Analysis of economic growth forecast based on regression model

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Abstract. In this paper, the population growth retardation model, the unitary linear regression model and the multiple linear regression model are established to solve the problem. After considering the year and population relationship, the total population and the future labor population are predicted by the growth retardation model, and the future education investment and the investment in fixed assets of the whole society are predicted by the unitary linear regression model. After considering such factors as education investment, total population, labor force population, and investment in fixed assets of the whole society, establish a linear relationship between the economy and these factors, and then solve the change of GDP under the joint influence of these factors through multiple regression analysis, and then predict that the economic growth rate in the next 20 years will be 4.71%, 4.49%, 4.29%, 4.10%, 3.93%, 3.78%, 3.64%, 3.51% 3.39%, 3.28%, 3.18%, 3.08%, 2.99% 2.91%, 2.83%, 2.75%, 2.68%, 2.61%, 2.55%, 2.48%. It can be seen that the future economic growth rate shows a downward trend. The growth rate of GDP per capita in the next 20 years will be 4.26%, 4.05%, 3.86%, 3.69%, 3.54%, 3.40%, 3.27%, 3.15%, 3.05%, 2.95%, 2.86%, 2.77%, 2.69%, 2.62%, 2.54%, 2.48%, 2.42%, 2.36%, 2.30%, 2.25%, showing a decreasing trend. Finally, it is concluded that the average annual growth rate of GDP per capita in the next 20 years will be 7%.

Keywords: Growth retardation model, linear regression and economic forecast.

1. Introduction

In recent decades, after China's per capita GDP has maintained rapid growth, China is experiencing significant changes in the determinants of its economic growth. Historically, China's economic growth has been driven by two main forces: the "demographic dividend" [1](the proportion of working age population in the total population has increased) and the improvement of labor productivity (due to the improvement of education level and the transfer of labor redistribution to more efficient production sectors). However, in recent years, the change in the composition of China's labor force and the deceleration of labor force redistribution threaten the economy and slow the growth. Therefore, if China wants its economy to continue to grow at a relatively high speed, it needs to focus on improving education [2] to cope with the decline of labor force size and labor productivity. Therefore, we need to establish an economic growth model, fully consider the impact of various factors on GDP in the model, and predict China's economic growth and per capita economic growth in the next 20 years.

At present, there are different research methods for economic growth prediction and analysis at home and abroad. Cheng Maolin[3] used the principal component nonlinear model in his article, and Li Yongdi proposed in her article to use ARMIA, deflator index method and principal component analysis to predict the total GDP and growth rate... However, although their research methods have improved the accuracy of economic growth prediction to a certain extent, they are slightly complicated. Therefore, on this basis, I will use a simple and understandable model to predict the GDP growth rate, and at the same time ensure the accuracy of the prediction. At the same time, I will analyze the impact of education on GDP to cope with the decline of labor force size and labor productivity. The research on this issue can provide suggestions for the government departments to implement measures for economic growth in the future.

2. Methods

2.1. Blocking growth model

The retarding growth model is obtained by modifying the basic assumptions of the exponential growth model. It takes this factor into account, that is, after analyzing the main reasons for the decline of the growth rate after the population increases to a certain amount, natural resources, environmental conditions and other factors play a retarding role in the growth of the population [4], and the retarding effect will become greater and greater with the increase of the population. If r is expressed as a function of x, r (x), it should be a minus function. So there is a growth rate function.

$$\frac{dx}{dt} = r(1-\frac{x}{xm})x \tag{1}$$

$$x(t0) = x0 \tag{2}$$

The final formula of block model can be obtained through classified variable method:

$$x(t) = \frac{x1}{1+(\frac{x1}{x0}-1)*e^{-r(t-t0)}} \tag{3}$$

2.2. Univariate linear regression model

We need to predict the changes of education investment and the investment in fixed assets of the whole society in the next 20 years, and these two factors can be regarded as the dependent variables of time, and have a linear relationship with time. Therefore, we can use a linear regression mode[5]l to solve the predicted values respectively.

Univariate linear regression is characterized by only one independent variable and one corresponding dependent variable, so it is a method to analyze the linear correlation of only one independent variable (independent variable x and dependent variable y).

The expression of the unary linear regression equation is:

$$y = kx + b \tag{4}$$

Where, y is the predicted value of the sample, i.e. the dependent variable of the regression equation, x is the characteristic value of the sample, i.e. the independent variable of the regression equation, and b is the intercept of the equation.

2.3. Multiple linear regression model

We hope to judge whether it is feasible for per capita economic growth to average 7% annually in the next 20 years? The key to judge this problem is to calculate the per capita economic growth rate in the next 20 years, and there is a relationship between the per capita economic growth rate in the next 20 years and the total GDP in the future. Therefore, the first step is to predict the GDP in the next 20 years, and the GDP is related to education investment, fixed asset investment in the whole society, the total population model, and the labor population. Therefore, when there is only one dependent variable corresponding to multiple independent variables, Multiple linear regression model[6] should be considered.

Multivariate regression model describes the correlation between a dependent variable and multiple independent variables. If the relationship is linear, linear multiple regression model can be used to describe it.

Multiple linear regression model expression:

$$y = k1*x1 + k2*x2 + ... + kn*xn + b \tag{5}$$

Where, b is a constant term, k1, k2... kn is a regression coefficient, k1 is x1, x2... xn is fixed, the effect of each unit of x1 on y is the partial regression coefficient of x1 on y; Similarly, when k2 is x1,

x2... xn is fixed, the effect of each unit of x2 on y, that is, the partial regression coefficient of x2 on y.

3. Model construction and result analysis

3.1. Analysis of Blocking Growth Model Construction

The solution process uses the fitting toolbox provided by MATLAB to solve, and the independent variable t is within the range of 1991-2019, and the time interval is 5 years for fitting. Total population curve fitted by MATLAB is shown in Figure 1.

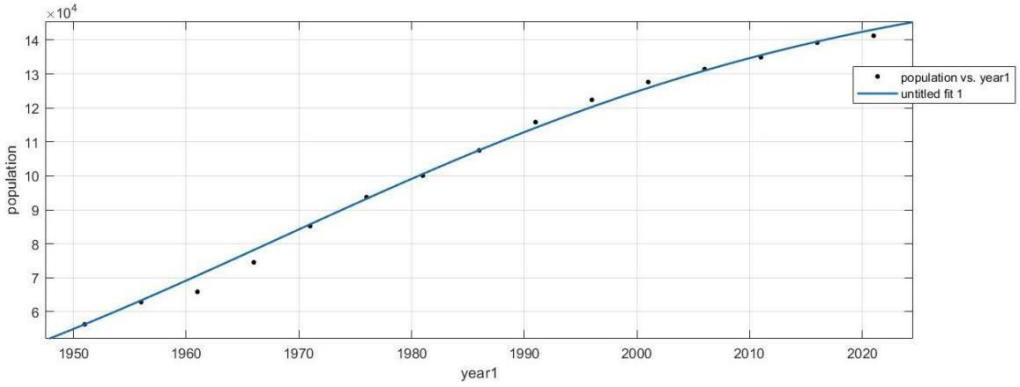

Figure 1. Total population curve fitted by MATLAB

Solve r=0.03713, x1=163300

$$x(t)=\frac{163300}{1+(\frac{163300}{115823}-1)*e^{-0.03713*(t-1991)}} \tag{6}$$

The predicted results of the total population from 2022 to 2042 are obtained (the red dots in the figure): Predicted total population in the future is shown in Figure 2.

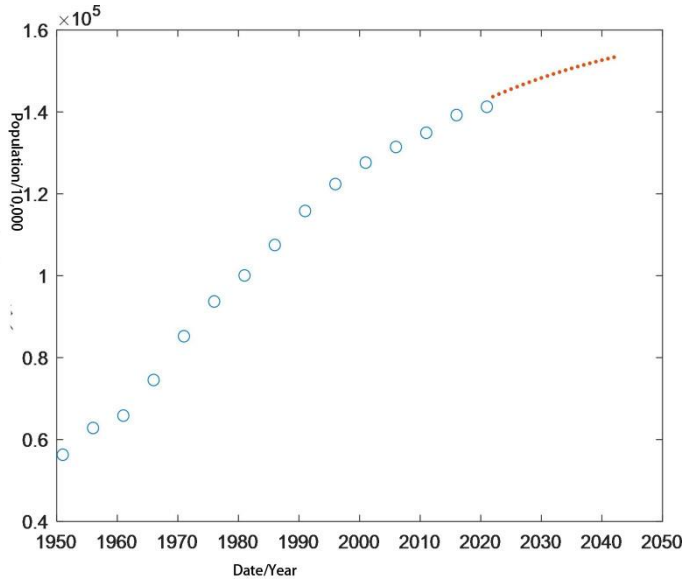

Figure 2. Predicted total population in the future

Similarly: solve r =0.07548, y1 =82370

$$y(t)=\frac{82370}{1+(\frac{82370}{66091}-1)*e^{-0.07548*(t-1991)}} \tag{7}$$

Therefore, the predicted number of labor force population in 2022-2042 is obtained (the part with red dots in the figure). Predicted future labor force population is shown in Figure 3.

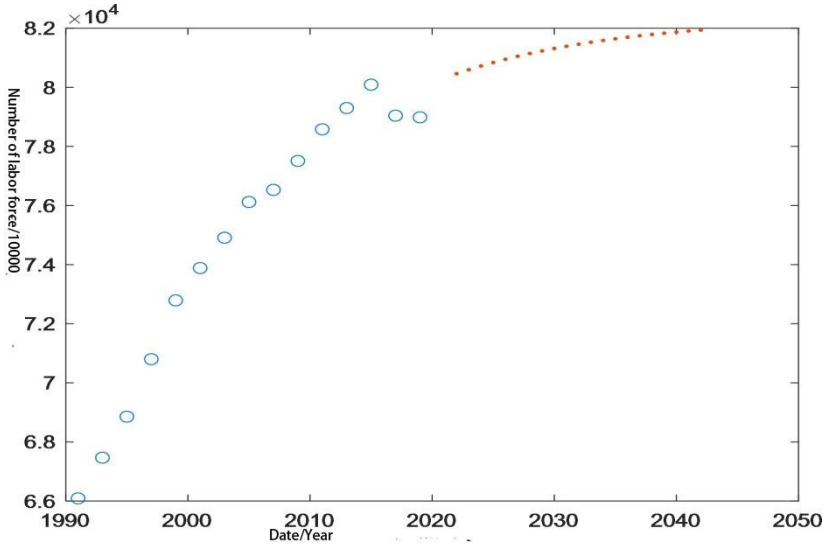

Figure 3. Predicted future labor force population

3.2. Construction and analysis of unitary linear regression model

Establish a single linear regression model for education investment [7-8] and fixed asset investment [9-10].

Assume that k1 is the linear regression coefficient of one variable used for education investment, and b1 is the linear regression constant of one variable.

Then there is the establishment of a model

$$E(t) = k1*t + b1 \tag{8}$$

$$G(t) = k2*t + b2 \tag{9}$$

The current share t is the independent variable, ranging from 2006-2019, and the education investment is the dependent variable, which is fitted through the MATLAB toolbox Linear function is used for fitting.

Solve k1=3119 b1=-6.249e+06

$$E(t)=3119*t-6249000 \tag{10}$$

Through SPSS software for significance T test and F test, the test results are close to 0, indicating that the significance is good.

Therefore, when the independent variable is 2022-2042, the following prediction results can be obtained: Predicted amount of future education investment is shown in Figure 4.

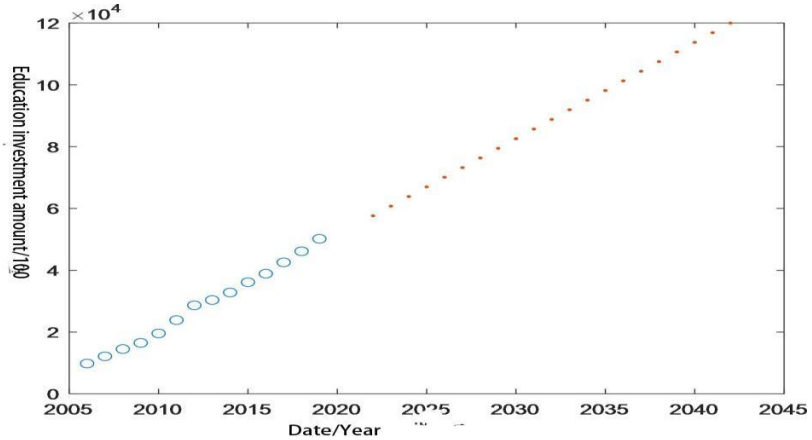

Figure 4. Predicted amount of future education investment

Similarly, the investment in fixed assets of the whole society is also taken as the independent variable, with the range of 2006-2019. The independent variable is taken as the investment in fixed assets of the whole society, and the fitting results are as follows:

Fixed asset investment curve of the whole society fitted by MATLAB is shown in Figure 5.

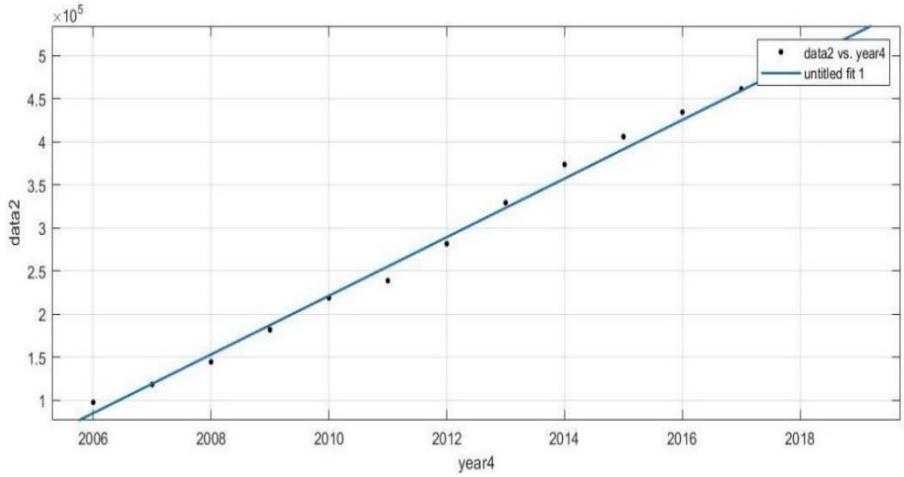

Figure 5. Fixed asset investment curve of the whole society fitted by MATLAB

Solve k2 = 3.404e+04, b2 = -6.819e+07

$$G(t) = 34040 * t - 68190000 \tag{11}$$

Predicted amount of fixed assets investment in the future is shown in Figure 6.

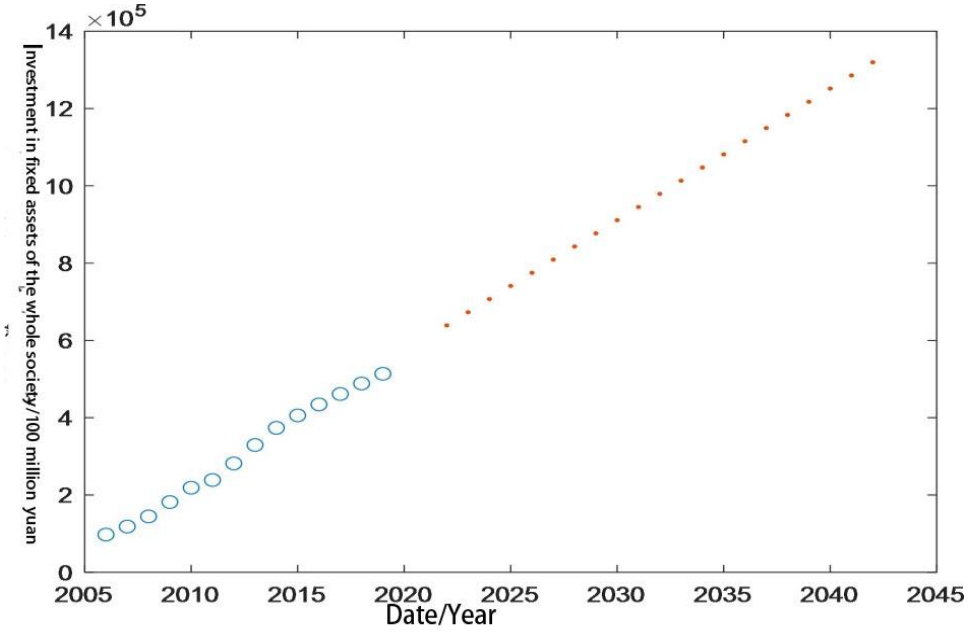

Figure 6. Predicted amount of fixed assets investment in the future

3.3. Construction and analysis of multiple linear regression model

We establish a multiple linear regression model based on education investment, investment in fixed assets of the whole society, total population size, and labor population as four independent variables, and GDP as the dependent variable.

Inspired by the linear relationship between China's GDP, total population and the investment in fixed assets of the whole society in Cobb Douglas production function

There will also be a linear relationship between education investment, fixed asset investment of the whole society, total population size, labor force population and GDP.

Suppose k4 is the regression coefficient of labor force population L to GDP Q, k5 is the regression coefficient of fixed asset investment G to GDP Q, k6 is the regression coefficient of education investment E to GDP Q, k7 is the regression coefficient of total population P to GDP Q, and b4 is the regression constant

$$lnQ=k4*lnL+k5*lnG+k6*lnE+k7*lnP+b4; \quad (12)$$

Through data collection, we can know the data of 2006-2019 education investment, labor force population, social fixed asset investment, total population and GDP.

Through multiple regression analysis with SPSS software

k4=-3.35; k5=0.205; k6=0.755; k7=0.291; b4=37.242;

Get the final expression:

$$lnQ=-3.35*lnL+0.205*lnG+0.775*lnE+0.291*lnP+37.291 \quad (13)$$

Curve of GDP forecast under all factors is shown in Figure 7.

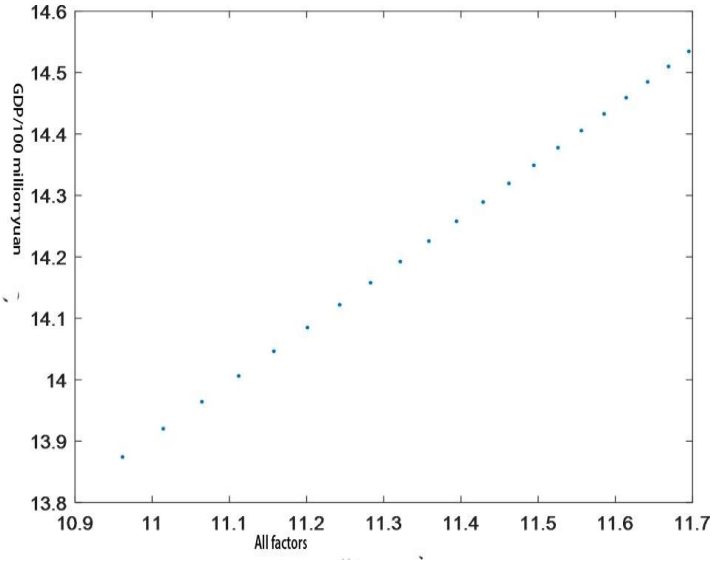

Figure 7. Curve of GDP forecast under all factors

After passing the GDP forecast, we can calculate the annual GDP growth rate: the annual GDP growth rate=((GDP of the next year - GDP of the previous year)/GDP of the previous year) * 100%.Therefore, the predicted GDP growth rate from 2022 to 2042 is obtained: Broken Line Chart of GDP Growth Rate is shown in Figure 8.

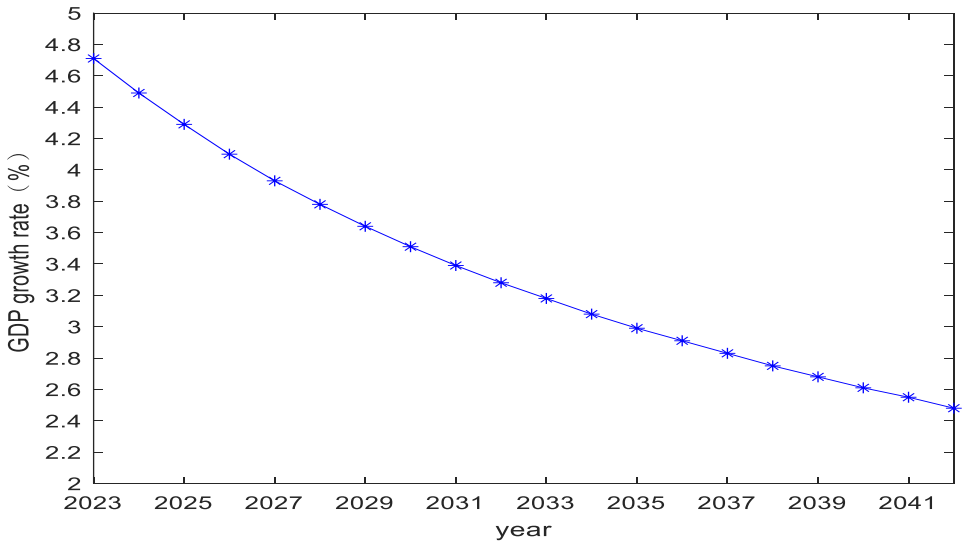

Figure 8. Broken Line Chart of GDP Growth Rate

Average annual growth rate of per capita GDP growth= ((GDP of the next year/total population of the next year - GDP of the previous year/total population of the previous year)/ (GDP of the previous year/total population of the previous year) * 100%

Therefore, the annual average growth rate of GDP per capita from 2022 to 2042 is predicted as follows: GDP per capita growth rate is shown in figure 9.

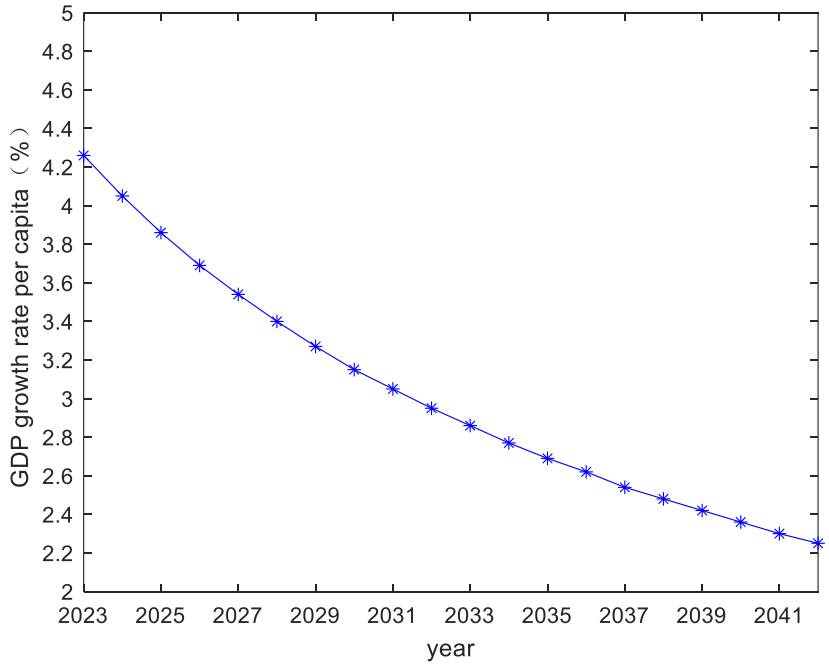

Figure 9. GDP per capita growth rate

4. Conclusion and discussion

4.1. Advantages of the model

The establishment of a growth retardation model rather than a direct exponential growth model makes the prediction results more accurate. The unitary linear regression model is established, which is relatively simple and easy to solve, and the predicted values are reasonable. It is objective and comprehensive to establish a multiple linear regression model, taking into account multiple factors that affect economic growth.

4.2. Deficiency and improvement of the model

There is insufficient data collection, which may not be objective. The establishment of multiple linear regression equation is relatively complex, with many unknowns, and it is not easy to solve.

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