Study on the Adjustments of Birth Control Policy on Population

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Abstract. In this paper, we study the adjustments of birth control policy on population. By using the national census data during 1985 to 1995, we establish a grey prediction model to forecast the total population in the future 15 year and compared it with the actual data. The conclusion is drawn that the birth control policy controls our country's population growth rate to some extent. Then, based on grey-relevant method, we analyze the factors affecting population growth in 2000 to 2010, and we obtain that the age structure and sex ratio are two main influencing factors. Based on these two main factors, we conclude that the family planning policy had an impact on population structure in our country, especially accelerated the ageing problem and the sex ratio imbalance.

Introduction

To study the effect of the one-child policy on population growth, we predict the future development through grey prediction model and compare the predicted value with the real one to discover its impact on the population and the major factors [1-3]. Then we established a gray correlation analysis and a linear regression model to discuss it. Then the new "separate two children" policy is effective or not is unknown [4-6].

According to "Beijing population and family planning regulations amendment", we know "separate two children" policy is established in March 2014 and has a significant influence on the recruit of primary schools, but there is certainly a lag period. Namely, children affected earliest are born in 2015 and the influence on the scale will not appear until 2021, which will not affect that of 2015-2020. We establish a fertility model by consulting the Beijing census data and the Beijing municipal bureau of statistics released by the Beijing statistical yearbook data and forecast the recruit of 2015-2025 by changing the total fertility rate.

The model

We gain the following data through the statistical yearbook of China population.

Table 1 the total population of China of 1985-1995 (unit: $)

year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
number	10.5851	10.75	10.93	11.1026	11.2704	11.4333	11.5823	11.7171	11.8517	11.985	12.1121

Now we establish the following GM(1,1) model to the total population in the future 15 year.

Step 1: Class-compare verification and judgment.

Establish time-series of population from 1985 to 1995 as follows:

$x^{(0)} = \left(x^{(0)}(1), x^{(0)}(2), \cdots x^{(0)}(11) \right)$,

Solve the step-ratio by $\sigma^{(0)}(k) = \dfrac{x^{(0)}(k-1)}{x^{(0)}(k)}$, then we have

$\sigma^{(0)} = (\sigma^{(0)}(2), \sigma^{(0)}(3), \cdots, \sigma^{(0)}(11))$

For all $\sigma^{(0)}(k) \in [0.846481724,\ 1.181360413]$, $k = 2,3,\cdots,11$, we can use $x^{(0)}$ to make satisfying GM (1, 1) model.

Step 2: modeling.

1) Data processing.

Accumulate the original data $x^{(0)}$, i.e.

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

where

$$x^{(1)}(k) = \sum_{i=1}^{k} (x^{(0)}(i)) \quad , \quad x^{(1)}(1) = x^{(0)}(1) = 10.5851$$

By $x^{(1)}(k) = x^{(1)}(k-1) + x^{(0)}(k), (k = 2,3,\cdots 11)$, we can obtain $x^{(1)}(k)$.

2) Establish the differential equation.

The first order differential equation is $\frac{dx^{(1)}}{dt} + ax^{(1)} = u$.

3) Estimat the parameter a, *u* and solve the model. By means of least square method, we can get

$$[au]^T = (B^T B)^{-1}(B^T x_n)$$

$$B = \left[-\frac{1}{2}(x^{(1)}(1) + x^{(1)}(2)),1; -\frac{1}{2}(x^{(1)}(2) + x^{(1)}(3)),1; \cdots; -\frac{1}{2}(x^{(1)}(n-1) + x^{(1)}(n)),1 \right]$$

$$Y = (x^{(0)}(2), x^{(0)}(3), \cdots, x^{(0)}(n))$$

Then we can calculate

$$z^{(1)}(i) = \frac{1}{2}\left[x^{(1)}(i-1) + x^{(1)}(i)\right], (i = 2,3,\cdots,11).$$

Therefore, B, Y can be calculated.

Using MATLAB for matrix calculation, we have a = -0.0131, $u = 10.5988$, thus

$$\frac{dx^{(1)}}{dt} - 0.0131x^{(1)} = 10.5988.$$

Take $x^{(1)}(0) = x^{(0)}(1) = 10.5851$, the solution (known as time response sequence) is

$$\hat{x}^{(1)}(k+1) = (x^{(1)}(0) - \frac{u}{a})e^{-ak} + \frac{u}{a} = 819.6538e^{0.0131k} - 809.0687.$$

4) Calculate the *k* value step by step to take accumulated sequence forecast, where

$$\hat{x}^{(1)}(1) = \hat{x}^{(0)}(1) = x^{(0)}(1) = 10.5851,$$

$$\hat{x}^{(0)}(k) = \hat{x}^{(1)}(k) - \hat{x}^{(1)}(k-1),\ k = 2,3,4,\cdots,11.$$

we obtain

$$\hat{x}^{(0)} = (10.5851\ 10.808\ 11.2419\ 11.3903\ 11.5406\ 11.6929\ 11.8472\ 12.0036\ 12.1620)$$

i.e. the predictors of population in China from 1985 to the end of 1995(unit: $).

Step 3: Model testing. The index values are shown in Table 2.

Table 2. GM (1, 1) model inspection table

Average accuracy	P^0=99.74%
Posterior error ratio	C=0.0672
The little of frequency	P=1.000

That the relative error $\varepsilon(k) < 10\%$ and average accuracy P^0>90% indicates that the precision is high and it is capable to predict. Using MATLAB to calculate the result, the predictions of population from 1996 to 2010 can be received. By the census data we know the true value over the past 15 years.

It can be seen clearly that the predicted value is very close to the real value from 1996 to 2000, but there is more error in 2000-2010, which also reflects the effect is not obvious as our country has been in transition after the implementation. Since 2000, the policy has been fully implemented and the effect increases enough to check population effectively.

The Grey-relevant method

According to statistical yearbook of China population, various factors affecting the population can be known after the full implementation of the one-child policy, such as Table 3.

Table 3. China's demographic statistics from 2000 to 2010

year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
At the end of the total population (m)	126743	127627	128453	129227	129988	130756	131448	132129	132802	133450	134091
Natural growth rate	7.58	6.95	6.45	6.01	5.87	5.89	5.28	5.17	5.08	4.87	4.79
Mortality	6.45	6.43	6.41	6.4	6.42	6.51	6.81	6.93	7.06	7.08	7.11
The urban population proportion	36.22	37.66	39.09	40.53	41.76	42.99	44.34	45.89	46.99	48.34	49.95
birthrate	14.03	13.38	12.86	12.41	12.29	12.4	12.09	12.1	12.14	11.95	11.9
Aging population ratio	7.0	7.1	7.3	7.5	7.6	7.7	7.9	8.1	8.3	8.5	8.9
Sex ratio	1.067	1.06	1.06	1.061	1.062	1.063	1.063	1.062	1.061	1.059	1.052

(1) Regard total population of urban areas by the end of the year as reference sequence $x_0(k), k=1,\cdots,11$ and other factors as comparing factors sequence $x_i(k), i=1,\cdots,6; k=1,\cdots,11$. They are the natural growth rate, mortality rate, the urban population proportion, the birthrate, and aging population ratio ,sex ratio, respectively.Initialize various factors to the standardized sequence $y_i(k), i=1,\cdots,6; k=1,\cdots,11$. Then we achieve dimensionless sequence.

(2) According to the dimensionless sequence,we obtain the absolute difference $\Delta_{0i}(k)=\left|y_0(k)-y_i(k)\right|$, $\Delta_{\min}=0$ $\Delta_{\max}=0.4260$.

(3) The correlation coefficient is calculated as follows:

Let $\rho=0.5$, then we have $\xi_{0j(k)}=\dfrac{0+0.5\times 0.4260}{\Delta_{0i}+0.5\times 0.4260}$.

(4) Calculate correlation and analyze factors for advantage. As each year from 2000 to 2010 is parallel, then we take $\omega_1=\omega_2=\cdots=\omega_{11}=\dfrac{1}{11}$. Correlation between comparison and reference factors is as follows:

$$r_{0i}=\frac{1}{11}\sum_{k=1}^{11}\xi_{0i}(k)(i=1,\cdots,6).$$

Comparing by calculation, we have $r_{02}>r_{06}>r_{05}>r_{04}>r_{03}>r_{01}$, from which it can be seen that mortality, aging population ratio and sex ratio have the most impact on population.

Multiple linear regression model

To further determine the influence of various factors on the population, we build multiple linear regression model [3]. Using MATLAB we can get the residual analysis diagram shown in Figure 1.

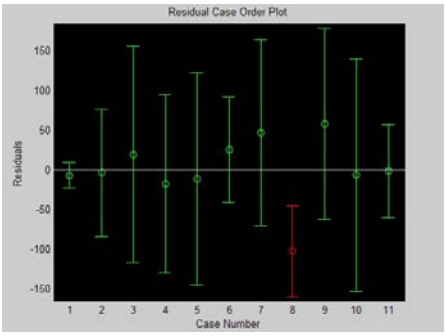

Figure 1. Residual analysis

$y=10439+210x_1+0x_2+700x_3-250x_4-1100x_5+6280x_6$, among which $R^2=1.000$ (Goodness of fit is very good), F(statistics)=3345, P=0.0000<0.05(Significance level is higher). From the figure, we have the error distributed on both ends of the origin is small. By contrasting the regression coefficient 0.0628 > 0.0110 > 0.0070 > 0.0025 > 0.0021 >0, we obtain the correlation coefficient among x_3, x_5, x_6 is higher, i.e., the urban population proportion, aging population ratio and sex ratio has larger influence on the general population. In a word, by the gray relational analysis and multiple linear regression model, aging population ratio and sex ratio are two main factors affecting the population growth during 2000-2010 when the one-child policy has been full implemented.

Conclusions

The GM(1,1) model can well predict the future population so it can be used to analyze the future population trends after the implementation of the corresponding policy , predict the future effects of general and take corresponding measures in time. Moreover, The Leslie model is presented in this paper to analyze the primary school enrollment in Beijing before and after the policy of “two separate children”. The data reflects the growth trend of enrollment, being good enough to forecast the future primary school enrollment scale, which provides a theoretical basis for the elementary school construction.

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References

[1] G.H. He. Forecast of regional Logistics requirements and application of grey prediction model, Journal of Beijing Jiaotong University(Social science Edition) 7 (2008) 35-36.

[2] S.F. Liu, T.B. Guo, Y.G. Dang, Grey Systems Theory and Its Application, Science Press, Beijing, 1999.

[3] Y.P. Wang, Population growth rate classical model of multiple regression analysis, Journal of Taiyuan Normal University (Natural Science Edition) 7 (2008) 76-79.

[4] L.J. Sun, Y.X. Sha, Y.Q. Dang, R. Ma, The financial evaluation of ST listed companies based on structural equation model, Journal of Qiqihar University 31 (2005) 87-90.

[5] W.Q. Chen, Z. Zhao, D.S. Li, The application of Leslie revised model in population prediction, World SCI-TECH R ＆ D 30 (2008) 219- 224.

[6] X. Zhang, Research on shower of gas assisted injection molding mould design, Master Thesis of Qingdao University of Science and Technology, 2011.