ISSN: 2664-9640

Development Status and Prospect of New- energy Vehicles From Big Data

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Abstract

Based on the current global energy situation, new-energy vehicles have been vigorously promoted and used all over the world. However, there are still some problems in the development of new-energy vehicles in China. This paper aims to predict the development prospect of new-energy vehicles by analyzing the development status of new-energy vehicles. The method of analysis is to conduct descriptive statistical analysis and visual processing on the big data of new-energy vehicles in combination with relevant statistical knowledge and mathematical modeling, find its internal relationship through the data, and predict the future market situation of new-energy vehicle industry through mathematical model. Finally, it is concluded that new-energy vehicles have great development potential, but there are still some technical barriers, which need to be solved by relevant departments by taking effective measures (such as carrying out the research on fuel cell stack, engine and its key materials). Research on the development status of new-energy vehicle industry is of great significance for the development of energy conservation and emission reduction in China.

Keywords

New-energy vehicles; Big data; Descriptive statistics; Visualization; Grey prediction model.

1. Background

Nowadays, the global energy and environmental system is facing great challenges. As a large producer of oil consumption and carbon dioxide emissions, cars need revolutionary changes. As countries around the world pay more attention to environmental protection, technological progress and energy security, internal combustion engines that consume fossil energy are gradually replaced by other energy power systems in the field of road transportation, which also brings a good opportunity for the development of new-energy vehicle industry with electrification as the technical background. For new-energy vehicles, China has issued some relevant supporting policies in recent years. The introduction of supporting policies plays a positive role in promoting both the research technology of new-energy vehicles and the new-energy vehicle industry. Under the influence of market and national policies, the trend of developing electric vehicle industry in China is imperative. Therefore, it is of great strategic significance to study the development strategy of new energy enterprises.

2. Analysis & Research

Firstly, through the visual processing of the sales data of new-energy vehicles, we can analyze its current market strategy.

According to the global sales data of new-energy vehicles, as shown in Figures 1-4.

ISSN: 2664-9640

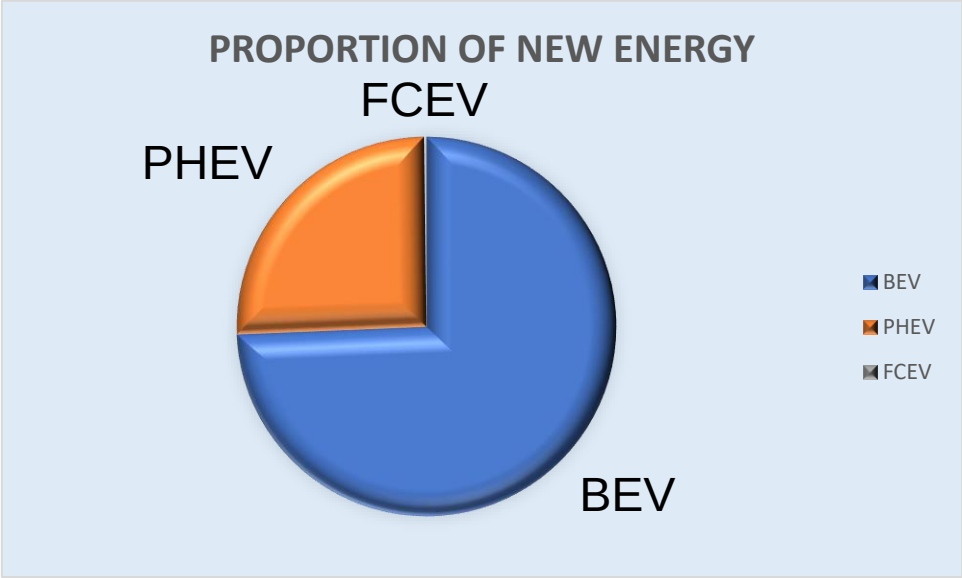

Figure 1. Pie chart of proportion of new energy

As can be seen from Figure 1, Bev accounts for the largest proportion of sales in new energy, up to 74.34%; PHEV ranked second, accounting for 25.46%; The proportion of FCEV is the smallest, accounting for only 0.19%. This shows that Bev is the most popular new energy.

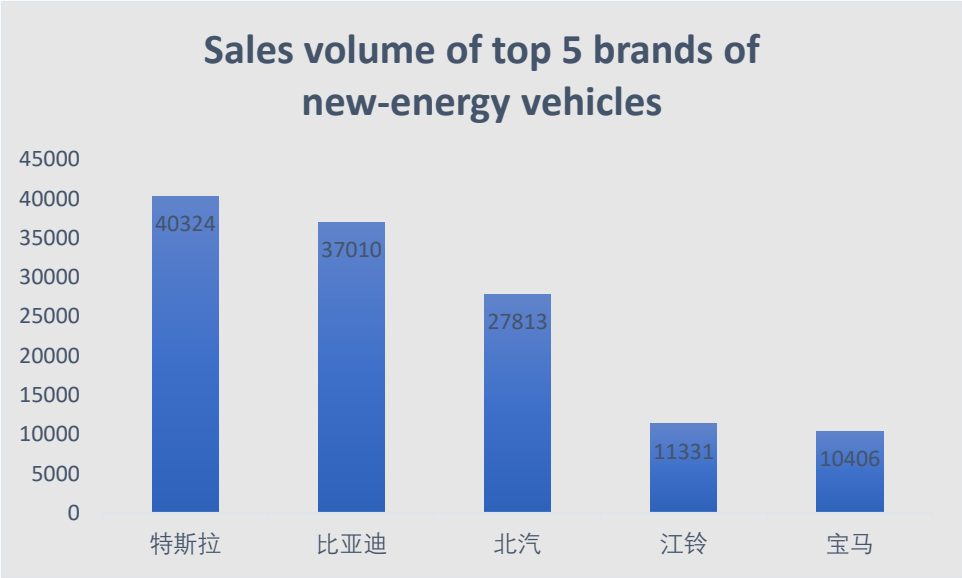

Figure 2 Bar chart of sales volume of top5 brands of new-energy vehicles

As can be seen from Figure 2, the top five brands in the sales volume of new-energy vehicles are Tesla, BYD, BAIC, Jiangling and BMW. Among them, Tesla and BYD are firmly in the top two, and there is a certain gap between the car sales of the latter brands and them.

As can be seen from Figure 3, the top five sales of new-energy vehicle series are Tesla Model 3, BAIC EU series, BAIC EC series, BYD E5 and BYD ev. Among them, the sales volume of Tesla Model 3 far exceeds that of subsequent brands.

According to figure 2 and figure 3, Tesla is the most popular brand among new-energy vehicles. At the same time, BAIC and BYD follow Tesla in sales, and they also have a large consumer group.

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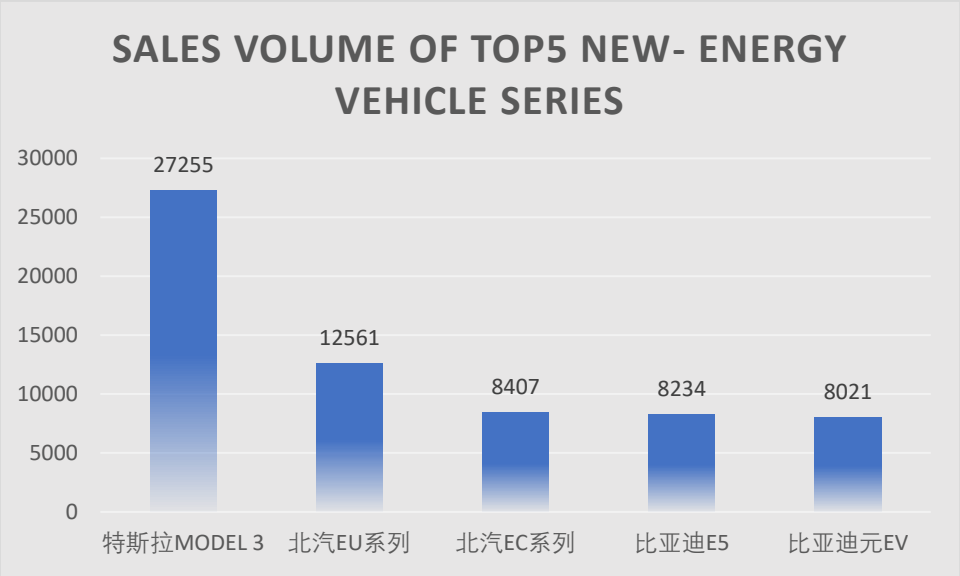

Figure 3 Histogram of sales volume of top5 new-energy vehicle series

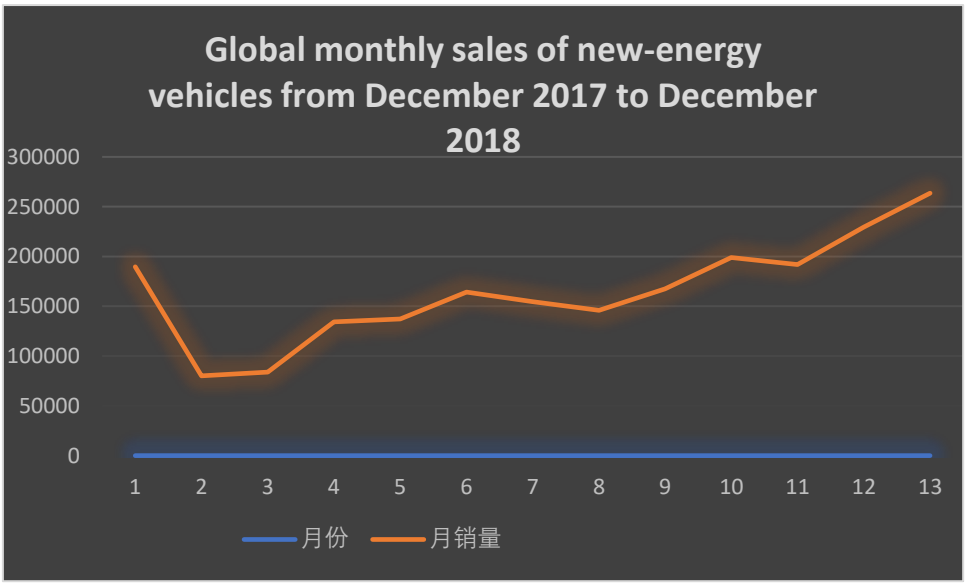

Figure 4 Broken line chart of global monthly sales of new-energy vehicles from December 2017 to December 2018

As can be seen from Figure 4, the global monthly sales of new-energy vehicles showed an overall upward trend from December 2017 to December 2018. Especially in 2018, the growth rate of monthly sales volume gradually increased, indicating that the users of new-energy vehicles are gradually increasing and their market is gradually expanding.

Secondly, the descriptive statistical analysis method is used to analyze the data related to the body and size of new-energy vehicles to understand the characteristics of their technical design. Some statistics of sales volume data in Table 1 and Table 2 are obtained as follows.

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Table 1. Sales of various body forms of new-energy vehicles

CAR	179658	68.17%
SUV	79588	30.20%
MPV	3101	1.18%
LCY	1210	0.46%
Mean		65889.25
Standard error		42087.96
Median		41344.5
Standard deviation		84175.91
Variance		7.09E+09
Kurtosis		-0.18087
Skewness		1.069692
Confidence (95.0%)		133942.7

Combined with table 1 and the right table, the average sales volume of various body forms of new-energy vehicles is 65889.25, and its kurtosis is -0.18087 < 0, indicating that the sales volume of new-energy vehicles is scattered about their body forms.

Table 2. Sales of new-energy vehicles with different body sizes

A	102039	38.72%
B	52660	19.98%
A00	50843	19.29%
A0	31406	11.92%
C	24265	9.21%
D	2344	0.89%
Mean		43926.17
Standard error		13872.77
Median		41124.5
Standard deviation		33981.22
Variance		1.15E+09
Kurtosis		1.402429
Skewness		0.885258
Confidence (95.0%)		35661.1

According to table 2 and the right table, the average sales volume of different body sizes of new-energy vehicles is 43926.17, and its kurtosis is 0.885258 > 0, indicating that the distribution of new-energy vehicle sales about its body size is relatively concentrated.

Finally, according to the annual sales data of global new-energy vehicles from 2010 to 2018 (Table 3), the grey prediction model is used to predict the sales of new-energy vehicles in the next few years.

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Table 3. Annual sales data of global new-energy vehicles from 2010 to 2018

Year	Annual sales volume
2010	7012
2011	52414
2012	141109
2013	217033
2014	329916
2015	567416
2016	786014
2017	1190512
2018	1951732

Establishment and solution of model

Step 1 Level ratio test

Establish the time series of global annual sales of new-energy vehicles from 2010 to 2018 as follows:

$$x^{(0)} = \left(x^{(0)}(1), x^{(0)}(2), \dots, x^{(0)}(9) \right)$$

$$= (7012, 52414, 141109, 217033, 329916, 567416, 786014, 1190512, 1951732)$$

Note: 1 ~ 9 are used to represent 2010 ~ 2018 respectively.

Solving stepwise ratio $\boldsymbol{\lambda}$（**k**）

$$\lambda（\mathrm{k}）=\frac{x^{(0)}(k-1)}{x^{(0)}(k)}$$

$$\lambda = \left(\lambda(2), \lambda(3), \dots, \lambda(9)\right)$$

=（0.133781, 0.371443, 0.650173, 0.657843, 0.581436, 0.72189, 0.660232, 0.609977）

Judgement of stepwise ratio

Due to all the λ（k）∈ [0.133781,0.72189],k=2,3,...,9.

Therefore, $x^{(0)}$ can be used as a satisfactory GM (1,1) modeling.

Step 2 GM (1,1) modeling

Accumulate the original data $x^{(0)}$, namely $x^{(1)}$ =（7012, 59426, 200535, 417568, 747484, 1314900, 2100914, 3291426, 5243158）

Construct data matrix B and data vector Y

$$\mathrm{B} = \begin{bmatrix} -\frac{1}{2} & （x^{(1)}(1) + x^{(1)}(2)） & 1 \\ -\frac{1}{2} & （x^{(1)}(2) + x^{(1)}(3)） & 1 \\ & \vdots & \vdots \\ -\frac{1}{2} & （x^{(1)}(8) + x^{(1)}(9)） & 1 \end{bmatrix}, \mathrm{Y} = [x^{(0)}(2), x^{(0)}(3), \dots, x^{(0)}(9)]$$

Calculate $\hat{u}$

$$\hat{u}=(\hat{a}, \hat{b})^T = (B^T \cdot B)^{-1} B^T Y = (-0.4340，70901).$$

So get a= -0.4340 , b= 70901.

Build model

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$$\frac{dx^{(1)}}{dt} - 0.4340x^{(1)} = 70901$$

Solved

$$x^{(1)}(k+1) = \left(x^{(0)}(1) - \frac{b}{a}\right)e^{-ak} + \frac{b}{a} = 170370e^{0.4340k} - 163360$$

Solve the generated sequence value $\hat{x}^{(1)}(k+1)$ and model restored value $\hat{x}^{(0)}(k+1)$

Let k = 1,2,..., 8, from the above time response function, $\hat{x}^{(1)}$ can be calculated. Among them,take $\hat{x}^{(1)}(1) = \hat{x}^{(0)}(1) = x^{(0)}(1) = 7012$.

Due to $\hat{x}^{(0)}(k) = \hat{x}^{(1)}(k) - \hat{x}^{(1)}(k-1)$,take k=2,3,...,9 and get

$$\hat{x}^{(0)} = \left(\hat{x}^{(0)}(1), \hat{x}^{(0)}(2), \dots, \hat{x}^{(0)}(9)\right)$$
$$= (\ 7012\ ,92589\ ,142907\ ,220570\ ,340439\ ,525453\ ,811012\ ,1251761\ ,1932036\ )$$

Step 3 model test

The calculation results of various inspection index values of the model are as shown in Table 4.

Table 4. Test values of the model

No	Year	Original value	Model value	Residual error	Relative error	Level ratio deviation
1	2010	7012	7012	0	0	
2	2011	52414	92589	-40174.7	0.76648819	0.7921
3	2012	141109	142907	-1797.48	0.01273827	0.4227
4	2013	217033	220570	-3536.69	0.01629562	-0.0106
5	2014	329916	340439	-10523.3	0.03189698	-0.0225
6	2015	567416	525453	41963.32	0.07395512	0.0963
7	2016	786014	811012	-24998.4	0.03180404	-0.122
8	2017	1190512	1251761	-61248.9	0.05144757	-0.0262
9	2018	1951732	1932036	19695.66	0.01009138	0.0519

Model residual test is mainly to check the relative error value and order ratio deviation value to test the effect of the model.

According to table 4 above, the relative error and order ratio deviation can be analyzed after the model is constructed. Due to the long time from 2010 to 2012, the relative error and order ratio deviation are too large, the data representation is not strong, and there is no reference value. Therefore, the data of these three years are not considered here. On this basis, the maximum relative error of the model is 0.07395512 < 0.1, which means that the fitting effect of the model meets high requirements. For the grade ratio deviation value, if the value is less than 0.2, it indicates that the requirements are met; if it is less than 0.1, it indicates that the higher requirements are met. The maximum relative error of the model is 0.0963 < 0.1, which means that the fitting effect of the model meets high requirements.

ISSN: 2664-9640

At the same time, through the calculation, the relative residual Q test: q = 0.1105; Variance ratio c test: C = 0.0479; Small error probability p test: P = 1.

The test standard of relative residual Q: if Q < 0.01, the model grade is good; If Q < 0.05, the model grade is good; If Q < 0.10, the model grade is qualified; If Q < 0.20, the model grade is reluctantly; If Q > 0.20, the model grade is unqualified.

Variance ratio C and small error probability p are used for model accuracy grade test, and the test criteria are shown in Table 5.

Table 5. Model p-value and C-value inspection standards

P	C	Evaluation
＞0.95	＜0.35	Good
＞0.80	＜0.50	Qualified
＞0.70	＜0.65	Barely qualified
≤0.70	≥0.65	Unqualified

The variance ratio calculated by the model is C = 0.0479 < 0.35, and the small error probability p = 1 > 0.95, which means that the accuracy grade of the model is very good.

Step 4 model fitting diagram

Drawing the fitting curve of the annual sales model of global new-energy vehicles from 2010 to 2018, as shown in Figure 5.

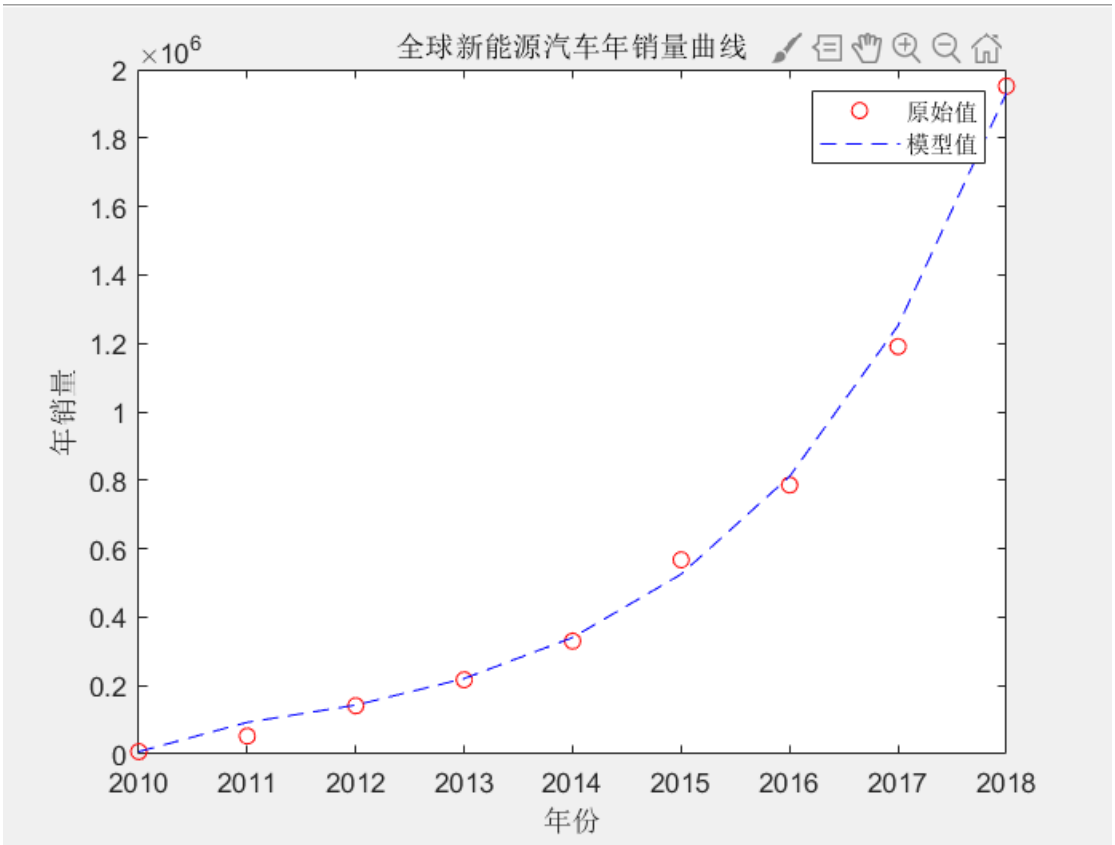

Figure 5 fitting curve of global annual sales of new-energy vehicles

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Step 5 model prediction results

Since GM (1,1) model is only applicable to medium and short-term prediction, this paper uses this model to predict the global sales of new-energy vehicles from 2019 to 2028.

From the above time response function

$$x^{(1)}(k+1) = \left(x^{(0)}(1) - \frac{b}{a}\right)e^{-ak} + \frac{b}{a} = 170370e^{0.4340k} - 163360$$

we can calculate $\hat{x}^{(1)}$. Then according to the formula $\hat{x}^{(0)}(k) = \hat{x}^{(1)}(k) - \hat{x}^{(1)}(k-1)$,

let $k = 10,11,\ldots,19$ and get $\hat{x}^{(0)} = \left(\hat{x}^{(0)}(10), \hat{x}^{(0)}(11), \ldots, \hat{x}^{(0)}(19)\right)$

$= (2982011, 4602598, 7103902, 10964551, 16923288, 26120329, 40315545, 62225218, 96041807, 148236179)$

Therefore, the global sales forecast of new-energy vehicles in 2026-2019 is as follows:

Table 6 Annual sales forecast of global new-energy vehicles from 2019 to 2028

Year	PV of annual sales
2019	2982011
2020	4602598
2021	7103902
2022	10964551
2023	16923288
2024	26120329
2025	40315545
2026	62225218
2027	96041807
2028	148236179

The forecast curve of global new-energy vehicle sales from 2019 to 2028 is drawn, as shown in Figure 6.

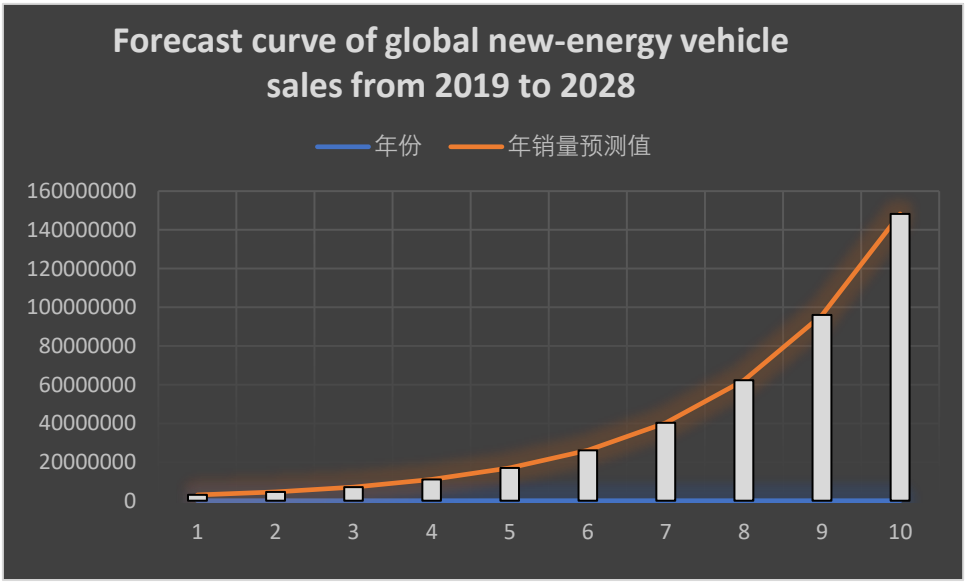

Figure 6 Forecast curve of global new-energy vehicle sales from 2019 to 2028

ISSN: 2664-9640

It can be seen from table 6 and Figure 6 that the global sales of new-energy vehicles will show a good performance of overall growth from 2019 to 2028. According to the prediction results of the model, the sales volume of global new-energy vehicles from 2019 to 2028 will increase by 52.79% year-on-year based on the sales volume from 2010 to 2018, and its market will gradually expand.

3. Conclusion

Based on the above analysis, new-energy vehicles have strong development potential. At present, Tesla, BYD and BAIC are in a leading position in the new-energy vehicle industry, and their development momentum is bound to drive other brands to build the whole industry better. Looking at the sales of new-energy vehicles, both globally and domestically, it shows a trend of accelerated growth, indicating that its consumer group is expanding and the demand is rising. The whole industry has a good development prospect. From the performance of the vehicle itself, there is a large gap in the sales of vehicles with different body forms and body sizes, indicating that there are certain technical barriers in the new-energy vehicle industry, so that the vehicle can not well meet the needs of the public.

Therefore, enhancing technological innovation ability is the central link of cultivating and developing new-energy vehicle industry. We should strengthen the dominant position of enterprises in technological innovation, guide the accumulation of innovation elements to advantageous enterprises, and improve the technological innovation system with enterprises as the main body, market-oriented and the combination of industry, University, research and application. Increase support through national science and technology plans, special projects and other channels, break through key core technologies and enhance industrial competitiveness. Only in this way can China's new-energy vehicle industry have core competitiveness and be in the forefront of the world.

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