A Study on Influencing Factors of Chinese Special Vehicle Usage Scenario Sales Based on Big Data

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Abstract. China's special vehicle market is rising day by day, and its sales are closely related to the domestic economic development. However, there are various use scenarios of special vehicles, including municipal vehicles, engineering vehicles, transport vehicles and coaching vehicles, etc., so the changes of sales volume under different use scenarios are also complex and diverse. It is necessary to define the usage scenario classification of special vehicles, construct the set of influencing factors on the sales volume of special vehicles based on the big data of the special vehicle industry. Conducting nonlinear regression analysis on the sales volume, and constructing the sales function under different usage scenarios, so as to provide reference for the manufacturers of special vehicles.

Keywords: Automobile industry data · Sales volume of special vehicles · Nonlinear regression · Special vehicle usage scenario

1 Introduction

Special vehicle is the general name of a class of vehicles that use automobile chassis and carry out appropriate transformation to cope with various operating scenarios. It belongs to a kind of commercial vehicle, which can be divided into cleaning class, refrigerated truck, highway construction maintenance and so on according to market segments. All kinds of chassis match the operation equipment of special vehicle production companies, so the production of special vehicles is oriented to the actual needs of the use scene, and it is relatively easy to break through the barriers of chassis brand.

As the sales of special vehicles are oriented by actual demand, both enterprises and individuals will give full consideration to the future work prospects, current use and transportation cost when purchasing special vehicles [1], so there are many factors influencing the actual sales of special vehicles in various market segments [2]. The expansion of infrastructure investment will boost the demand for special engineering vehicles. For example, the sales of concrete pump trucks will increase significantly. The development of food cold chain and the increase of residents' demand for meat food have promoted the increase of sales of refrigerated trucks. Increased emphasis on

terminal transportation and increased investment by logistics companies in "last-mile transportation" have boosted sales of light minitrucks, such as express delivery vehicles.

As early as December 2021, Foton publicly stated that it would establish a presence in China's new-energy refrigerated truck market. This move of Foton is in line with the market background of the transformation of livestock and poultry products into the cold chain transportation, as well as many policies on COVID-19 prevention and control, energy conservation and emission reduction. Foton Company's big data analysis of cold chain car contributed to this correct decision. In the end, Foton Automobile's new energy cold chain car market share from almost zero, increased to more than 13%.

In the field of commercial vehicles, some scholars have analyzed and studied the influencing factors of the market. They analyzed the development trend of new energy commercial vehicles by combining the development prospect of new energy [3] and the policy promotion of energy conservation and emission reduction in various countries [4]. Through the analysis of historical sales volume, some scholars further realized the forecast of sales volume [5], and combined different use scenarios of new energy commercial vehicles and various influencing factors of sales volume for regression and prediction. When predicting the market performance of vehicles, some scholars give full consideration to the effect of infrastructure and cost reduction [6], and take the future infrastructure and cost changes into account, so as to make the market prediction more accurate. Some scholars expand from the market and make predictions based on technological prediction and social change brought by market changes [7].

Different from other scholars' existing studies, this paper focuses on the factors affecting the performance of special vehicles in the market. Compared with ordinary commercial vehicles, the sales volume of special vehicles is more closely related to market demand and policy orientation. This paper establishes the unique classification dimension of special vehicles, and concludes the correlation equation between the sales volume of special vehicles and economic factors based on the analysis of the big data of the use scenarios of special vehicles, which provides certain reference for the production strategy and product planning of automobile enterprises.

2   Big Data of Special Vehicle Market

The market big data of special vehicles includes the big data of sales by region, market segment, body parameters and other dimensions, as well as economic indicators such as steel prices, oil prices and infrastructure investment across the country.

2.1   Categories of Market Big Data

The big data of special vehicle market firstly includes the data generated in the production and sales process of the automobile industry. It usually contains the market share of the special vehicle, the model of the special vehicle, the sales of the special vehicle, the spare parts of the special vehicle and other related contents. It includes a wide range and more content, and its accuracy directly affects the analysis results and quality of sales influencing factors in each market segment of special vehicles.
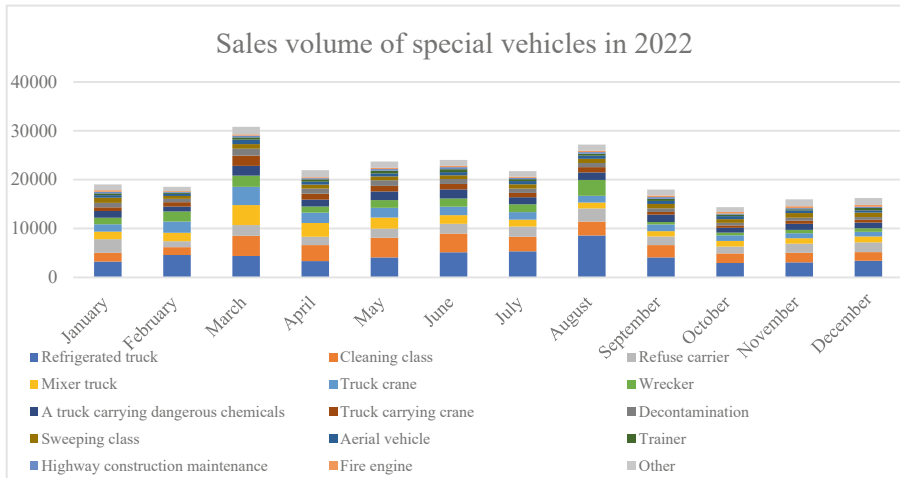
Fig. 1. Sales changes of special vehicles in 2022

The sales data of special vehicle market used in this paper are taken from terminal sales in the market monitoring platform of China Auto Information Technology (Tianjin) Co., Ltd.. We select the sales data of special vehicle in 2022 and show it by month and market segment as Fig. 1:

There are many factors affecting the consumption of special vehicles. In this paper, GDP growth rate, CPI growth rate, PPI growth rate, PMI index, China's highway logistics freight index, urban fixed asset investment and oil price are selected as the factors affecting the sales of special vehicles.

GDP growth rate: GDP growth and decline can directly affect the national industrial, municipal and real estate construction, thus affecting the market sales of Chinese special purpose vehicles.

CPI growth rate: reflects the price fluctuation of the society. The lower the price, the more frequent the consumption, the sales volume of express vehicles and so on May increase [8].

PPI growth rate: reflects the price fluctuation of the means of production purchased by the producers. Generally speaking, the lower the price of raw materials, the more vigorous the production, and the sales of special vehicles used in production, such as engineering vehicles, may increase [9].

PMI index: reflects the development situation of the national manufacturing industry. The higher the PMI index is, the expansion of the manufacturing industry is obvious; otherwise, the manufacturing industry is strictly contracted [10].

China Road logistics freight rate index: a barometer of China's logistics popularity. A rise in freight rate index generally means busy logistics, and the sales of special vehicles for freight transportation in the market may increase.

Urban fixed asset investment: represents the amount of investment in urbanization construction. Generally speaking, the more investment, the more special vehicles used in construction [11].

Oil price: The higher the oil price, the higher the cost of transportation of special fuel vehicles, sales are blocked. Accordingly, sales of new energy vehicles are likely to rise. There are slight differences between different regions. This paper selects monthly average gasoline 92's prices in Beijing.

2.2   Categories of Special Vehicle

Special vehicle products are more segmented, there are 19 segments of refrigerated truck, bulk tank truck, hazardous chemicals, concrete pump truck, mixing truck, truck crane, all ground crane. Excluding special models such as coach cars, this paper divides them into three scenarios: transportation operation, engineering operation and urban operation. As shown in Table 1:

Table 1. Usage scenario of special vehicles in 2022

Use Scenario	2022 Total sales	Product segmentation
Transportation operation	71072	Refrigerated truck
		Bulk tanker
		A truck carrying dangerous chemicals
Engineering operation	59751	Concrete pump truck
		Mixer truck
		Truck crane
		All-surface crane
		Truck carrying crane
		Special operation
Urban operation	108593	Aerial vehicle
		Highway construction maintenance
		Refuse carrier
		Sweeping class
		Decontamination
		Cleaning class
		Wrecker
		Fire engine
Other	12129	Trainer
		Other

3   Regression Analysis of Economic Influencing Factors

The influence factors and the weight of their influence in different scenarios of special economic vehicles are inconsistent. As can be seen from the market trend chart (Fig. 2), the peak sales of vehicles in the three scenarios are slightly different, and only the vehicles in urban operation have two peak sales.

Transportation sales peak in August, engineering sales peak in March. Therefore, this paper studies the sales volume of the three scenarios respectively.

3.1   Regression Analysis of Sales Volume of Special Vehicles for Transport Operation

The monthly sales volume of special vehicles for transport operations was taken as the dependent variable, and the monthly GDP growth rate, CPI growth rate, PPI growth rate, PMI index, China road logistics freight rate index, urban fixed asset investment and oil price data in 2022 were taken as the independent variables to conduct regression analysis.

Use argument x_1, x_2, x_3, x_4, x_5, x_6, x_7, to respectively represent urban fixed asset investment, China highway logistics freight index, oil price, GDP growth rate, CPI growth rate, PPI growth rate and PMI index data. Suppose that the sales volume changes caused by the fluctuations of various influencing factors are multiplicable [12], that is, the sales volume equation is non-linear, then:

$$y_1 = \lambda x_1^{b_2} x_2^{b_3} x_3^{b_4} e^{(b_5 x_4 + b_6 x_5 + b_7 x_6 + b_8 x_7)} \tag{1}$$

λ, $b_1 \sim b_8$ and other constants in the formula are independent of each other. Where, dependent variable y_1 represents sales of special vehicles for transport operations. The
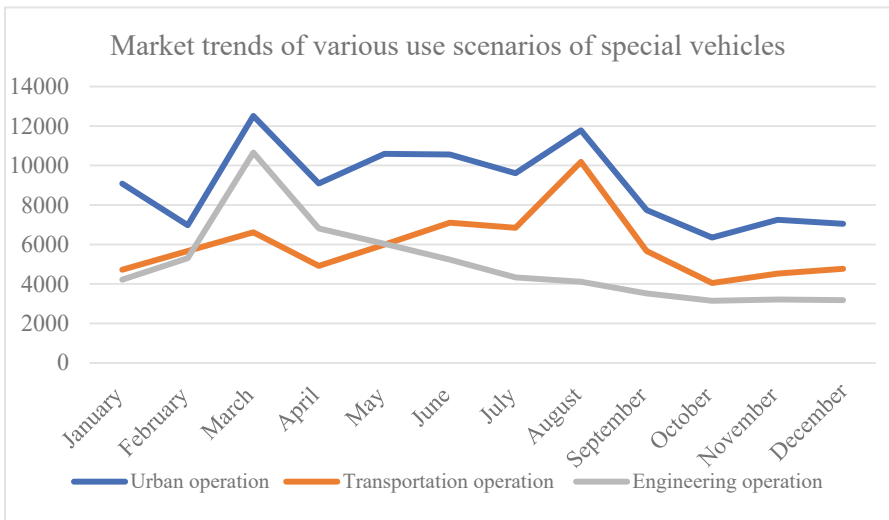

Fig. 2. Market trends of various use scenarios of special vehicles

Table 2. Variable regression results of sales volume of special vehicles for transport operations

Parameter	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8
Value	155.561	0.835	-34.998	3.451	0.016	-0.474	-0.493	-0.029

Table 3. Analysis of variance of regression function of special vehicles for transport operations

Source	Sum of squares	Degree of freedom	Mean square
Regression	449473817.4	8	56184227
Residual error	1750348.603	4	437587.15
Total before correction	451224166	12	
Corrected total	30288400.67	11	

Dependent variable: transportation operations
a. $R^2 = 1$-(sum of residual squares) /(modified sum of squares) $= .942$.

above formula can change the structure into:

$$\ln y_1 = b_1 + b_2 \ln x_1 + b_3 \ln x_2 + b_4 \ln x_3 + b_5 x_4 + b_6 x_5 + b_7 x_6 + b_8 x_7 \quad (2)$$

The values of dependent and independent variables in 2022 are calculated by regression, and the final result is in Table 2:

The R^2 of regression calculation reaches 0.942, which is close to 100%. Table 3 shows that the model can explain the change of transportation sales volume to a large extent.

By substituting the results in Table 2 into the formula, the sales function of special vehicles for transport operations is:

$$y_1 = e^{155.561} + x_1^{0.835} x_2^{-34.998} x_3^{3.451} e^{(0.016x_4 - 0.474x_5 - 0.493x_6 - 0.029x_7)} \quad (3)$$

3.2   Regression Analysis of Sales Volume of Special Vehicles for Urban Operation

With the processing of special vehicles for transport operations, the regression calculation results of special vehicles for urban operations are described in the following Table 4:

The R^2 of regression calculation reaches 0.771, as shown in Table 5, indicating that the model can explain the change of urban operation sales volume to a large extent.

Table 4. Variable regression results of sales volume of special vehicles for urban operation

Parameter	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8
Value	140.398	0.801	-31.26	3.155	0.016	-0.539	-0.317	-0.043

Table 5. Analysis of variance of regression function of urban operation special vehicle

Source	Sum of squares	Degree of freedom	Mean square
Regression	1017392276	8	127174034.5
Residual error	10301443.08	4	2575360.769
Total before correction	1027693719	12	
Corrected total	44990414.92	11	

Dependent variable: transportation operations
a. R^2 = 1-(sum of residual squares) /(modified sum of squares) = .771.

Table 6. Variable regression results of sales volume of special vehicles for engineering operations

Parameter	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8
Value	186.97	1.319	-42.181	2.607	0.028	-0.433	-0.142	-0.065

The results in Table 4 were substituted into the formula, and y_2 was used to represent the dependent variable -- sales volume of urban special vehicles for operation, and the sales function of urban special vehicles for operation was obtained as:

$$y_2 = e^{140.398} + x_1^{0.801} x_2^{-31.26} x_3^{3.155} e^{(0.016x_4 - 0.539x_5 - 0.317x_6 - 0.043x_7)} \tag{4}$$

3.3 Regression Analysis of Sales Volume of Special Vehicles for Engineering Operation

The regression calculation results of special vehicles for engineering operations are described in Table 6:

The R^2 of regression calculation reached 0.893, close to 100%, as shown in Table 7, indicating that the model could explain the change of engineering operation sales volume to a large extent.

The results in Table 6 were substituted into the formula, and y_3 was used to represent the dependent variable -- sales volume of special vehicles for engineering operations. The sales function of special vehicles for engineering operations was obtained as follows:

$$y_3 = e^{186.97} + x_1^{1.319} x_2^{-42.181} x_3^{2.607} e^{(0.028x_4 - 0.433x_5 - 0.142x_6 - 0.065x_7)} \tag{5}$$

4   Comparative Analysis of Influencing Factors Weight

The regression formulas of special vehicle sales in the three scenarios have something in common: the sales volume of the three scenarios is positively correlated with urban fixed asset investment, oil price and GDP growth, while negatively correlated with China's road logistics freight index, CPI growth rate, PPI growth rate and PMI index.

Table 7. Analysis table of variance of regression function of special vehicle for engineering operation

Source	Sum of squares	Degree of freedom	Mean square
Regression	342601152.2	8	42825144.03
Residual error	5380908.763	4	1345227.191
Total before correction	347982061.0	12	
Corrected total	50466894.25	11	

Dependent variable: transportation operations

a.R^2 = 1-(sum of residual squares) /(modified sum of squares) = .893.

Among the various influencing factors of special vehicles for transport operations, the absolute value of the weight of oil price and PPI growth is higher than that of other usage scenarios. Different from other scenarios, although the rise in oil prices increases the cost of vehicles to a certain extent, part of the oil tanker and chemical tanker in the transport vehicles are used to transport crude oil or refined products, and the rise in oil prices will drive the sales of these vehicles. The higher the PPI growth rate, the higher the price of the means of production purchased by the producers. Then the increased economic pressure on the production side, which will reduce the demand for freight transport, and the demand for special vehicles for transport operations will drop immediately.

The negative impact of CPI growth on urban special use vehicles is significantly higher than that on other use scenarios, because the economic pressure of consumers will increase as prices rise, and shopping and even travel will decrease. The demand for living environment has been reduced, and the sales of municipal vehicles such as water sprinkling and sanitation have decreased significantly. The negative impact of urban special vehicles on China's highway logistics freight index is obviously weaker than other scenarios, and these vehicles are generally not used for highway logistics transport.

The positive impact of construction vehicles on urban fixed asset investment and GDP growth is higher than that of the other two usage scenarios. The rise of these two indicators represents the increase of real estate construction and infrastructure projects, and the sales of engineering operations increase significantly. The negative impact of engineering vehicles on China's highway logistics freight index and PMI index is higher than the other two scenarios, because the highway transportation cost of engineering vehicles has always been very high, and the increase of freight will increase the cost of engineering vehicles. At the same time, the rise of PMI index will drive the capital flow to commercial consumption, reduce the social funds for construction, reduce the amount of projects, and also drive the negative growth of the vehicle for engineering operations.

5   Conclusion

Based on industry big data, this paper conducts regression analysis on the sales volume of special vehicles in different usage scenarios, and finally obtains the regression function of sales volume under the three usage scenarios as shown in Table 8:

Table 8. Regression functions for each usage scenario

Usage scenario	Function
Transport operation	$y_1 = e^{155.561} + x_1^{0.835} x_2^{-34.998} x_3^{3.451} e^{(0.016x_4 - 0.474x_5 - 0.493x_6 - 0.029x_7)}$
Urban operation	$y_2 = e^{140.398} + x_1^{0.801} x_2^{-31.26} x_3^{3.155} e^{(0.016x_4 - 0.539x_5 - 0.317x_6 - 0.043x_7)}$
Engineering operation	$y_3 = e^{186.97} + x_1^{1.319} x_2^{-42.181} x_3^{2.607} e^{(0.028x_4 - 0.433x_5 - 0.142x_6 - 0.065x_7)}$

In the table above, $x_1, x_2, x_3, x_4, x_5, x_6, x_7$ respectively represent urban fixed asset investment, China road logistics freight index, oil price, GDP growth rate, CPI growth rate, PPI growth rate and PMI index data.

When the sales volume regression function is obtained, several rules of reference for special vehicle production enterprises are summarized:

1. The production of special vehicles for transport operations should be carried out in the period when the PPI index is relatively low. At this time, the production work on the supply side is more active and the demand for road transport is large. Residents' consumption and other factors have little impact on the expansion of demand for such special vehicles.
2. The production of special vehicles for urban operations should be carried out in the period when the social CPI index is relatively low. At this time, the residents' demand for materials and living standards will rise, and the demand for municipal vehicles will increase.
3. In the production of special vehicles for engineering operations, full consideration should be given to local housing construction and infrastructure construction. Therefore, when GDP growth is fast and social capital is pouring into industrial construction, the demand for engineering operations vehicles will rise.

There are still many shortcomings in this paper: the selection of dependent variables is narrow, and the lack of extensive research and evidence on the economic factors affecting the special vehicle. In the future, more full consideration will be given to economic and non-economic factors affecting the sales of special vehicles.

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