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Prediction and Analysis of Private Car Ownership in China

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Abstract: The rapid development of economy in China provides huge development space for private cars. The research of car ownership is a fundamental work for urban planning and social development. Forecasting is always one of the main objectives in time series analysis. Accurate forecasting of car ownership is of great significance for urban development, transportation planning and sustainable development in China. This paper uses trend extrapolation to forecast the future private car ownership in China and evaluates the forecasting accuracy. The results show, by 2020, the private car ownership is expected to more than 100 times that of 1999, if we do not adopt appropriate policies to control the car ownership. Compared with previous work, this paper gives better prediction results and the corresponding suggestions.

Keywords: Private car ownership, trend extrapolation, prediction accuracy

I. INTRODUCTION

After joining the WTO, China's car produce and sales is growing rapidly. China's auto production and sales exceeded 19 million in 2012, which refreshed the world record again, and ranked first in the world for four consecutive years. Meanwhile, the number of private car ownership was also expanding speedy, total number of private car from 5.34 million to 88.39 million between 1999 and 2012.

In recent years, with the increasing car prices continued to decline in the domestic market and the living standards of residents in China continue to improve, the private car has gradually entered the ordinary family although it is a kind of high-grade consumer goods. At the same time, with the upgrading of resident consumption structure, China's private car-buyers show rapid growth momentum, becoming the decisive force of China's automobile industry, and it also has become an inevitable trend in social and economic development. However, this situation of the private cars growth more and quickly also brings a series of social problems such as air pollution, heavy traffic, tight parking spaces and so on. Research of car ownership is a fundamental work in urban planning, social and economic development. At present, the forecasting is a hot research topic in scientific research and playing an important role in many fields such as modern political, economic, managerial, military and life. The scientific forecast of private car ownership is the key to the development of Chinese highway traffic short and long term development planning, which is significant for solving a series of problems, such as the traffic congestion, energy crisis, environmental pollution, resource shortage and so on.

Tomas [1] established the dynamic car ownership model by taking the family as unit. Dargay and Gately [2], based on the innovation diffusion model-Gompertz model as the research tool and according to relevant data of car ownership of the 26 world developed country and developing country in 1960-1992, predicted the car development trend in the next few years. Joyce Dargay, Dermot Gately, and Martin Sommer [3] established prediction model where the auto saturation were a function of some factors such as city level, population density and so on. The study showed that automobile amount would increase from 8 billion to more than 20 billion vehicles in 2002 to 2030. Based on the above research, we will use the trend extrapolation model to forecast and analyze the future private car ownership in China and evaluate the prediction accuracy in this paper.

II. TREND CURVE MODEL

Many business forecasting methods project future values of a variable as a function of its own past history. Let y_t denote the observed quantity of interest at time t. Given a time series of observations, one possibility is to fit to these data a deterministic function of time. The equation to be estimated is then of the general form

$$f(y_t) = g(t, \alpha) + u_t \tag{1}$$

where f and g are specified functions, the latter involving a vector of unknown parameters α, and

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where u_t is a random error term. For example, g might be a polynomial in time, while f might be the logarithmic function. Once the parameters of the trend function have been estimated, the fitted function is projected forward to derive forecasts.

Special considerations suggest other functions in some applications while the choices of linear, quadratic, and log-linear functions are obvious possibilities. In marketing applications, the quantity y_t might represent the percentage of households purchasing or owning some product. Then the function g should have an asymptote, representing market saturation. Further, it is believed that, when a new product is introduced, sales and ownership initially experience a period of rapid growth, followed by a mature period of steady growth, and eventually slow movement to a saturation level. This suggests a trend function that is S-shaped, such as the logistic function, with $f(y_t) = y_t$ in Equation (1), and $g(t, \alpha) = \mu[1+\alpha e^{(1-\beta t)}]^{-1}$.

Meade [4] provides a much fuller discussion of sales forecasting through fitted trend functions. There are two main difficulties in this approach. First, the specification of an appropriate trend function is quite arbitrary. Possibly several alternative functions might be tried. But the experience suggests that, while different functions might fit observed data almost equally well, these fitted functions can diverge quite rapidly when projected forward (see, e.g., Freedman et al. [5]). In these circumstances, it is difficult to place much confidence in medium-term or long-term forecasts. Second, it is commonly assumed, for both parameter estimation and the derivation of forecasts, that the error terms u_t in (1) are uncorrelated. However, the experience suggests that many business time series exhibit very strong autocorrelation patterns. Indeed, for short-term forecasting it is likely to be more important to anticipate departures from any long-run trend function than to specify that function well. Consequently, short-term forecasts derived under the assumption that the error terms in (1) are uncorrelated are likely to be seriously suboptimal. Of course, it is quite feasible to incorporate sophisticated auto-correlated error structures in (1), but this is rarely done in practice. The forecasting methods we discuss next concentrate on trend extrapolation forecasting.

Trend extrapolation is a very simple forecasting method that is useful if it is believed that the historic trend in the data is smooth and will continue on its present course into the near future. The trend extrapolation is best computed in Eviews soft using OLS regression techniques.

III. THE TREND EXTRAPOLATION MODELING AND ITS SOLVING

Forecasting is always an important, if not the most important, objective in time series analysis. It has wide applications in the fields of economics, telecommunication, meteorology, etc. In many forecasting methods, trend extrapolation forecasting car ownership has a good prediction results. It is the choice of historical data by using the difference to the original time series into stationary series, ie, using difference smoothing the data to non-stationary series to stationary series, create a dynamic sequence, the computing method of regression equation, regression equations, and investigated by testing its significance, in order to facilitate the practical value of discriminant regression equation.

There are commonly four prediction model for the trend extrapolation prediction, namely, polynomial curve prediction model, exponential curve prediction model, logarithmic curve prediction model and growth curve prediction model. People use mainly the pattern recognition method and difference method to select the appropriate model [6].

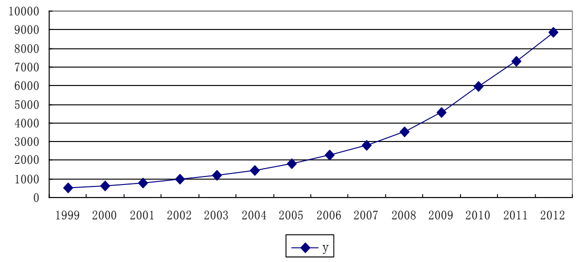

Figure 1. The trends of Chinese private car ownership.

After sorting the data (The data come from “China statistical yearbook”.), we put them into the scatter plots and the fitting of the trend line (See Figure 1, where is used to represent the private car ownership. According to Figure 1, we can select exponential curve prediction models.

Secondly, we calculate the line speed of private car ownership, and the calculation results are shown in Table 1.

Table 1 shows that the line speed of the observed value is roughly equal, which is in line with the digital characteristics of exponential curve model. Combined with a comprehensive analysis of the scatter plot, we finally choose an exponential curve to create a predictive model

$$\hat{y}_t = ae^{bt}$$

Both logarithmic, the above model can be turned into the following form

$$\ln \hat{y}_t = \ln a + bt$$

Using the Eviews 6.0 software and the OLS method, we get the regression equation from Table 2:

$$\ln \hat{y}_t = 5.923 + 0.227t \ \ (AR(1) = 0.519) \qquad (2)$$

$$t = (135.78) \ \ (56.17) \ \ \ (2.995)$$

$$Adj\text{-}R^2 = 0.9995 \quad F = 9657.3 \quad DW = 1.32$$

Table 1. The line speed of private car ownership.

Years	t	y_t	y_t / y_{t-1}
1999	1	534	—
2000	2	625	1.170
2001	3	771	1.234
2002	4	969	1.257
2003	5	1175	1.213
2004	6	1450	1.234
2005	7	1809	1.248
2006	8	2273	1.256
2007	9	2803	1.233
2008	10	3501	1.249
2009	11	4575	1.307
2010	12	5939	1.298
2011	13	7327	1.234
2012	14	8839	1.206

Table 2. The results of the regression equation Using the Eviews 6.0 software and the OLS method

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.9233	0.043626	135.7760	0.0000
T	0.2268	0.004038	56.17140	0.0000
AR(1)	0.5192	0.173345	2.995303	0.0135
R-squared	0.9995	Mean dependent var		7.7494
Adjusted R-squared	0.9994	S.D. dependent var		0.8710
S.E. of regression	0.0217	Akaike info criterion		-4.6234
Sum squared resid	0.0047	Schwarz criterion		-4.4931
Log likelihood	33.0523	F-statistic		9657.34
Durbin-Watson stat	1.3199	Prob(F-statistic)		0.0000

Passing ADF test on the regression equation residual "e" confirms that the long-term equilibrium is true, and as a whole, this equation has passed the test, and there was no autocorrelation. So the required exponential model is

$$\hat{y}_t = 373.531\, e^{0.227t} \qquad (3)$$

IV. The Precision Model and its Evaluation

Generally, information on related time series can also be incorporated, through an amalgamation of the methodologies of regression and time-series analysis. On many occasions the forecaster has available several alternative possible approaches. It might then be useful to consider *combining* forecasts from different sources. Since alternative approaches might be adopted, it is sensible to *evaluate* the performance of a specific approach to forecasting. This might suggest inadequacies and point to directions for possible improvements in forecast quality.

The prediction accuracy refers to how well the prediction model fitting, that is, the goodness of the simulation value produced by prediction model and the actual value of history fitting. We use the developed models to predict and compare the predicted value with the observed value (See Table 3), and calculate the corresponding error (See Table 4).

Table 3. Comparison the predicted value with the observed value.

Years	t	y_t	$\hat{y}_t$
1999	1	534	469
2000	2	625	588
2001	3	771	738
2002	4	969	926
2003	5	1175	1162
2004	6	1450	1458
2005	7	1809	1830
2006	8	2273	2296
2007	9	2803	2881
2008	10	3501	3616
2009	11	4575	4537
2010	12	5939	5693
2011	13	7327	7144
2012	14	8839	8964

From Table 4, we can obtain the following results:

The average absolute error

$$MAD = \frac{\sum_{t=1}^{n} |y_t - \hat{y}_t|}{n} = \frac{1028.5}{14} = 73.5 \qquad (4)$$

The average relative absolute error

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{y_t - \hat{y}_t}{y_t}\right| = \frac{1}{14} \times 0.4812 == 3.44\% \qquad (5)$$

The standard deviation of the forecasting error

$$SDE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(y_t - \hat{y}_t\right)^2} = \sqrt{10014.36} = 100.07 \qquad (6)$$

Table 4. The corresponding error of the predicted value and the observed value.

Years	$\lvert y_t - \hat{y}_t \rvert$	$\lvert y_t - \hat{y}_t \rvert / y_t$	$(y_t - \hat{y}_t)^2$
1999	65.3	0.139	4262
2000	36.8	0.063	1357
2001	33.0	0.045	1086
2002	42.9	0.046	1839
2003	12.9	0.011	166
2004	8.3	0.006	68
2005	20.9	0.011	436
2006	23.2	0.010	537
2007	78.3	0.027	6133
2008	114.6	0.032	13123
2009	38.1	0.008	1451
2010	246.0	0.043	60493
2011	183.2	0.026	33560
2012	125.3	0.014	15690

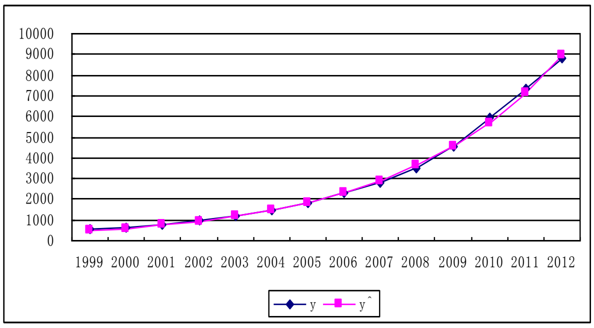

Figure 2. Comparison chart of the observed value (y_t) and predicted value ($\hat{y}_t$)

The results of calculating the error and Figure 2 show that the prediction model (2) has higher precision, it is suitable for medium and long-term forecasting. We use (3) to forecast the annual car ownership as shown in Table 5.

Table 5. The part predictive value of the private car ownership （Unit: million）.

Years	2013	2014	2015	2016
Private car ownership	11249	14115	17712	22226
Years	2017	2018	2019	2020
Private car ownership	27889	34996	43915	55105

V. CONCLUSIONS

As can be seen from the prediction data in table 5, in the future, the number of private cars will still be in a period of rapid growth in China. If we do not adopt appropriate policies to control this condition, by 2020, private car ownership is expected to more than 100 times that of 1999, from the side, which reflects the rapid development of the national economy and the upgrading of economic strength. On the other hand, rapid growth of private car ownership will bring traffic congestion, energy, environmental pollution, resource shortages and a series of problems, which cannot help worrying: First, in recent years the rapid growth of motor vehicles is an important problem of urban traffic congestion, and the supply of road is far behind the pace of the development of private cars. Second, the excessive development of private cars will lead to an energy crisis; Oil becomes an important strategic issue; Increase of private cars will make the energy security of the country threatened. Third, vehicle emissions are one of the major hazards of air pollution, and noise pollution caused by car horns is a serious problem. Fourth, with rapid increase of the private car ownership, the corresponding expansion of roads and the parking infrastructure has become an inevitable requirement. The construction of roads and parking lot will make the problem of shortage of resources in land more serious. To effectively alleviate these problems, we should do proper guidance, constraints and norms through a variety of policy and the means of market regulation on the development of private cars. For example, to limit private car ownership [7], to encourage people to avoid peak season, green travel, improve travel efficiency; Limit the use of private cars [8], to promote carpool carrying, improve the utilization rate, reduce the no-load; Vigorously develop public transport and other means [9], trying to promote bicycle, motor vehicle rental services; Increase public parking spaces, such as the establishment of three-dimensional parking spaces, so as to ease situation of the tight parking spaces. In view of the present condition of consumption, the timely adoption of some effective measures is also necessary to complement in order to further improve and promote the consumption of private cars. Only under the guidance of relevant national policies, the healthy development of China's private consumption will be sustained.

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