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Prediction of Automobile Sales in Tibet based on Grey Prediction Model

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Abstract

Nowadays, with the continuous development of the external industrial market environment of China's automobile industry and the continuous improvement of residents' quality of life and consumption level, automobile sales are also changing. Taking Tibet Autonomous Region as an example, this study establishes GM (1,1) prediction model to predict automobile sales in Tibet, so as to provide reference for the good and sustainable development of automobile consumption market and relevant decisions in Tibet.

Keywords

Tibet; Car Sales; GM (1,1) Model; Trend Predictioneless.

1. Introduction

Grey GM (1,1) model is often used to predict large random data. Due to the factors of car purchase policy, car enterprise discount, oil price, economic level and whether the road traffic flow is crowded, the data has great randomness and is very in line with the characteristics of grey model. Therefore, grey GM (1,1) prediction model is adopted in this study. Based on the grey system theory of Chinese scholar Professor Deng Julong, the grey prediction model uses the original data to form the original sequence x (0) and generates the sequence x (1) through the accumulation generation method, so as to weaken the randomness of the original data and make it show more obvious characteristic laws. Generate the transformed sequence and establish a differential equation model, namely GM model. GM model has the characteristics of less data and high prediction accuracy. GM (1,1) model represents a first-order, one variable differential equation model.

2. Methodology

2.1 Eliminate the Seasonal Index of Car Sales

Establish a broken line chart of the automobile sales data from 2016 to 2021 to facilitate the observation of the change trend, as shown in Figure 1.

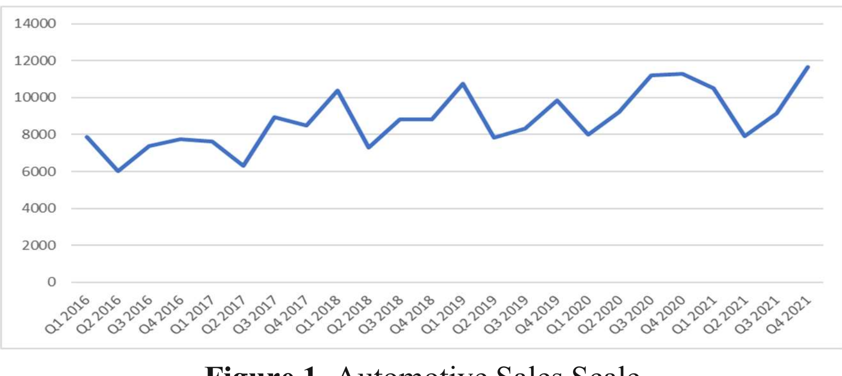

Figure 1. Automotive Sales Scale

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From Figure 1, it can be seen that the car sales are obviously seasonal, but the data of the first and second quarters of 2020 are obviously abnormal due to the impact of 2019 novel coronavirus. Therefore, the average values of the first quarter of 2019 and 2021 and the second quarter of 2019 and 2021 are taken as the car sales in the first quarter and the second quarter of 2020.

First, remove the seasonal factors and choose the seasonal index method. Find the seasonal index. The seasonal indexes of Q1-Q4 are: 1.13, 0.83, 0.98 and 1.06, and eliminate the seasonal factors of the data, as shown in Table 1.

Table 1. Auto Sales Scale Eliminating Seasonal Index

	Car sales	Four-quarter moving average	Centralized moving average	Seasonal index of each year	Car sales to eliminate seasonal effects
Q1 2016	7858				6957.862475
Q2 2016	6021				7258.534891
Q3 2016	7379	7251.75	7223.875	1.021473932	7492.979801
Q4 2016	7749	7196	7230	1.071784232	7333.349007
Q1 2017	7635	7264	7459.5	1.023527046	6760.407228
Q2 2017	6293	7655	7748.5	0.812157192	7586.440802
Q3 2017	8943	7842	8187.625	1.092258133	9081.138143
Q4 2017	8497	8533.25	8657.625	0.98144699	8041.226805
Q1 2018	10400	8782	8767.75	1.186165208	9208.675202
Q2 2018	7288	8753.5	8794.625	0.828687977	8785.949557
Q3 2018	8829	8835.75	8883	0.993920973	8965.377241
Q4 2018	8826	8930.25	8999.875	0.980680287	8352.579473
Q1 2019	10778	9069.5	9007.625	1.196541819	9543.375128
Q2 2019	7845	8945.75	9071.875	0.864760592	9457.433353
Q3 2019	8334	9198	9180.5	0.907793693	8462.731218
Q4 2019	9835	9163	9166.1875	1.072965178	9307.457411
Q1 2020	10638	9169.375	9220.0625	1.153788274	9419.412193
Q2 2020	7870.5	9270.75	9454	0.83250476	9488.174532
Q3 2020	8739.5	9637.25	9619.75	0.908495543	8874.494778
Q4 2020	11301	9602.25	9605.4375	1.176521111	10694.82219
Q1 2021	10498	9608.625	9659.3125	1.086826832	9295.449257
Q2 2021	7896	9710	9755.125	0.809420689	9518.915711
Q3 2021	9145	9800.25			9286.258338
Q4 2021	11662				11036.4584

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2.2 The Grey Prediction GM (1,1) Model is Established

Use the Grey Prediction GM (1,1) model to test the level ratio of the data. Select the data of eight quarters in recent two years to form the original sequence. Establish the original sequence of automobile sales:

x(0)=(x(0)(1), x(0)(2), x(0)(3), x(0)(4), x(0)(5), x(0)(6), x(0)(7), x(0)(8))=(9307.909, 9593.993, 11150.109,10996.899, 9227.144, 9499.376, 9119.669, 11400.936) (1)

Calculation of order ratio λ(k).

$$\lambda(k)=x=\frac{x^{(0)}(k-1)}{x^{(0)}(k)}\ (k=2, 3, 4, 5, 6, 7, 8) \quad (2)$$

λ=(λ(2), λ(3), λ(4), λ(5), λ(6), λ(7), λ(8))=(0.97, 0.86, 1.01, 1.19, 0.97, 1.04, 0.80) (3)

All λ is within the allowable coverage θ=($e^{-\frac{2}{n+1}}$,$e^{\frac{2}{n+1}}$)=[0.80,1.25], x(0) can be used as a satisfactory GM (1,1) model.

Accumulate the original data x(0),i.e.

x(1) =(9307.90, 18901.90, 30052.01, 41048.91, 50276.05, 59775.43, 68895.10, 80296.04) (4)

Construct data matrix B and data vector Y.

$$B=\begin{bmatrix} -\frac{1}{2}\left(x^{(1)}(1)+x^{(1)}(2)\right) & 1 \\ -\frac{1}{2}\left(x^{(1)}(2)+x^{(1)}(3)\right) & 1 \\ -\frac{1}{2}\left(x^{(1)}(3)+x^{(1)}(4)\right) & 1 \\ \vdots & \\ -\frac{1}{2}\left(x^{(1)}(7)+x^{(1)}(8)\right) & 1 \end{bmatrix}, Y=\begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ x^{(0)}(4) \\ \vdots \\ x^{(0)}(7) \end{bmatrix} \quad (5)$$

Calculate a and b and model them:

$$U=(\hat{a},\hat{b})T=(BT\cdot B)\text{-}1BTY=\begin{pmatrix} 0.000496 \\ 10163.371199 \end{pmatrix} \quad (6)$$

Get a = 0.000496, b = 10163.371199.

The established model is :

$$\frac{dx^{(1)}}{dt}+0.000496x(1)= 10163.371199 \quad (7)$$

Bring in formula:

X(1)(k+1)=(x(0)(1) - $\frac{b}{a}$)e^{-ak} + $\frac{b}{a}$ = -20500907.575635*e^(-0.000496*k)+ 20510215.484706 (8)

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From:

$$x^{\wedge(1)}(1)= x^{\wedge(0)}(1)= x^{(0)}(1)= 9307.909071$$

$$x^{\wedge(0)}(k)= x^{\wedge(1)}(k) - x^{\wedge(1)}(k-1) \quad k=2, 3\ldots8$$

$$x^{\wedge(0)}=(x^{\wedge(0)}(1), x^{\wedge(0)}(2), x^{\wedge(0)}(3), x^{\wedge(0)}(4), x^{\wedge(0)}(5), x^{\wedge(0)}(6), x^{\wedge(0)}(7), x^{\wedge(0)}(8))=(9307.91, 10156.24, 10151.21, 10146.18, 10141.16, 10136.13, 10131.11, 10126.09) \tag{9}$$

Model and analyze the original data, as shown in Table 2.

Table 2. Raw Data Modeling Analysis Table

actual value	Fit Value	residual	%
9593.9930	10156.2423	-562.2493	-5.8604
11150.1089	10151.2109	998.8981	8.9586
10996.8986	10146.1819	850.7166	7.7360
9227.1444	10141.1555	-914.0110	-9.9057
9499.3756	10136.1315	-636.7558	-6.7031
9119.6694	10131.1100	-1011.4406	-11.0908
11400.9361	10126.0910	1274.8451	11.1819

Residual sequence is:

$$Z(0)=(Z^{\wedge(0)}(1), Z^{\wedge(0)}(2), Z^{\wedge(0)}(3), Z^{\wedge(0)}(4), Z^{\wedge(0)}(5), Z^{\wedge(0)}(6), Z^{\wedge(0)}(7), Z^{\wedge(0)}(8))=(0, -562.25, 998.90, 850.72, -914.01, -636.76, -1011.44, 1274.85) \tag{10}$$

7. Calculate the standard deviation S1 of the original data X (0) and the standard deviation S2 of the residual. Mean square deviation ratio C and small error probability P.

$$S1=\sqrt{\frac{1}{n}\sum_{k=1}^{n}[x^{\wedge(0)}(k)-\bar{x}]^2}=\sqrt{\frac{1}{8}\sum_{k=1}^{8}[x^{\wedge(0)}(k)-\bar{x}]^2} \tag{11}$$

$$S2=\sqrt{\frac{1}{n}\sum_{k=1}^{n}[Z^{\wedge(0)}(k)-\bar{u}]^2}=\sqrt{\frac{1}{8}\sum_{k=1}^{8}[Z^{\wedge(0)}(k)-\bar{u}]^2} \tag{12}$$

$$C=\frac{S_2}{S_1}= 1.0181 \tag{13}$$

$$P=\{|\varepsilon(k)-\bar{\varepsilon}|<0.6745S1\}= 0.1429 \tag{14}$$

The accuracy inspection required by the system is level I (very good): $C \leq 0.35$, $P \geq 0.95$, level II (good): $C \leq 0.5$, $P \geq 0.8$, level III (general): $C \leq 0.65$, $P \geq 0.7$, level IV (unqualified): $C \geq 0.65$, $P \leq 0.7$. Because C = 1.0181 and P = 0.1429 do not meet the accuracy test requirements, continue to model and analyze the residual sequence Z(0), and model and analyze the residual sequence Z(0) to obtain a new residual sequence Z(1).

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$$Z(1)= (Z^{(1)}(1), Z^{(1)}(2), Z^{(1)}(3), Z^{(1)}(4), Z^{(1)}(5), Z^{(1)}(6), Z^{(1)}(7), Z^{(1)}(8))=(0, -860.37, 248.13, 1200.80, 381.65, -166.86, -1096.20, 255.0211) \quad (15)$$

By calculating the mean square error ratio C and small error probability P. C = 1.8126, P = 1.5714. It does not meet the requirements of the accuracy test table, and continues to model and analyze the residual sequence Z(1).

When the sixth residual sequence analysis is carried out, the residual sequence:

$$Z(6)= (Z^{(6)}(1), Z^{(6)}(2), Z^{(6)}(3), Z^{(6)}(4), Z^{(6)}(5), Z^{(6)}(6), Z^{(6)}(7), Z^{(6)}(8))=(0, -49.62, 293.13, 69.51, -400.78, -366.41, 136.68, 403.57) \quad (16)$$

By calculating the mean square deviation ratio C and the small error probability P. The solution is C = 0.3153, P = 1.0000. It meets the requirements of grade I (very good) in the accuracy test table, with a = 0.228191 and B = 1152.562080. Therefore, the final prediction model is:

$$X(1)(k+1)= -4473.893150e^{-0.228191k}+5050.876471 \quad (17)$$

Comparing the actual value with the fitting value, it can be seen that the grey GM (1,1) model has a good fitting effect on the automobile sales index in Tibet, and the average fitting relative error absolute value is 2.43%, so it can be used to predict the automobile sales in Tibet.

According to the grey GM (1,1) model formula, the predicted values of the next four times are N1 = 10350.25, N2 = 10825.59, N3 = 11415.37, N4 = 12133.29. Through quarterly conversion, it can be concluded that the car sales in Tibet in the first quarter of 2022 were 11689, 8980, 11242 and 12821 in the second quarter, the third quarter and the fourth quarter. Compared with 2021, 2022 has improved in all quarters.

3. Results and Discussion

In order to further verify the trend prediction of automobile sales, the automobile consumption of Lhasa autonomous region and even the whole country in recent years is analyzed. From the policy released in the past two years, 2020 is a year of the outbreak of new coronavirus pneumonia, which is a major change in a hundred years. Wuhan was the first to close the city, and the local governments have also taken a series of measures according to the epidemic : factory holidays, home office, and comprehensive closure of entertainment venues. A large number of workers are unemployed and the economy is seriously affected, resulting in no rapid growth in automobile sales in 2020. 2021 is the post-epidemic era. Although the epidemic has not ended, it has been effectively controlled. The economy has improved, but after the impact of the 2020 epidemic, the general consumption capacity of a large number of people has not improved, so the growth of automobile sales in Tibet in 2021 is not obvious. However, with the rapid development of economic recovery in the second half of 21 years, the economic state of 2022 is predicted well (' Economic Blue Book : Analysis and Prediction of China ' s Economic Situation in 2022 ' issued on December 6,2021). It points out that the global economy will continue to recover in the future, but the recovery is facing uncertainty. China 's economy is expected to grow by 8.0 per cent in 2021 and an average of 5.1 per cent in 2020-2021. Given the continuing global epidemic, China 's economy is expected to grow by about 5.3 per cent in 2022, up from the average growth rate for the two years 2020-2021). Tibet is sparsely populated, with 12,28,400 square kilometres of land and a permanent population of 3,648,100 in the seventh census. Highway travel is still the main mode of travel in the region. Therefore, it is predicted that the automobile market will develop rapidly and automobile sales will grow rapidly in 2022.

4. Conclusion

With the continuous improvement of public transport infrastructure, the choice of public travel modes is also more diversified. Public transport travel modes such as subway and light rail can make public travel more convenient and fast in today ' s increasingly serious traffic congestion. The emergence and popularization of shared cars, on the one hand, can solve the public travel problems, on the other hand, do not need to bear the increase in the cost of life caused by the purchase of cars. Therefore, for the automobile enterprises in Tibet and other provinces and cities, more reasonable, scientific and advanced marketing strategies should be formulated in combination with the comprehensive consideration of their own automobile product characteristics and external macro environment to further achieve stable and sustainable development.

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