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Analysis on the Population Forecast of Guangxi Province During the 14th Five -Year Plan Period ——Based on GM(1,1)

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ABSTRACT
Background: At present, China's population problem has getting worse. The birth rate keeps dropping, while the aging population is growing. So it is urgent to solve the population problem. Methods: We take the population of Guangxi Province from 2011 to 2018 as the original data, and use the GM (1,1) to forecast the population of Guangxi province during The 14th Five-Year Plan. Results: ①The total population of Guangxi is increasing; ②The growth rate of population under 14 is reducing, while that of the population over 65 is increasing; ③The number of people with primary and junior high school education is decreasing, while that with high school and college education is increasing. Conclusions: Guangxi Province has a low population growth rate, a serious aging problem and a low level of education.
Keywords: *GM (1,1), The 14th Five-year plan population forecast*

1. INTRODUCTION

With the rapid development of China's economy, the population problem is becoming more and more prominent. According to statistics, the natural growth rate of China's population had increased from 4.79% in 2011 to 3.81% in 2018, with a growth rate of - 20.4%. The population over 65 had increased from 122.88 million in 2011 to 166.58 million in 2018, with the growth rate of 35.56%, and the proportion of the total population increased from 9.12% to 11.93%. This reflects that China's demographic dividend and the number of working age population has disappeared. Guangxi is the province with the largest minority population in China. The population development trend has a certain impact on the formulation of population policy in China. Therefore, it is very important to predict the population of Guangxi Province. In this study, we take the population of Guangxi Province from 2011 to 2018 as the original data, and use the GM (1,1) to forecast the population of Guangxi province during The 14th Five-Year Plan and put forward reasonable suggestions through empirical analysis.

2. AN ANALYSIS OF THE CURRENT SITUATION OF POPULATION IN GUANGXI PROVINCE

According to the statistical almanac data of Guangxi province, the total population of Guangxi shows an upward trend from 2011 to 2018. The sex ratio is balanced. The urban population increased while the rural population decreased. The population of ethnic minorities is growing slowly. Zhuang nationality becomes the majority of ethnic minorities in Guangxi.

In terms of age structure, the population aged 0-14 accounted for 21.8% in 2011 to 22.06% in 2018, with a growth rate of 1.22%; the population aged 15-64 accounted for 68.37% in 2011 to 67.98% in 2018, with a growth rate of - 0.06%; the population over 65 years old accounted for 9.83% in 2011 to 9.96% in 2018, with a growth rate of 2%. This means that the age structure of the population in Guangxi province shows the shape of "small at both ends and large in the middle". The The growth rate of newborn population is low, the number of the working population of working age is of negative growth, and the growth rate of the aging population is high.

In terms of education level, the overall education level in Guangxi is relatively low. About 30% of the school-age population only have a primary school education, about 40% have junior high school education, and only one third of the total population have high school and college education. However, according to the statistical data from 2011 to 2018, the number of people with high school and college degree or above shows a steady upward trend, while the number with primary and junior high school education shows a downward trend. This shows that the education level in Guangxi is improving, which facilitates positive significance for the development of the region.

3. EMPIRICAL PROCESS AND RESULT ANALYSIS OF GM (1,1) OF POPULATION FORECAST IN GUANGXI PROVINCE

3.1. Data Source and Modeling

The data of GM (1,1) is extracted from the statistical yearbook of Guangxi province from 2012 to 2019, as shown in Table 1. Before modeling, we should conduct data validation first. Only after the data is verified, GM (1,1) can be established.

Taking the total population, age structure (include 0-14,15-64,and over 65), education structure (include primary school, junior high school, high school, and population of junior college and above) as the original data column.

Recorded as $M_i^{\ 0} = \{ m_i^{\ 0}(1), m_i^{\ 0}(2), ..., m_i^{\ 0}(n) \}, i = 1,2...8$

The rank ratio of the sequence is $\lambda_i(k) = \frac{m_i^{\ 0}(k-1)}{m_i^{\ 0}(k)}$ $k = 2,3...n$

All the original data columns are brought into the above formula.Series $M_i^{\ 0}(i = 1,2...7)$ falls into $\lambda = (e^{-\frac{2}{n+1}}, e^{\frac{2}{n+1}})$, （0.800737403,1.248848869）, It is considered that these series $M_i^{\ 0}$ can be predicted by establishing GM (1,1). However, in the series $M_8^{\ 0}$, there is a first-order ratio that falls outside this range. Therefore, take constant C = 80 and do translation transformation to make the rank ratio of series fall into this range.

Taking the total population, age structure (include 0-14, 15-64, and over 65), education structure (include primary school, junior high school, high school, and population of junior college and above) as the original data column. Respectively recorded as,

$$M_i = \{ m_i^{\ 0}(1), m_i^{\ 0}(2), ..., m_i^{\ 0}(n) \};\ i = 1,2...8 \quad (1)$$

Carry out 1-AGO calculation

$$M_i^{\ 1} = \{ m_i^{\ 1}(1), m_i^{\ 1}(2), ..., m_i^{\ 1}(n) \} \quad (2)$$

$$7,\ m_i^{\ 1}(k) = \sum_{i=1}^{k} m_i^{\ 0}(k); l = 1,2...n \quad (3)$$

Construct data matrix B and data vector Y,

$$B = \begin{bmatrix} -\frac{1}{2}\{m_i^{\ 1}(2) + m_i^{\ 1}(1)\} & 1 \\ -\frac{1}{2}\{m_i^{\ 1}(3) + m_i^{\ 1}(2) & 1 \\ \cdots\cdots & \cdots\cdots \\ -\frac{1}{2}\{m_i^{\ 1}(k) + m_i^{\ 1}(k-1) & 1 \end{bmatrix},\ Y = \begin{bmatrix} m_i^{\ 0}(2) \\ m_i^{\ 0}(3) \\ \cdots\cdots \\ m_i^{\ 0}(n) \end{bmatrix}, \quad (4)$$

$$i = 1,2...8 \quad k = 1,2...n \quad (5)$$

Calculation parameters

$$\hat{\alpha} = \begin{bmatrix} a \\ b \end{bmatrix} = (B^T B)^{-1} B^T Y \quad (6)$$

The time response function obtained is as follows:

Table 1 Original population data of Guangxi Province

Year	Total Population	Age structure (unit: 10000)			Education structure (unit: 10000)			
	(unit: 10000)	0-14	15-64	Over 65	Primary School	Junior Middle School	Senior High School	College or Above
	M^0_1	**M^0_2**	**M^0_3**	**M^0_4**	**M^0_5**	**M^0_6**	**M^0_7**	**M^0_8**
2011	5199	1133.38	3554.56	511.06	1612.04	1973.36	565.14	305.73
2012	5240	1150.70	3578.92	510.38	1552.39	2051.05	578.42	309.27
2013	5282	1139.33	3632.43	510.24	1534.81	2081.44	599.41	326.09
2014	5475	1181.51	3764.06	529.43	1578.59	2157.37	624.7	346.78
2015	5518	1218.93	3748.93	550.14	1531.46	2017.41	670.02	452.08
2016	5579	1231.84	3792.05	555.11	1544.51	2038.83	693.84	457.10
2017	5600	1238.16	3804.64	557.2	1531.63	2045.66	722.23	459.24
2018	5659	1248.38	3846.99	563.64	1527.56	2066.79	760.26	466.22

$$\hat{m}_1^{1}(\mathrm{k}+1)=\{\ m_1^{0}(1)+398899.0724\ \}e^{0.012953047k}-398899.0274$$

$$\hat{m}_2^{1}(\mathrm{k}+1)=\{\ m_2^{0}\ (1)+69709\ \}e^{0.016k}-69709 \quad (7)$$

$$\hat{m}_3^{1}(\mathrm{k}+1)=\{\ m_3^{0}\ (1)+317820\ \}e^{0.0112k}-317820 \quad (8)$$

$$\hat{m}_4^{1}(\mathrm{k}+1)=\{\ m_4^{0}(1)+26978\ \}e^{0.0184k}-26978 \quad (9)$$

$$\hat{m}_5^{1}(\mathrm{k}+1)=\{\ m_5^{0}(1)-588363\ \}e^{-0.00265k}+588363 \quad (10)$$

$$\hat{m}_6^{1}(\mathrm{k}+1)=\{\ m_6^{0}(1)-846467\ \}e^{-0.00247k}+846467 \quad (11)$$

$$\hat{m}_7^{1}(\mathrm{k}+1)=\{\ m_7^{0}(1)+11567\ \}e^{0.0463k}-11567 \quad (12)$$

$$\hat{m}_8^{1}(\mathrm{k}+1)=\{\ m_8^{0}(1)+5962.42888\ \}e^{0.0609k}-5962.42888$$

According to Professor Liu Sifeng's research on the relationship between the period predicted by GM (1,1) land the range of development coefficient, when the development coefficient - a $\leqslant$ 0.3, the GM (1,1) can be used for medium and long-term prediction[1]. The eight development coefficients obtained by calculation are within the range, so it can be used to predict the population of Guangxi province in the next seven years. Then, according to the time response sequence, the calculated value of the generated number is calculated, Find the original data restore value

$$\hat{m}^0(k)=\hat{m}^1(k)-\hat{m}^1(k-1),\ \hat{m}^0(1)=x^0(1). \quad (13)$$

3.2. Empirical Testing Process

In order to ensure the accuracy, GM (1,1) is generally tested after the modeling. The inspection process includes: residual test, post detection error test and small error probability test. The accuracy of data analysis of GM (1,1) is shown in Table 2.

3.2.1. Residual test

Suppose the original sequence is

$$M_i^{0}=\{\ m_i^{0}(1),m_i^{0}(2),...,m_i^{0}(\mathrm{n})\ \} \quad (14)$$

The simulation sequence of the corresponding prediction model is as follows;

$$\hat{M}_i^{0}=\{\ \hat{m}_i^{0}(1),\hat{m}_i^{0}(2),\ldots,\hat{m}_i^{0}(\mathrm{n})\ \} \quad (15)$$

Table 2 Index inspection grade

Index	I	II	III	IV
Average relative error α	0.01	0.05	0.1	0.2
Mean square deviation ratio C	0.35	0.5	0.65	0.8
Small error probability P	0.95	0.8	0.7	0.6

Then, the sequence of the corresponding residuals is

$$\varepsilon_i^{0}=(\varepsilon_i^{0}(1),\varepsilon_i^{0}(2),\ldots,\varepsilon_i^{0}(\mathrm{n})) \quad (16)$$

Among them,

$$\varepsilon_i^{0}=m_i^{0}(k)-\hat{m}_i^{0}(k);k=1,2\ldots n \quad (17)$$

Then, the fitting relative error

$$\Delta_{i(k)}=\left|\frac{\varepsilon_i^{0}(k)}{m_i^{0}(k)}\right|;k=1,2\ldots\mathrm{n} \quad (18)$$

Then, the average relative error is $\overline{\Delta}_i=\frac{1}{\mathrm{n}}\sum_{k=1}^{n}\Delta_{i(k)}$

Given α , when $\overline{\Delta}<\alpha$, the model is called residual qualified model.

3.2.2. Mean square error ratio and small error probability

Let M_i^{0} be the original sequence, $\hat{M}_i^{0}$ the corresponding simulated sequence, and ε_i^{0} the residual sequence between M_i^{0} and $\hat{M}_i^{0}$,

$$\overline{m}_i=\frac{1}{\mathrm{n}}\sum_{k=1}^{\mathrm{n}}m_i^{0}(k)\ \ S_{i1}^{2}=\frac{1}{\mathrm{n}}\sum_{k=1}^{n}(m_i^{0}(k)-\overline{m}_i)^2, \quad (19)$$

Mean and variance of M_i^{0} , respectively;

$$\bar{\varepsilon}_i=\frac{1}{\mathrm{n}}\sum_{k=1}^{\mathrm{n}}\bar{\varepsilon}_i^{0}(k),\ S_{i2}^{2}=\frac{1}{\mathrm{n}}\sum_{k=1}^{n}(\varepsilon_i^{0}(k)-\bar{\varepsilon}_i)^2, \quad (20)$$

Mean and variance of residuals,

The mean square error ratio is $C=\frac{S_{i2}}{S_{i1}}$,

Given C_0 , when $C<C_0$, the model is called mean square error ratio qualified model.

Small error probability

$$P=\left\{(\varepsilon_i^{0}(k)-\bar{\varepsilon}_i)<0.6745S_1\right\} \quad (21)$$

Given P_0 ,when $P>P_0$, the model is called small error probability qualified model.

According to the above calculation, the accuracy test results of these eight groups of data are shown in Table 3. The accuracy tests of GM (1,1) except for M_6 are completely qualified. One of the test indexes of M_6 reaches the second level accuracy, it can be considered as qualified; the remaining two inspection indexes are in the third level, it can be considered as barely qualified.In general, the eight groups of data have passed the accuracy test and can be used for long-term prediction.

4. ANALYSIS OF EMPIRICAL RESULTS

The GM (1,1) of population forecast in Guangxi province has passed a series of tests and obtained high accuracy. Therefore, the GM (1,1) can be used to forecast the population of Guangxi from 2020 to 2025. The prediction results are shown in Table 4.

According to Table 4, the total population of Guangxi province shows an increasing trend. The population of all ages is growing. The number of people with junior high school education is declining, and the number of people with senior high school education is increasing. It is estimated that in 2025, the total population will reach 62.3455 million, the population under 14 will reach 13.8687 million, the population aged 15-64 will reach 41.7952 million, and the population over 65 will reach 6.4789 million. The number of people with primary school education will reduce to 15.0256 million, that of junior high school education will reduce to 2015.15 million, the number of people with high school education will reach 10.5078 million, with an increase rate of 26.01%; the number of people with college degrees or above will be 880.95, with a growth rate of 35.63%.

Table 3 Accuracy test results

Index	M1	M2	M3	M4	M5	M7	M8
α	0.0064	0.0076	0.0062	0.008	0.006	0.0052	0.0416
C	0.2393	0.2766	0.2913	0.2762	0.4884	0.065	0.3752
P	1	1	1	1	1	1	0.875

5. CONCLUSION AND SUGGESTION

By using the GM (1,1) to predict the population of Guangxi, we can find that the birth rate of Guangxi is low. The labor supply will show a downward trend in the future. The elderly account for 14.13% of the total population. This shows that the aging problem in this region has become serious. The total dependency ratio reaches 48.68%, indicating that the labor force in this region has a heavy burden of dependency. In terms of education level, the number of people with low education decreased, while that with high education increased, the overall education level was improved, the cultural quality of the population was generally improved, and the proportion of highly educated talents was increasing year by year, which played a positive role in the economic development of the region. Population is an important guarantee for urban development. In order to speed up economic development in Guangxi province, we must solve all kinds of population problems, include aging, low birth rate and education level.

5.1. Sustainable Development of the Elderly Industry

Guangxi is one of the most aging provinces in China. Elderly care industry is relatively perfect. However, there are still many problems like idle resources and insufficient effective supply[2]. Nursing homes are either expensive or lack of hardware. According to the survey, nursing home occupancy rate of Guangxi hits about 3%, and the vacancy rate is relatively higher[3]. Therefore, Guangxi government should set up sound pension institutions, and supervise the pricing,hardware equipment and services of such pension institutions. As a multi-ethnic region, the geographical location of Guangxi is also very advantageous. The government can leverage the local folk customs and abundant medicinal material resources to develop a number of pension service institutions with national characteristics.

5.2. Establishing a Sound Social Security System

Guangxi government must improve the basic endowment insurance system, ensure that the basic pension of enterprise retirees participating in social plan is paid in full and on time, establish a diversified pension service system composed of government, society and family, provide medical, educational, nursing, entertainment and other services for the elderly, establish a social assistance system for the poor elderly, and constantly improve their living standards[4]. At the same time, the government should vigorously promote the traditional culture of "filial piety", encourage family support for the aged, and take the family pension as a supplement to the social pension, so as to build a harmonious society in which the elderly can rely and have security.

Table 4 Forecast results

Year	M1	M2	M3	M4	M5	M6	M7	M8
2020	5843.57	1280.1	3952.24	590.98	1522.63	2040.16	833.5	649.55
2021	5919.75	1300.77	3996.69	601.95	1518.59	2035.13	873.02	690.37
2022	5996.93	1321.78	4041.63	613.12	1514.57	2030.12	914.42	733.75
2023	6075.11	1343.13	4087.08	624.5	1510.55	2025.12	957.78	779.86
2024	6154.31	1364.83	4133.04	636.09	1506.55	2020.13	1003.2	828.87

2025	6234.55	1386.87	4179.52	647.89	1502.56	2015.15	1050.78	880.95

5.3. Formulate Policies to Encourage Childbearing

In 2016, after the Fifth Plenary Session of the 18th CPC Central Committee announced the policy to allow all married couples to have two children, the birth rate in Guangxi did not rise significantly, which means that the implementation of the two-child policy is facing many obstacles. In order to eliminate these obstacles, Guangxi government should introduce relevant policies to encourage childbirth, such as adjusting the medical expenses of childbirth, encouraging enterprises to pay infant care fees, implementing paternity leave etc. To formulate policies to encourage childbearing is not only to respond to the call of the state, but also to help reserve the potential local labor force.

5.4. Increase Local Government's Support for Higher Education

Higher education in Guangxi is not only a cornerstone of education development, but also a cornerstone of social development. According to the forecasts, the population with higher education accounts for only a small proportion of the total population, mainly due to ethnic characteristics and geographical location. Therefore, the government should give some policy support to ethnic minority students, such as adding scores to the national college entrance examination, offering courses related to minority culture and offering Chinese courses. Secondly, colleges and universities can offer courses related to the local tourism industry to attract more local students. Finally, the government should invest a lot of human resources and financial resources, make use of local advantages, and create colleges and universities with local characteristics to promote local education development.

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