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Forecast of New Energy Logistics Vehicle Ownership in Beijing Under Double Carbon Target

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Abstract

In the international and domestic multiple pressure, double carbon background, in order to better implement the green concept, the logistics industry has been vigorously and actively promoted green transport, green distribution. Through the use of new energy logistics vehicles this green transport, to ensure the quality of the original logistics service at the same time, can achieve energy saving and emission reduction and save logistics transportation costs, to achieve the most efficient use of the environment and resources replacement effect. Based on the analysis of the basic status of new energy logistics vehicles in Beijing, this paper focuses on predicting the future ownership of new energy logistics vehicles in Beijing through bass prediction model and improvement, so as to provide reference for the green development of Beijing's urban distribution logistics transportation industry.

Keywords: new energy logistics vehicles, bass prediction model, double carbon

1. Introduction

In order to break the confinement of environmental pollution and energy shortage on the automobile industry, countries around the world have vigorously promoted new energy vehicles. Stimulated by a series of policies and regulations issued by the government, the development momentum of new energy vehicles in China is strong. Among them, the most effective is the subsidy policy. The government expects to the production and sales of new energy vehicles in 2025 at least 20% of the total production and sales of automobiles.

With the rapid development of new energy vehicle industry in recent ten years, the research on the promotion of new energy vehicles has attracted wide attention of scholars at home and abroad. At present, the research on the promotion of new energy vehicles at home and abroad is mainly divided into two categories. One is to collect the degree of attribute preference of customers for the price, technology and policy of new energy vehicles, which is generally considered to be related to the adoption decision through the actual questionnaire survey and use the statistical analysis method to obtain the factors affecting the promotion of new energy vehicles.

For example, Han Liu (2019) based on questionnaire survey data, through weight analysis, T-test, and structural equation methods, it is concluded that price is the primary concern when consumers purchase electric vehicles, followed by product performance, energy costs, infrastructure, government policies, etc. One is to predict the emission reduction effect of new energy vehicles through model analysis and comparison of various models. For example, Fan Shoubin et al. (2015) predicted the future vehicle emission situation in Beijing Sub-Center, which showed that eliminating high-emission vehicles can only achieve better emission reduction effect in the short term and promoting clean energy vehicles can achieve sustainable emission reduction effect. Fan Wubo et al (2021) analyzed the characteristics of motor vehicle emission and the effect of prevention and control of emission reduction in Chengdu and concluded that the promotion of clean energy vehicles will lead to the increase of VOCs emissions, and the emission reduction benefits of promoting clean energy vehicles need to be further demonstrated. Yang Wen et al. (2018) set up 13 policy assessment scenarios for motor vehicles in Beijing-Tianjin-Hebei region and found that eliminating high pollution emission standard motor vehicles could reduce CO and HC emissions by nearly 50% in Beijing-Tianjin-Hebei region.

Most of the above articles are the analysis of the factors affecting the promotion of new energy vehicles and the emission reduction effect of new energy vehicles, rarely involving how new energy logistics vehicles replace traditional logistics vehicles, and few scholars analyze the traditional logistics vehicles from the perspective of the government. The forecast analysis of the replacement of electric logistics vehicles. The cleaning of traditional logistics vehicles is in response to the green, environmentally friendly sustainable development strategy. This paper selects Beijing as the research area and predicts the future sales of logistics vehicles based on the bass model, in order to provide reference for the green development of logistics vehicles in 2030 carbon peak, 2060 carbon neutral and other regions.

2. Beijing New Energy Logistics Vehicle Market Overview

As the capital of China, Beijing in the promotion of new energy logistics vehicles is not as fast as the industry expected. Another relevant data also shows that at present, Beijing freight vehicle ownership of about 530,000, new energy ownership of about 22,000, accounting for only 4.17% (2015–2020 Beijing new energy logistics vehicle sales are shown in Figure 1). However, it is undeniable that among the main sources of PM2.5 in Beijing, the proportion of local mobile pollution sources is still as high as 45%. As an important means to control environmental pollution, it is inevitable to accelerate the electrification transformation of freight logistics vehicles with greater pollutant emissions.

Starting now, Beijing area more than 4.5 tons (including 4.5 tons below refrigerated trucks and special vehicles) diesel freight vehicles will no new quantity, can only be replaced in the stock figures, namely scrapped a new one. New purchases of pure electric trucks and hydrogen energy trucks are not restricted. With the implementation of Beijing motor vehicle and non-road mobile machinery emission pollution prevention and control regulations (1/5/2020), Beijing to further promote the elimination of high-emission old motor vehicles update program (2020–2021), 2020 to promote the implementation of vehicle diesel reduction development work program and 2020 Beijing new energy light truck operation incentive program and other related favorable policies, Beijing's new energy logistics vehicle market is further released.

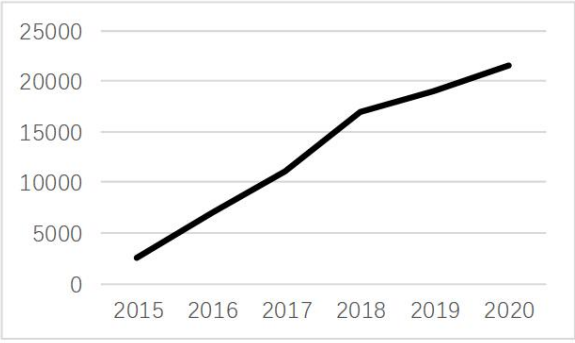

Figure 1. The number of new energy logistics vehicles in Beijing (Car number)

3. Method

3.1 Bass Model

The Bass model was first proposed by Frank Bass in the United States and was originally a model used to predict the sales of durable consumer goods. Since the application is very successful, it was gradually used in various fields, especially in high-tech fields, such as broadband. The parameters of the model include the number of users, penetration rate and model coefficients. Model coefficients P and Q represent external and internal effects, respectively. According to the Bass model hypothesis, when the network appears, the growth rate of network users is mainly affected by two factors: one is the external influence of publicity, promotion, mass media and so on; the second is oral communication, that is, the internal influence of those who have been online on those who have not been online. According to Bass, Internet users can be divided into two groups. One group is only influenced by mass media, and the other group is only influenced by oral communication. Bass calls the former as innovators and the latter as imitators. It is expressed by P and Q respectively. P is called innovation coefficient and Q is called imitation coefficient. The P value represents the speed of initial user development, and the specific value is between 0.00 and 1.00. The closer the value is to 1, the faster the innovator accepts the network. The Q value is a parameter that indicates the speed of product diffusion, that is, the degree of persistence of followers in using the network. Its specific value is also between 0.00 and 1.00. The closer the value is to 1, the faster the network spreads among potential user groups. P and Q can be obtained from the historical situation of the number of Internet users.

The core idea of the model is that the purchasing decision of the innovation group is independent of the other members of the social system, while the time of the imitation group purchasing new products is affected by the social system, and this effect increases with the increase of the number of purchasers, because the purchasing decision time of the imitation group is affected by the members of the social system. The basic form of the Bass model is as follows:

$$n(t) = p[m - N(t)] + q\frac{N(t)}{m}[m - N(t)] = \left[p + q\frac{N(t)}{m}\right][m - N(t)]$$

where n(t) is the number of adopters at time t; n(t) is the cumulative number of adopters at the beginning of 0-t, p is the external influence coefficient, q is the internal influence coefficient; m is the largest number of potential adopters in the market (i.e., market potential). p [m-N(t)] denotes the number of adopters who purchase new products because of external influences, called innovative adopters; q (N(t))/m [m-N(t)] denotes the number of adopters who are affected by the previous purchaser and are called imitative adopters.

Let $N(t) = y$, the differential equation is solved.

$$\frac{dy}{dt} = [m - y][p + q\frac{y}{m}]$$

$$\frac{dy}{dt} = -\frac{q}{m}(y - m)(y + \frac{pm}{q})$$

$$\frac{dy}{(y - m)(y + \frac{pm}{q})} = -\frac{q}{m}dt$$

$$\frac{[(y - \frac{pm}{q}) - (y - m)]dy}{(y - m)(y + \frac{pm}{q})} = -(p + q)dt$$

$$\frac{dy}{y - m} - \frac{dy}{y + \frac{pm}{q}} = -(p + q)dt$$

Integrating both sides separately yield:

$$\ln(y - m) - \ln(y + \frac{pm}{q}) = -(p + q)t$$

can be obtained $\frac{y - m}{y + \frac{pm}{q}} = Ce^{-(p+q)t}$

From the above bass model expression, when t=0, the $C = -\frac{q}{p}$ .So the analytical solution of the Bass model is

$$N(t) = m[\frac{1 - e^{-(p+q)t}}{1 + \frac{q}{p}e^{-(p+q)t}}] \qquad \text{Formula 2}$$

3.2 Parameter Estimation

This paper takes Beijing as an example.

Because China's new energy logistics vehicles have just begun to develop and lack historical data, it is impossible to directly obtain the parameter estimation value of the Bass diffusion model.

Therefore, we use the analogy method to estimate the parameters, that is, select the historical data of traditional automobiles with similar diffusion paths to new energy logistics vehicles, obtain their p and q values according to the relevant information of traditional automobiles, and then substitute the parameters into the new product diffusion model to obtain the Bass model parameters p and q of new energy vehicles. The m value in the model needs to be estimated separately.

Diffusion model is mainly used to predict, using Bass model can predict the diffusion behavior of new energy logistics vehicles in Beijing. The Bass model assumes that consumers only buy a product once, that is, there is no repeat purchase. In this way, the number of buyers can be defined as the product sales. In fact, because the traditional car is a durable consumer goods, its life is very long, so this assumption is more consistent with the new energy logistics vehicle diffusion process. There are three parameters required by the Bass model, namely p, q, m, where p, q and m are key parameters.

In this paper, the traditional annual car ownership data from 2005 to 2012 are selected, and the estimation of p and q is obtained by nonlinear least squares estimation. The initial year of the development of traditional automobiles in China is 2005, when t = 1.

Table 1. Traditional car ownership in China (million)

year	2005	2006	2007	2008	2009
private car	1848	2333	2876	3501	4574
year	2010	2011	2012	2013	2014
private car	5939	7327	8839	10502	12339

The following table is estimated by SPSS curve, and the coefficient $R^2 = 0.999$, which is greater than 0.9, and is greater than other models, indicating that the fitting degree of the quadratic model is more significant than other models. Maximum market potential m = 1257477, p = 0.0204, q = 0.5173, the results of p and q are less than 1, the imitation coefficient q is greater than the innovation coefficient p, which conforms to the general law of diffusion of innovative products. It shows that the diffusion of private cars is slow due to the small number of innovative adopters in the early stage of development. When the number of innovative adopters reaches a certain amount, the diffusion speed is affected by the imitators in the social system, resulting in the rapid diffusion of their sales among potential consumers

4. Example Analysis

4.1 Estimation of Market Maximum Potential M

By the end of 2018, Beijing had 5830 new energy logistics vehicles, an increase of 27.96% over 2017. In 2018, the total number of permanent residents in Beijing was 21.536 million, that is, an average of 3694 people purchased a new energy logistics vehicle. In 2018, the number of commercial vehicles was 95.6 million. According to relevant data, China's new energy logistics vehicle market was in the early stage of development. The average number of new energy logistics vehicles per thousand people is about 3. Then, within the affordability of urban roads, the maximum market potential of new energy logistics vehicles in Beijing is 300,000 units.

Table 2. Sales of new energy logistics vehicles in Beijing over the years (vehicles)

Year	Annual sales	Cumulative holdings
2015	2493	2493
2016	4489	6982
2017	4200	11182
2018	5830	17012
2019	2051	19063
2020	2550	21613

According to the China Statistical Yearbook and related literature we get Beijing new energy logistics vehicle sales over the years.

4.2 Estimation of External Influence Coefficient P and Internal Influence Coefficient q

The model used in this paper is the original Bass model. The parameter estimation method selects the nonlinear least square method and the least square method to estimate the parameters. Here, the nonlinear regression parameter estimation with better results is taken (for the two parameters p and q, according to the relevant information of the traditional automobile, the p and q of the traditional automobile diffusion are calculated), that is, p = 0.0204, q = 0.5173. The nonlinear least square method is used to estimate the initial value, and the specific calculation is carried out by the statistical software SPSS.

The optimal solution is obtained by nonlinear least squares iteration with SPSS software. In general, the q value is greater than p, that is, p = 0.012, q = 0.022.

4.3 Fit Analysis

It can be seen from the figure that when the estimated values of p and q are 0.011 and 0.063 respectively, the iteration reaches the optimal solution, and R^2 = 0.976. It can be seen that the fitting degree of the results is significant at the 95% significance level.

Assume that the initial year of Beijing new energy logistics vehicles is 2015, in 2014 when t = 0, that is, 2015 when t=1. Substituting the results of parameter estimation into the model, the number of new energy logistics vehicles N(t) in t years can be obtained. Therefore, the estimated number of new energy logistics vehicles for 2015–2020 can be obtained. The results are shown in Table 3.

Table 3. Fit analysis results

Year	New Energy Logistics Vehicle Ownership	predicted value	Percentage error
2015	2493	3237	29.84%
2016	6982	7222	3.98%
2017	11182	10112	9.57%
2018	17012	15000	11.83%
2019	19063	18898	0.87%
2020	21613	22530	4.24%

According to the above table, the average error of the model for the annual sales of new energy logistics vehicles in Beijing from 2015 to 2020 is 10.06%, and the prediction accuracy is 89.94%, which is more accurate.

5. Sales Forecast Based on Impact Factors

In the process of popularization and application of new energy logistics vehicles, the opening of road rights is also a positive supporting policy. The open right of way aims to accelerate the process of market acceptance of new energy logistics vehicles by giving new energy logistics vehicles a convenient advantage over traditional logistics vehicles. With the gradual withdrawal of national financial subsidies, in the current new energy logistics vehicle operating economy is not as good as the traditional logistics vehicle, the right of way advantage will become the current logistics enterprises and end users to choose new energy logistics vehicle key factors. Therefore, the implementation and improvement of the right of way policy will become an important factor affecting the new energy logistics vehicle market sales.

The above improved Bass model takes into account the influencing factors such as time and policy. Under the background of mandatory replacement by the government, we assume that the right of way of new energy logistics vehicles is completely open, and it is expected that enterprises will replace traditional logistics vehicles on a large scale. Some policies promulgated at this stage, such as the Beijing New Energy Logistics Distribution Vehicle Priority Policy Promotion and Implementation Meeting held in Beijing in August 2019, proposed that Beijing will increase the proportion of pure electric truck licenses and implement differentiated traffic measures by quarter. But the current pass mode is more carried out in the stock market, so the policy of the new energy logistics vehicle sales is not obvious. Secondly, at present, Beijing is not like Shenzhen, Chengdu and other regions to completely liberalize the right of way, but to guide logistics enterprises to gradually increase the proportion of new energy logistics vehicles under the premise of ensuring the total amount of logistics vehicles. This gradual approach cannot quickly stimulate the demand for new energy logistics vehicles in the market. So, we assume an

ideal state—Beijing right of way completely open, re-scoring it, get a new parameter estimate, and then compare it with the previous improved model prediction.

Referring to Yang Xiaoting's (2015) research on the promotion policy of new energy vehicles, the influencing factors of this paper mainly focus on the internal purchase factors of the vehicle itself and the external crowd purchase factors. The internal purchase factors mainly include the mileage, after-sales service level, safety, sales price and use cost; external purchase factors include government subsidies, charging pile convenience, road rights, and replacement policies.

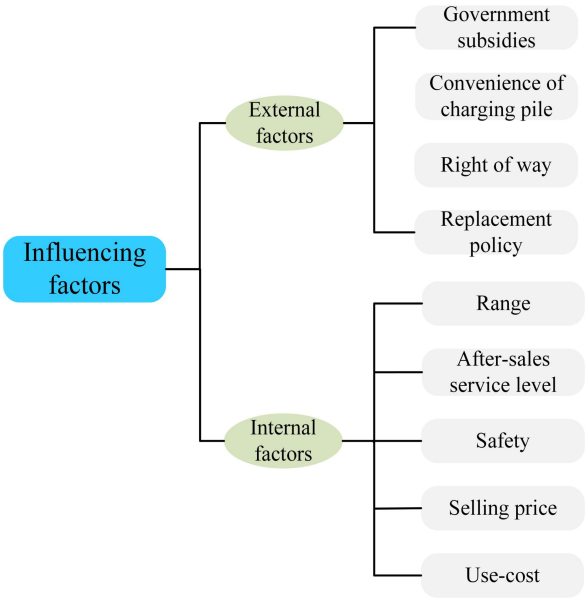

Figure 2. Influencing factors of sales volume

Based on the above analysis, the Delphi method can be used to score the key parameter indicators of each target market. The rating results are shown in the following figure:

Table 4. Expert rating results

	Traditional logistics vehicle	New energy logistics vehicle
Government subsidies	50	90
Convenience of charging pile	100	30
Right of way	0	100
Replacement policy	0	60
External factors	150	320
Range	90	80
After-sales service level	30	80
Safety	60	70
Selling price	20	80
Use-cost	20	100
Internal factors	220	410

The Adjustment Coefficient of Internal and External Factors Based on the Difference of Internal and External Factors of Two Automobiles α_2, α_1

Quorum $\alpha = \frac{New\ Energy\ Logistics\ Vehicle\ Score}{Traditional\ logistics\ vehicle\ score}$

Then the pi and qi values of new energy logistics vehicles are obtained. The specific parameters are expressed as;

$$p_i = p\alpha_1 \qquad \text{Formula 3}$$

$$q_i = q\alpha_2 \qquad \text{Formula 4}$$

This improves the values of the parameters p and q in the bass model. Calculate the values of p and q, respectively, as follows:

$$p_i = p\alpha_1 = 0.011 * \frac{320}{150} = 0.023$$

$$q_i = q\alpha_2 = 0.063 * \frac{410}{220} = 0.117$$

Bring the improved p_i、q_i values into Formula 2 $N(t) = m[\frac{1 - e^{-(p+q)t}}{1 + \frac{q}{p} e^{-(p+q)t}}]$. The forecast of Beijing's new energy logistics vehicle ownership in the next ten years from 2021 to 2030 is as follows:

Table 5. New energy logistics vehicles in the future

Year	2021	2022	2023	2024	2025
Predicted value of new energy logistics vehicles	64394	69448	73842	77662	80982
Year	2026	2027	2028	2029	2030
Predicted value of new energy logistics vehicles	83869	86379	88561	90458	92107

In conjunction with the notice of the Beijing Municipal Commission of Transport on the implementation of the Beijing New Industries Prohibition and Restriction Catalogue (2022 Edition) by the road freight industry, it is clear that diesel freight vehicles of 4.5 tons or more (including refrigerated vehicles and special vehicles of 4.5 tons or less) in the Beijing area will have no new quantity and can only be replaced in the stock figure, that is, one new vehicle will be scrapped. New purchases of pure electric trucks and hydrogen energy trucks are not restricted. And the above prediction is under the ideal condition of completely opening the right of way on the road of new energy logistics vehicles. According to the current policy issued by the Beijing municipal government, this ideal state is entirely possible to be realized.

6. Discussion

In this paper, the improved bass model is used to predict the ownership of new energy logistics vehicles in Beijing at the time of carbon peak. The number of new energy logistics vehicles will be affected by policies, purchasing power, road rights and other factors, so we must consider the impact of a series of impact factors on the results. This paper mainly uses road rights and other factors as the main impact factors to improve the parameters in the bass model. It can be seen that when the road rights are fully opened, the sales of new energy logistics vehicles will get an explosive growth, which is in line with the Beijing municipal government's goal of taking the lead in achieving double carbon. It can also provide data support for policy issues such as road right obstruction in the development of new energy logistics vehicles in Beijing. At the same time, it can also provide reference for the forecast of new energy logistics vehicle ownership in other cities.

The model used in this study is based on the bass model, and the single bass model can only be used to calculate a single purchase, so the study does not consider repeated purchases. In fact, new energy logistics vehicles are repeated purchases. Future research could include repeat purchases in the bass model to make predictions more accurate.

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