index system

Primary index	Secondary index
Infrastructure and operations	NEV Charging Piles in China Public Transport Vehicles in Operation Trams in Operation Total Tram Line Length Tram Ridership
Market acceptance	NEV Count in China Sales Growth Rate Sales (10,000 vehicles)
Industry scale and development trend	Avg. Electric Mopeds per 100 Households at Year-End

3. Research on the factors influencing the development of new energy electric vehicles

3.1 Data visualization and trend analysis

The data of each indicator is visualized as follows Figure 1:

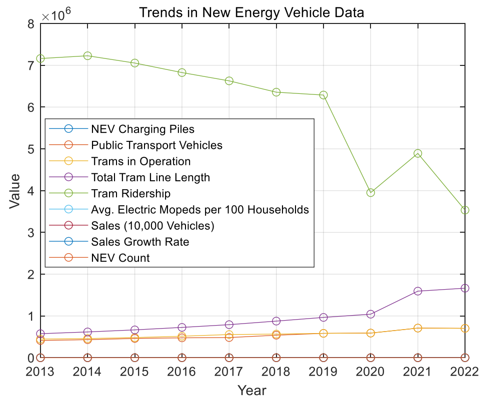

Figure 1. Trend diagram of each indicator

China's new energy vehicle industry has shown strong growth, with increasing numbers of charging piles, bus vehicles, and tram lines. Sales have also increased significantly, reflecting the popularity of the market. Globally, the number of new energy charging piles has grown rapidly, with China accounting for the majority of new fast charging piles. China plays a pivotal role in the global electric vehicle market, accounting for over 60% of sales.[3]

3.2 Pearson Correlation analysis

Pearson Correlation analysis is a statistical method used to measure the strength and direction of the linear relationship between two continuous variables. This method uses the Pearson correlation coefficient (also known as the Pearson product-moment correlation coefficient) to describe the linear relationship between two variables. The Pearson correlation coefficient is usually expressed by r.[4]

Pearson The correlation coefficient is calculated as follows:

$$r = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2 * \sum(Y_i - \bar{Y})^2}}$$

among:

The X_i and Y_i are the *i* th observations of the two variables.

$\bar{X}$ and $\bar{Y}$ are the means of *X* and *Y* , respectively.

Molecules are covariance) (*X*) and) (*Y*).

The denominator is the product of the respective standard deviations of) (*X*) and) (*Y*).

Pearson The correlation coefficient ranges between-1 and 1:

r =*1* indicates a complete positive correlation.

r = -*1* indicates a complete negative correlation.

$r = 0$ indicates no correlation.

The model analysis results are as follows Figure 2:

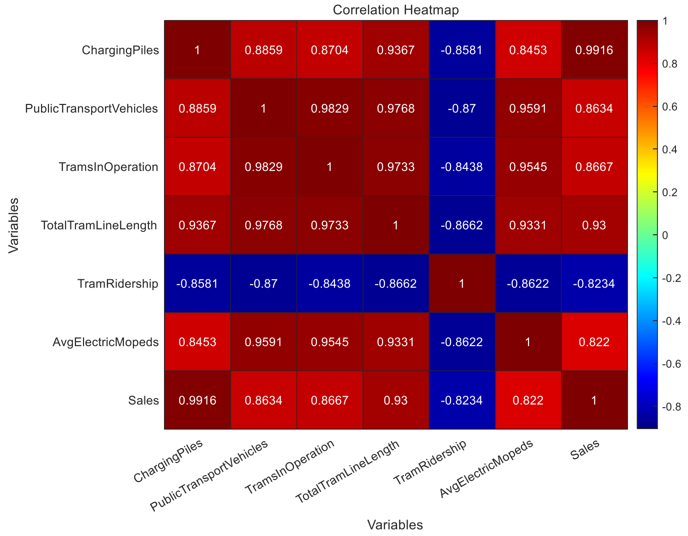

Figure 2. Heat map of the correlation analysis

It can be seen from the model results that each index has differences in its influence on the sales volume of new energy vehicles. An increase in the number of charging facilities, public transport vehicles and trams can promote sales, while the increased popularity of public transport passengers and electric motorcycles may reduce demand. The decrease in the overall vehicle sales growth rate may have a negative impact on new energy vehicle sales.[5]

3.3 And the Xgboots-shap analysis

XGBoost Using the gradient lifting algorithm, combined with regularization items and split indicators, to achieve efficient, flexible and portable machine learning. By constructing a virtual data set, SHAP calculates the contribution value of each feature, approximately calculates the Shapley value, and explains the model prediction results.[6]

XGBoost The model prediction results are as follows Figure 3:

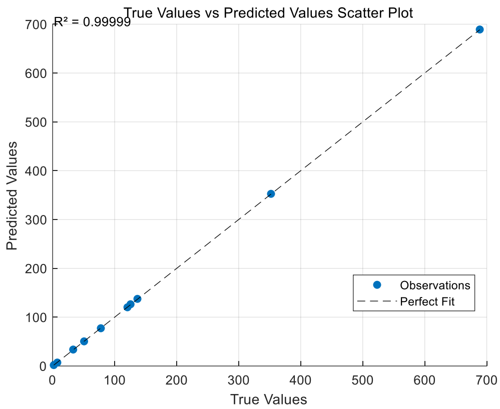

Figure 3. Model training fitting effect diagram

The model results showed an extremely high degree of fit (R^2=0.99999), and the predicted value was highly consistent with the true value.

Taking the corresponding annual Shapley value of each index as the average, the Sharp value of each indicator is obtained as Figure 4:

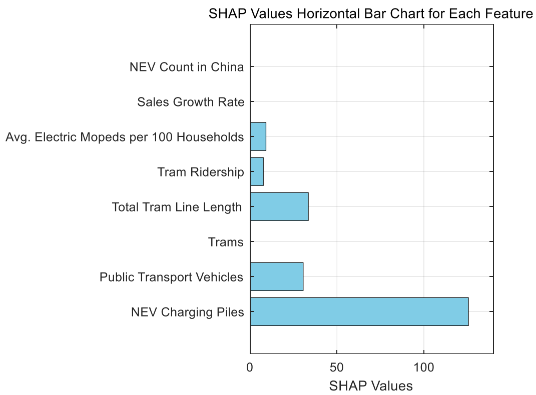

Figure 4. Overview of the SHAP values of each indicator

Looking at the shot value distribution chart, it can be seen that the key factors for the development of China's new energy vehicle industry are charging infrastructure and the length of the operation and operation lines of public transport new energy vehicles. Public acceptance and usage also had some influence, while other factors had less influence on the model prediction.

4. Research on the development prediction of new energy electric vehicles

4.1 The index prediction model for GA-LSTM

The steps of LSTM hyperparameter tuning using genetic algorithm (GA) include determining the tuning parameters, calculating the model output, seeking optimization through GA iteration, taking the regression results as the fitness value, and comparing with the historical results, and finally output the optimal model parameters.[7] LSTM was trained on the obtained parameters to the F1 or lowest hyperparameter with the best effect. The LSTM parameter is obtained as follows Table 2:

Table 2. The LSTM model parameter table

Parameter name	value
Number of neurons in the hidden layers	128
LSTM number of plies	2
Dropout Scale	20%
Batch Size	64
Learning rate	64
Frequency of training	100
Optimizer	Adam

4.2 The index prediction model for GA-LSTM

The predicted value of each indicator is obtained from LSTM, and the forecast trend of each indicator is as follows Figure 5:

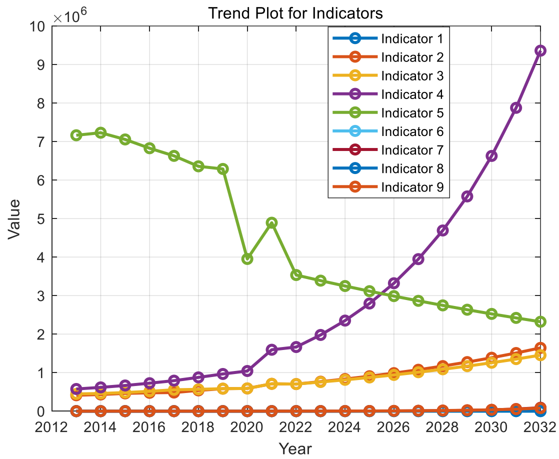

Figure 5. Trend chart of the predicted value of each indicator

China's new energy vehicle industry forecasted strong growth from 2023 to 2032, with increasing charging piles, public transport adoption, and expanded bus/tram lines.[8] Sales and ownership skyrocketed, indicating broad market acceptance.[9] Infrastructure development and market acceptance are critical for future growth.

4.3 The index prediction model evaluation of GA-LSTM

Calculate the MAPE value of each indicator, and the results are as follows Figure 6:

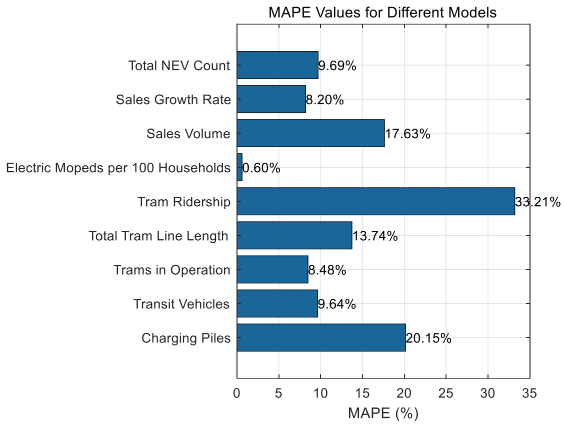

Figure 6. Bar graph of the MAPE values for each indicator

From the MAPE value of each index, it can be seen that the MAPE of public bus and tram passenger volume (33.208%) is the highest, indicating that its prediction error is large and is affected by many factors. The MAPE (0.603%) at the end of every 100 households is the lowest, indicating that the prediction accuracy is high, because it is relatively stable. The MAPE of the number of charging piles for new energy vehicles (20.147%) and the sales volume (17.628%) are relatively high, which may be due to the rapid development of the market and policy changes.

5. Research on the development prediction of new energy electric vehicles

5.1 Model building

This study developed a model to analyze the impact of urban electric vehicles (including electric buses and electric vehicles) on the ecological environment. Considering the urban population of about 1 million, the model focuses on a key environmental factor: carbon dioxide emissions (CO 2).[10]

A. The electrification rate of electric vehicles is defined as the proportion of electric vehicles in the total number of vehicles, which is calculated as follows:

EV electrification rate = number of electric vehicles / total number of vehicles

B. By comparing the annual average carbon dioxide emissions of each fuel vehicle and electric vehicle (X ton and Y ton, respectively, including $Y < X$), we estimated the reduction in carbon dioxide emissions caused by the electrification of electric vehicles, using the formula:

CO 2 reduction EVs = Quantity X * (X-Y)

5.2 Model solving

In our study, the initial population of the cities was set at 1 million people. Given the number of cars, we assumed 50 cars per 100 population. Regarding the initial electrification rate, namely the popularity of electric vehicles in cities, we assume that it accounts for 10% of the carbon dioxide emissions of fuel vehicles. The average annual carbon dioxide emissions from fuel vehicles are 4.6 tons. The emissions from electric vehicles are mainly from power generation, and we set their annual emissions at 15 tons.

The model solution results are shown as follows Figure 7:

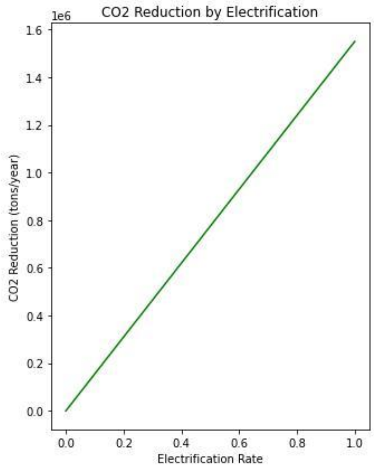

Figure 7. Trend chart of electrification rate for carbon dioxide emission reduction in cities with one million population

As you can see: When there are no electric cars, the carbon dioxide emission reduction is zero. When all the vehicles were electric vehicles, the carbon dioxide emission reduction was the largest, at 145,000 tons per year. This suggests that if the city replaces all its cars with electric cars, it couldsignificantly reduce CO 2 emissions and improve air quality each year. With the improvement of the electrification rate, the air quality improves better, which shows a square level increase.[11]

6. Conclusion

China's new energy vehicle industry showed strong growth, with key factors including charging infrastructure, public transport and sales growth rates. The XGBoost-SHAP and GA-LSTM analyses demonstrate the importance of these factors for future development, but the model still needs further optimization. Electrification of urban electric vehicles can reduce carbon dioxide emissions and improve air quality to some extent. This study provides a scientific basis for the new energy vehicle industry, and also provides a reference for the sustainable development of urban environment.

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