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Change Trend Analysis of China's Population

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ABSTRACT

Two-child policy is bound to affect the future population quantity and structure change in China. In order to forecast the change trend of China's population caused by the two-child policy, we establish a population forecast model based on grey system theory. Concretely, a population forecast model based on the GM (1, 1) model is presented, and the application example is given from the population data from 2000 to 2014. Moreover, some policy suggestions on the development of the population are proposed based on the population forecast results of the future ten years.

Keywords: Population quantity forecast; Two-child policy; GM (1, 1) model

INTRODUCTION

China's family planning policy has been implemented for more than 30 years, as a whole has obtained the good effect of population control, but there are many problems existing in the current family planning policy, i.e., it has entered the stage of an aging population for the one-child family, there is a serious imbalance in population sex ratio, the total fertility rate entered into the low fertility countries, the demographic dividend gradually disappear, etc. In the aspect of education, the enrollment quantity declines year by year, the workforce absolute numbers began to enter into the drop channel. As the implementation of two-child policy, the problem of population change becomes a social hot spot once again.

For the change trends in the population after two-child policy, many scholars presented their opinions and views. For example, Liu and Wang [1] carried on the new interpretation for the two-child policy, and considered the policy thinking from multiple sides. Yang [2] combined population growth theory, dualist approach and human capital theory to discuss the population policy from multi-perspectives. Sui [3] presented separate two-child policy to slow the future labor force decline and aging speed of age structure, but it can't change the future labor force decline and the aging trend of age structure. Chi [4] pointed out that China's population policy has been in focus as the world's most populous country. Different from the previous studies of China's population policy, this paper used the methods and means of economics to analyze China's population adjustment policy from the perspective of law and economics system design and arrangement. Zhang [5] presented the social impact of open two-child policy to our country, and showed that the open two-child policy is beneficial to the improvement of the socialization of individual early, and is beneficial to relieve the pressure of supporting the elderly and reduce the occurrence of loss of family alone, but also has negative influences. Ruan et al. [6] carried out simulation experiment to the separate two-child policy by the system dynamics model, and found that the policy of new numbers of the second child does not materially alter China's population structure. Liang et al. [7] predicted the population size and structure after the implementation of the separate two-child policy according to sixth census data for the phase school-age population of 20 years of China compulsory education.

From above references, some scholars made their own unique insights and discussion for the family planning policy adjustment in recent years, but the discussion of the trend of China's population changes for two-child policy are rare. In this paper, in order to forecast the change trend of China's population caused by the two-child policy, a population forecast model based on grey GM (1, 1)

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model [8, 9] is established, and the application example is given to show the feasibility and reasonableness of the presented model.

POPULATION FORECAST MODEL BASED ON THE GM (1, 1) MODEL

Based on the grey system theory, a population forecast model based on grey GM (1, 1) model is presented as follows.

(1) Data test and Data Processing of Original Data Series

Suppose that the original data of population in past *n* years is

$$x^{(0)} = [x^{(0)}(1), x^{(0)}(2), \cdots, x^{(0)}(n)] .$$

And the class ratio $\sigma^{(0)}(k)$ is

$$\sigma^{(0)}(k) = \frac{x^{(0)}(k-1)}{x^{(0)}(k)}, \quad k = 2,3,\ldots,n.$$

If all values of $\sigma^{(0)}(k)$ are within the range $X = (e^{-\frac{2}{n+1}}, e^{\frac{2}{n+1}})$, then the original data of population can be used to make the GM(1,1) modeling. If this condition is not satisfied, we can make a data process to the original population data series, for example, we can make the following translation transformation

$$y^{(0)}(k) = x^{(0)}(k) + c, (k = 1, 2, 3, \cdots n) .$$

Then we can get a new series

$$y^{(0)} = [y^{(0)}(1), y^{(0)}(2), \cdots, y^{(0)}(n)] ,$$

which satisfies that its values of $\sigma^{(0)}(k)$ are within the range $X = (e^{-\frac{2}{n+1}}, e^{\frac{2}{n+1}})$.

(2) 1-AGO for the Translation Transformation Series

For the new translation transformation series $y^{(0)} = [y^{(0)}(1), y^{(0)}(2), \cdots, y^{(0)}(n)]$, we make a 1-AGO process, the 1-AGO series is denoted as

$$x^{(1)} = (x^{(1)}(1), x^{(1)}(2), \cdots, x^{(1)}(n)) ,$$

where

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i) = x^{(1)}(k-1) + x^{(0)}(k) .$$

(3) Establish the Population Forecast Model, i.e.,

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = b ,$$

where *a* and *b* are parameters. We can use the method of the least squares solution to estimate them, the estimate results are

$$\hat{a} = \begin{bmatrix} a \\ b \end{bmatrix} = (B^T B)^{-1} B^T Y ,$$

where

$$B = \begin{bmatrix} -\frac{1}{2}[x^{(1)}(1) + x^{(1)}(2)] & 1 \\ -\frac{1}{2}[x^{(1)}(2) + x^{(1)}(3)] & 1 \\ \vdots & \vdots \\ -\frac{1}{2}[x^{(1)}(n-1) + x^{(1)}(n)] & 1 \end{bmatrix}, Y = \begin{bmatrix} x^{(0)}(1) \\ x^{(0)}(2) \\ \vdots \\ x^{(0)}(n) \end{bmatrix},$$

and the forecast equation is

$$\hat{x}^{(1)}(k+1) = (x^{(0)}(1) - \frac{b}{a})e^{-ak} + \frac{b}{a},$$

and the forecast values of original series is

$$x^{(0)}(k+1) = x^{(1)}(k+1) - x^{(1)}(k) = (1-e^{c})[x^{(0)}(1) - \frac{b}{a}]e^{-ck}.$$

(4) Model Test

The residual error test method is used to test the above forecast model.

Residual error is defined as

$$e(k) = x^{(0)}(k) - \hat{x}^{(0)}(k).$$

The relative residual error is defined as

$$\Delta_k = \left|\frac{e(k)}{x^{(0)}(k)}\right| \times 100\%,$$

and the mean relative error is

$$\bar{\Delta} = \frac{1}{n}\sum_{k=1}^{n}\Delta_k.$$

If $\Delta(k) < 0.2$, then the forecast precision of the presented model is in a general level. If $\Delta(k) < 0.1$, then the forecast precision of the presented model is in a higher level.

AN APPLICATION EXAMPLE OF POPULATION FORECAST

In this section, an application example of population forecast is given to show the feasibility and reasonableness of the presented model.

Let the population data in the years of 2000 to 2013 be the original data series, i.e.,

$$\begin{aligned} x^{(0)} &= [x^{(0)}(1), x^{(0)}(2), \cdots, x^{(0)}(13)] \\ &= [12.6743, 12.7627, 12.8453, 12.9227, 12.9988, 13.0756, 13.1448, \\ &\quad 13.2129, 13.2802, 13.3450, 13.4091, 13.4735, 13.5404, 13.6072] \end{aligned}$$

Then the class ratio of $x^{(0)}$ is

$$\sigma^{(0)}(k) = \frac{x^{(0)}(k-1)}{x^{(0)}(k)}, \quad k = 2, 3, \ldots, 13,$$

that is

$$\begin{aligned} \sigma^{(0)}(k) &= [\sigma^{(0)}(2), \sigma^{(0)}(3), \cdots, \sigma^{(0)}(13)] \\ &= [0.9931, 0.9936, 0.9940, 0.9941, 0.9941, 0.9947, 0.9948, \\ &\quad 0.9949, 0.9951, 0.9952, 0.9952, 0.9951, 0.9951] \end{aligned}$$

Obviously, all the values of class ratio are all within the range $\sigma(k) \in (e^{-7}, e^{7})$, thus the original can be used to make the GM(1,1) modeling.

Next we make a 1-AGO process for the original data series, we have

$$\begin{aligned} x^{(1)} = [&74.4426, 87.2053, 100.0506, 112.9733, 125.9721, 139.0477, 152.1925, \\ &165.4054, 178.6856, 192.0306, 205.4397, 218.9132, 232.4536, 246.0608] \end{aligned}$$

and

$$\begin{aligned} z^{(1)} &= 0.5(x^{(1)}(k) + x^{(1)}(k-1)) \\ &= (19.0556, 31.8595, 44.7435, 57.7042, 70.7414, 83.8516, 97.0304, \\ &\quad 110.2770, 123.5896, 136.9667, 150.4080, 169.9149, 177.4887, 191.1314) \end{aligned}$$

thus we have

$$B=\begin{pmatrix} -z^{(1)}(2) & 1.0000 \\ -z^{(1)}(3) & 1.0000 \\ -z^{(1)}(4) & 1.0000 \\ -z^{(1)}(5) & 1.0000 \\ -z^{(1)}(6) & 1.0000 \\ -z^{(1)}(7) & 1.0000 \\ -z^{(1)}(8) & 1.0000 \\ -z^{(1)}(9) & 1.0000 \\ -z^{(1)}(10) & 1.0000 \\ -z^{(1)}(11 & 1.0000) \\ -z^{(1)}(12) & 1.0000 \\ -z^{(1)}(13) & 1.0000 \end{pmatrix}=\begin{pmatrix} -19.0556 & 1.0000 \\ -31.8595 & 1.0000 \\ -44.7435 & 1.0000 \\ -57.7042 & 1.0000 \\ -70.7414 & 1.0000 \\ -83.8516 & 1.0000 \\ -97.0304 & 1.0000 \\ -110.2770 & 1.0000 \\ -123.5896 & 1.0000 \\ -136.9667 & 1.0000 \\ -150.4080 & 1.0000 \\ -169.9149 & 1.0000 \\ -176.4836 & 1.0000 \end{pmatrix},\quad Y=\begin{pmatrix} x^{(0)}(1) \\ x^{(0)}(2) \\ x^{(0)}(3) \\ x^{(0)}(4) \\ x^{(0)}(5) \\ x^{(0)}(6) \\ x^{(0)}(7) \\ x^{(0)}(8) \\ x^{(0)}(9) \\ x^{(0)}(10) \\ x^{(0)}(11) \\ x^{(0)}(12) \\ x^{(0)}(13) \end{pmatrix}=\begin{pmatrix} 12.6743 \\ 12.7627 \\ 12.8453 \\ 12.9227 \\ 12.9905 \\ 13.0756 \\ 13.1448 \\ 13.2129 \\ 13.2802 \\ 13.3450 \\ 13.4091 \\ 13.4735 \\ 13.5404 \\ 13.6072 \end{pmatrix}.$$

Using the method of the least squares solution,

$$a=(B^TB)^{-1}B^TY=(a,\ b)^T,$$

we have

$$a=-0.0054,\quad b=12.6026.$$

Thus the forecast equation is

$$\hat{x}^{(1)}(k+1)=(x^{(0)}(1)-\frac{b}{a})e^{-ak}+\frac{b}{a}=2346.4891e^{0.0054k}\text{-}2333.8,$$

and the forecast formula of original series is

$$x^{(0)}(k+1)=x^{(1)}(k+1)-x^{(1)}(k)=2346.4891(1-e^{-0.0054})e^{0.0054k}.$$

For the above mode, we now make a model test by using the residual error test method. The relevant calculation results of error test are listed in the Table 1.

From the results in Table 1, we conclude that the presented population forecast model in this paper has higher forecast precision, so we can use this model to forecast the future population data. Here we forecast the population quantity from 2017 to 2025, and the population forecast results are listed in the following Table 2.

Table1. *The relevant calculation results of error test*

Year	Original values	Model values	Residual error	Relative error
2000	12.6743	12.6743	0	0
2001	12.7627	12.7746	-0.0119	0.0932
2002	12.8453	12.8442	0.0011	0.0856
2003	12.9227	13.9141	0.0086	0.0767
2004	12.9905	12.9845	0.0060	0.0462
2005	13.0756	13.0052	0.0204	0.1560
2006	13.1448	13.1262	0.0186	0.1415
2007	13.2129	13.1977	0.0152	0.1150
2008	13.2802	13.2696	0.0106	0.0798
2009	13.3450	13.3419	0.0031	0.0234
2010	13.4091	13.4145	-0.0054	0.0403
2011	13.4735	13.4876	-0.0141	0.1047
2012	13.5404	13.5610	-0.0206	0.1521
2013	13.6072	13.6201	-0.0129	0.0948
2014	13.6782	13.6796	-0.0014	0.0102
Mean relative error				0.0871

Table2. *The population forecast results*

Year	The total forecasted population (billion)
2017	13.7838
2018	13.8589
2019	13.9344
2020	14.0102
2021	14.0765
2022	14.0932
2023	14.1075
2024	14.1151
2025	14.1276

From the forecast results in Table 2, we can conclude that when implement two-child policy, the new born population of every year from 2017 to 2020 is around 2.3-5.3 millions. Thus the new policy can inhibit the birth accumulation to a certain degree. If the two-child policy is full opening o in 2016, then the total population in 2020 will exceed 1.4 billions, and it reaches 1.413 billion in 2026, then the population begin to decline.

SOME SUGGESTIONS ON THE DEVELOPMENT OF POPULATION

Now our country has achieved a low fertility level, but because of the larger population base, the current low fertility and low population growth situation of the population are not optimistic. It should be appropriate to relax the population policy to make the population structure is more reasonable to create more favorable conditions for sustainable development. China's population is now facing a huge crisis, and to improve China's fertility rate is an immediate problem. Therefore, we give the following suggestions on the development of population.

First, in order to improve the fertility rate, the government needs to increase the input on women's and children's maternity hospital, and distribute the medical resources according to the population distribution. On the one hand, the government should fully provide free pregnancy, and reproductive health check before marriage. On the other hand, due to the women who meet two-child policy is a fair number of women over the age of 35, so we must focus on women's reproductive risk. And increase the prevention intensity of birth defects, and strengthen the construction ability of maternal and neonatal emergency treatment.

Second, the government needs to increase investment in education system, energetically develop the public education, increase the degree supply, allocate the sources of nurseries kindergartens, compulsory education and social security rationally, which are to meet the demand of the new population. The government also needs to reform the household registration management, enroll school-age children nearby, and implement the free education under the appropriate conditions for young children.

Third, the government needs to improve the law, that is, adjust and implement the reproductive system of paternity leave and maternity, and prevent the job discrimination. The government needs to decrease the enterprise burden to protect women's equal employment. Moreover, the country will soon reach the employment peak, and the employment pressure will continue to maintain a higher level, so the government should promote employment policy, increase the employment channels and encourage and support self-employment for more and more people in order to solve the employment pressure.

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