Research on electric vehicle ownership prediction based on BASS model: A case study of Yunnan Province

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Abstract. In order to forecast the number of electric vehicles in Yunnan Province, based on BASS model, this paper uses extensive analogy method to explore the acquisition of m, p and q model parameters, forecasts the purchasing power of the market, and estimates the innovation coefficient and imitation coefficient from three aspects of high potential scenario, base potential scenario and low potential scenario. The number of new energy electric vehicles in Yunnan Province in three scenarios from 2022 to 2035 is predicted. The forecast results show that under the condition of high potential development, the number of new energy vehicles in Yunnan Province will reach 409,600 in 2022; in the case of benchmark potential development, the number of new energy vehicles will reach 291,400 in 2022; in the case of low potential development, the number of new energy vehicles in Yunnan Province will reach 155,400 in 2022.

1 Introduction

At present, the Yunnan provincial government is following the national policy to vigorously develop new energy vehicles. The new energy vehicle market in Yunnan Province has a certain development foundation, but it still needs to be promoted. The key development of new energy vehicles based on electric vehicles is clearly put forward in China's "Twelfth Five Year Plan".

Compared with traditional fuel vehicles, electric vehicles have the advantages of small pollutant emissions, low energy consumption and low cost. In addition, the large-scale and orderly development of electric vehicles plays a positive role in driving the development of the upstream and downstream industries of electric vehicles. The prediction of the development trend of electric vehicle ownership is an important reference for the planning and construction of electric vehicle charging service network. Therefore, accurate prediction of electric vehicle ownership has important practical significance, and the core theory of new product diffusion model is BASS model and its extended model.

To a certain extent, consumers' interest in electric vehicles will be affected by price, substitution cost, policy and other factors, and ultimately affect the market potential of electric vehicles. The maximum market potential restricts the consumption of electric vehicles, which is related to the total number of new civil vehicles in that year. If electric vehicle technology continues to progress, vehicle costs continue to decrease, cost performance ratio improves, infrastructure such as charging piles continues to improve, the cost of gasoline vehicles and other fuel vehicles is at a high level, and the government provides a larger preferential subsidy policy for electric vehicles, then consumers will be more willing to buy electric vehicles, the proportion of electric vehicles in the newly added civil vehicles in that year has increased correspondingly, and the market potential of electric vehicles is relatively large. On the contrary, consumers' willingness to buy electric vehicles is low, and the market potential is small.

Through the investigation, it is found that there are many methods to predict the number of electric vehicles. For example, artificial bee colony planning symbolic regression sr-abc is used to predict China's passenger car ownership[1-2], electric vehicle ownership prediction method based on multiple linear regression[3-5] and proportional substitution method, and methods such as government planning target calculation method[6], thousand people ownership method and electric vehicle industry research are proposed to carry out electric vehicle ownership prediction. According to a class of Riccati equation, an accurate discrete BASS model is constructed, and the research shows that the model and its solution converge to the original continuous model[7]. A search algorithm based on nonlinear least square rule is given to estimate the model parameters, and the fitting effect is good[8]. The BASS model with weekend coefficient is

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constructed to obtain the improved BASS model. Guided by the theory of consumer decision-making process, the multiple regression model is established with the parameters of the improved BASS model as the dependent variable[9]. The joint prediction model is obtained by combining the improved BASS model and the parametric regression model, which can achieve better results[10]. Based on the universal applicability, easy operation and good effect of BASS model, this paper sets the maximum market potential of electric vehicles in three scenarios of high, benchmark and low according to the proportion of electric vehicles in the total number of newly added civil vehicles in that year through literature research and questionnaire survey according to different assumptions (see **Table 1**), it also predicts the number of electric vehicles in Yunnan Province under three scenarios.

2 Introduction of BASS model

The expression of BASS diffusion model is as follows:

$$\frac{dN(t)}{dt} = p[m - N(t)] + q\frac{N(t)}{m}[m - N(t)] \quad (1)$$

In the above **Formula 1**, the left side is the number of non cumulative adopters when t is used; the cumulative number of adopters when N(t) is t; m is the biggest potential of the market; p, q is external influence coefficient (or innovation coefficient) and internal influence coefficient (or imitation coefficient). The first term p [m-N (t)] of the equation represents the number of innovation adopters, whose purchase decisions are only affected by external factors, not by those who have adopted the product; the second represents the number of imitators whose purchase decisions are influenced by the people who have adopted the product.

The **Formula 2** for the discrete-time version of BASS model is as follows:

$$\mathrm{f(t+1) = p[1 - F(t)] + qF(t)[1 - F(t)]} \quad (2)$$

Where p is the innovation coefficient predicted above, q is the imitation coefficient, and is the proportion of the cumulative number of new product consumers in the total number of potential consumers in t period. It is the proportion of the number of new consumers to the number of potential consumers in t + 1 period.

The key of BASS model lies in the acquisition of m, p and q. Usually, the three coefficients can be obtained by fitting on the basis of existing data, and can also be obtained by analogy, that is, using the correlation coefficient of similar products, BASS model expresses the essence of diffusion process with mathematical equation, which greatly simplifies people's understanding of innovation diffusion and makes it systematic.

3 BASS model parameter estimation

The parameter estimation of BASS model p and q is widely used to compare new energy vehicles with different types of products (high value consumables weight accounts for 20%, the weight of electronic products with high replacement speed and high technology content is 35%, and the weight of sales and retention of electric vehicles in the United States in previous years is 45%. Combined with the regional development of new energy vehicles in Yunnan Province, the p and q values are shown in table 1 below. P, Q is between 0.00 and 1.00. We set the initial value of innovation consumption coefficient p of Yunnan new energy vehicles to 0.0423, which increases accordingly. With the development of technology and progress, the growth rate slows into a flat period. The initial value of the imitation coefficient q is set to 0.615.

Table 1. Innovation coefficient (P) and imitation coefficient (Q) of new energy vehicles

Year	Coefficient of innovation（P）	Imitation coefficient（Q）
2021	0.076	0.774
2022	0.077	0.783
2023	0.085	0.792
2024	0.09	0.7995
2025	0.095	0.807
2026	0.958	0.8156
2027	0.1	0.822
2028	0.1005	0.8295
2029	0.101	0.837
2030	0.1015	0.8445
2031	0.102	0.8495
2032	0.1025	0.8545
2033	0.103	0.8595
2034	0.1034	0.8645
2035	0.1038	0.8695

4 prediction results of electric vehicle ownership

According to the development of Yunnan Province, the development environment of new energy vehicles in the future is divided into the following three scenarios, as shown in **Table 2**:

Table 2. Assumptions of different potential scenarios

Type	Assumed condition	New energy vehicles Maximum market potential
High potential scenario	Infrastructure construction has been accelerated and improved far beyond expectations. Technology breakthrough, cost performance greatly improved; oil prices are high; the government continues to subsidize and incentivize	Electric vehicles accounted for 90 per cent of new civilian vehicle additions that year

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Baseline potential scenario	Steady progress in infrastructure construction can achieve the planned goals; the technology has been steadily improved without breakthrough, and the cost performance has been steadily improved. Oil prices are at low to medium levels; subsidies and incentives are stable or decreasing	Electric vehicles accounted for 60 per cent of new civilian vehicle additions that year
Low potential scenario	Infrastructure development has failed to meet expectations; no substantial progress in electric vehicle technology and no improvement in cost performance; a prolonged downturn in oil prices; subsidies and incentives have been stable or reduced or even drastically reduced	Electric vehicles accounted for 30 per cent of all new civilian vehicles added that year

Then, the new energy vehicle ownership and vehicle ownership in Yunnan Province were substituted into the BASS model and solved for different scenarios respectively. The obtained results are shown in **Table 3**:

Table 3. BASS Model calculation results

Year	High potential scenario		Baseline potential scenario		Low potential scenario	
	f(t)	F(t)	f(t)	F(t)	f(t)	F(t)
2021	0.1337	0.1011	0.1381	0.1101	0.1404	0.1149
2022	0.1404	0.1085	0.1453	0.1181	0.1478	0.1229
2023	0.1524	0.1161	0.1575	0.1259	0.1599	0.1307
2024	0.1616	0.1234	0.1667	0.1332	0.1691	0.1379
2025	0.1706	0.1304	0.1755	0.1402	0.1779	0.1448
2026	0.1757	0.1368	0.1806	0.1464	0.1828	0.1508
2027	0.1834	0.1431	0.1881	0.1524	0.1902	0.1567
2028	0.1878	0.1488	0.1924	0.1580	0.1944	0.1620
2029	0.1920	0.1542	0.1964	0.1630	0.1983	0.1668
2030	0.1960	0.1592	0.2002	0.1678	0.2020	0.1714
2031	0.1995	0.1639	0.2034	0.1721	0.2051	0.1756
2032	0.2028	0.1683	0.2066	0.1762	0.2082	0.1795
2033	0.2060	0.1724	0.2096	0.1801	0.2111	0.1832
2034	0.2089	0.1764	0.2124	0.1837	0.2138	0.1867
2035	0.2118	-	0.2151	-	0.2164	-

The final NEV ownership calculated by the BASS model is shown in **Figure 1** below:

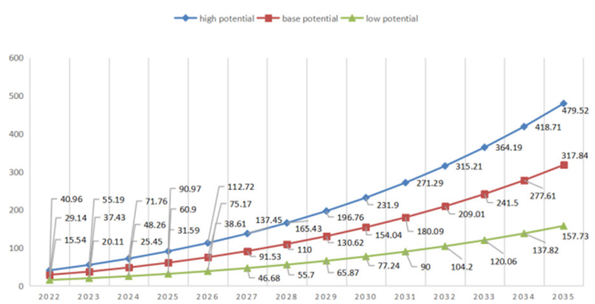

Figure 1. Forecast results of new energy vehicle ownership in Yunnan Province

5 Model Test

By comparing the actual number of new energies vehicles in the three years from 2018 to 2020 with the predicted number of new energy vehicles, the prediction effect of this model is tested. The following data are obtained through investigation and combined with the predicted data of 2018 to 2020, and the following **Table 4** is obtained:

Table 4. Comparison of 2018-2020 data

Year / (Ten thousand cars)	2018	2019	2020
Forecasting under high potential scenarios	3.63	9.85	18.6
Forecast under the baseline potential scenario	3.63	7.81	13.53
Forecast under low potential scenarios	3.63	5.67	8.41
Real data	4.3	5	5.5

6 Conclusion

The parameters of BASS model are estimated by using extensive analogy method. According to BASS model and the data of Yunnan Province's car ownership and new energy vehicle ownership in 2018, the development of Yunnan Province's new energy vehicle ownership is predicted and calculated in three different ways: high potential, benchmark potential and low potential. According to the prediction results of the model, in the case of high potential development, the number of new energy vehicles in Yunnan Province will reach 409600 in 2022; in the case of benchmark potential development, the number of new energy vehicles will reach 291400 in 2022; in the case of low potential development, the number of new energy vehicles in Yunnan Province will reach 155400 in 2022. The prediction results from 2018 to 2020 are consistent with those under the low potential scenario, and the average absolute error method is used to calculate the accuracy of 90.6%.

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