A Study on the Relationship between Population Aging and Economic Development in Sichuan Province Based on Grey MGM (1,m) Model

Yi ZHANG

College of Mathematics and Information China West Normal University Nanchong, Sichuan, the People's Republic of China

Keywords: Population aging, Economic development, Grey MGM (1,m) Model.

Abstract. Based on the data of GDP per capita and the proportion of the aged population in Sichuan Province from 1994 to 2010, a multivariable grey MGM(1,2) model is established. The fitting degree of the model is as high as 93%, so the model is reliable. The relationship between population aging and economic development in Sichuan has been obtained: population aging has a greater positive impact on itself, a greater inhibitory effect on economic development, and economic development has a strong positive impact on itself, and has a weak side effect on population aging. Population aging and economic development are interrelated and complement each other. Some countermeasures and suggestions are put forward for the problem of population aging.

Introduction

With the rapid development of the global economy, the problem of population aging is becoming increasingly prominent in the 21st century. China will also be faced with various problems brought about by the aging of the population. How to correctly treat and deal with the relationship between population aging and economic development? The rapid aging of the population will bring great pressure to the future economic and social development. How to cope with the challenge of aging and realize the development of economic and social sciences, Fast and good development is particularly important.

In order to make an in-depth and detailed analysis of the relationship between the aging population and economic development in Sichuan Province, We select the GDP per capita as indicators of economic development and the proportion of population over 65 years old as population aging in Sichuan Province. Based on the relevant data from 1994 to 2010, we use the multivariate grey MGM(1,2) model to study the relationship between them.

Since its birth in 1982, grey system theory has been widely used in economy, management and engineering technology. Grey prediction model is one of the core contents of grey system theory. Therefore, it is superior to the traditional prediction method. The multivariable grey MGM(1,m) model is mainly used to study the correlation between the multi-column data, and can predict each column data according to the fitting model[1]. This model is both an analytical model and a prediction model, so it is widely used in real life production. Now, we will use grey MGM(1,2) model to analyze the relationship between population aging and economic development in Sichuan.

Introduction of Multivariable Grey MGM(1,m)[2-3]

Let the original data matrix be $X^{(0)} = \{X^{(0)}_1, X^{(0)}_2, \cdots, X^{(0)}_m\}^T$, in which the $X^{(0)}_j$ is the observed value series at the time of 1,2,...,n, that is $X^{(0)}_j = \{x^{(0)}_j(1), x^{(0)}_j(2), \cdots, x^{(0)}_j(n)\}^T, j = 1,2,\cdots,m$, the newly generated data matrix $X^{(1)}$ is called 1-AGO matrix of the original data matrix, that is $X^{(1)} = \{X^{(1)}_1, X^{(1)}_2, \cdots, X^{(1)}_m\}^T$, in which $X^{(1)}_j$ is 1-AGO series of $X^{(0)}_j$, that is $X^{(1)}_j = \{x^{(1)}_j(1), x^{(1)}_j(2), \cdots, x^{(1)}_j(n)\}^T, x^{(1)}_j(i) = \sum_{k=1}^{i} x^{(0)}_j(k), j = 1,2,\cdots,m, i = 1,2,\cdots,n$.

The grey differential equation of the multivariable grey MGM(1,m) model is
\[
\frac{dT^1(t)}{dt} = AX^1(t) + B, \text{ in which } A = (a_{ij})_{m \times n}, B = (b_1, b_2, \ldots, b_m)^T, \text{ the time response of the model is } X^1(t) = e^{A(t-1)}(X^1(1) + A^{-1}B) - A^{-1}B, \text{ and the whitening differential equation of the model is } x_j^{(0)}(k) = \sum_{l=1}^{m} a_{jl} z_l^{(1)}(k) + b_j, j = 1, 2, \ldots, m, k = 2, 3, \ldots, n. \text{ in which } z_l^{(1)}(k) = \frac{1}{2}(x_l^{(1)}(k-1) + x_l^{(1)}(k)) \text{ for } l = 1, 2, \ldots, m, k = 2, 3, \ldots, n. \text{ By the least square method, the parameter can be obtained: } \hat{\alpha}_j = (\hat{\alpha}_{j1}, \hat{\alpha}_{j2}, \ldots, \hat{\alpha}_{jm}, \hat{b}_j)^T = (P^TP)^{-1}P^TY_j, \text{ in which } P = \begin{bmatrix}
0 & z_1^{(1)}(2) & \cdots & z_1^{(1)}(m) \\
0 & z_1^{(1)}(3) & \cdots & z_1^{(1)}(m) \\
\vdots & \vdots & \ddots & \vdots \\
0 & z_1^{(1)}(n) & \cdots & z_1^{(1)}(m) \\
\end{bmatrix}, Y_j = \begin{bmatrix}
x_j^{(0)}(2) \\
\vdots \\
x_j^{(0)}(n) \\
\end{bmatrix}, j = 1, 2, \ldots, m, \text{ thus the parameter matrix } A \text{ and the parameter vector } B \text{ can be obtained: } \hat{A} = (\hat{\alpha}_{j1}, \hat{\alpha}_{j2}, \ldots, \hat{\alpha}_{jm})^T, \hat{B} = (\hat{b}_1, \hat{b}_2, \ldots, \hat{b}_m)^T. \text{ So, the response formula of the model is: } \hat{X}^1(t) = e^{\hat{\alpha}(t-1)}(X^1(1) + \hat{A}^{-1}\hat{B}) - \hat{A}^{-1}\hat{B}, \text{ and its reduction vector is: } \hat{X}^{(0)}(k) = \hat{X}^1(k) - \hat{X}^1(k-1), k = 2, 3, \ldots, n.
\]

**An Analysis of the Relationship between Population Aging and Economic Development in Sichuan Province**

We select the GDP per capita and the proportion of population over 65 years old as indicators of economic development and population aging in Sichuan Province. According to Sichuan Statistics, we select the data from 1994 to 2010 as the research object.

According to the data in the table, the dimensions of GDP per capita and the proportion of population over 65 years old in Sichuan Province are not consistent. In order to make the analysis results more reliable, before modeling, we first make a transformation to eliminate the influence of dimension.

Let the proportion of population over 65 years of age be a sequence \( x_1 = (x_1(1), x_1(2), \ldots, x_1(n)) \), and the per capita GDP sequence be a series \( x_2 = (x_2(1), x_2(2), \ldots, x_2(n)) \), let \( x_j^{(0)}(k) = \frac{x_j(k)}{x_1(l)}, j = 1, 2, k = 1, 2, \ldots, n \), so we establish a grey MGM( 1,2) model for the sequences \( x_1^{(0)} = (x_1^{(0)}(1), x_1^{(0)}(2), \ldots, x_1^{(0)}(n)), x_2^{(0)} = (x_2^{(0)}(1), x_2^{(0)}(2), \ldots, x_2^{(0)}(n)) \). The result can be calculated by Matlab:

\[
A = \begin{pmatrix}
0.0408 & -0.0037 \\
-0.2087 & 0.2292
\end{pmatrix}, \quad B = \begin{pmatrix}
0.9794 \\
1.2695
\end{pmatrix}
\]

\[
x_1^{(1)}(k) = 0.0408 z_1^{(1)}(k) - 0.0037 z_1^{(1)}(k) + 0.9794 \\
x_2^{(1)}(k) = -0.2087 z_1^{(1)}(k) + 0.2292 z_1^{(1)}(k) + 1.2695
\]

We can get the fitting results of the model.

From the fitting results of the model, we can see that the fitting effect of the model is very good. The average relative error for the GDP per capita is: 3.31, the accuracy is 96.699. The average relative error for the proportion of the aged population over 65 is: 6.70, and the accuracy is 93.300. Therefore, the model is valid.

By observing the structure of the model, we can draw the conclusion that the aging of the population is mainly influenced by itself, and that economic development has a certain negative impact on it. Although it is very weak, it has a certain inhibitory effect on the aging of the
population. The economic implication behind it is that with the development of economy, the number of per capita resources is becoming increasingly scarce, the income of the aged population is decreasing, the cost of living and medical treatment is increasing, the policy of the second child is gradually opening up, and the birth rate is increasing. Economic development is also affected by itself and the aging of the population, and the side effects of population aging on economic development are more obvious, almost as well as the impact of economic development on their own. The positive effect is quite the same, the reason is that the aging of the population will lead to the decrease of the quality and quantity of labor force and the reduction of the demand for social consumption, etc., which will have a great inhibitory effect on the economic development.

### Table 2. Model fitting results.

| Year | The proportion of population over 65 years old (%) | The GDP per capita (yuan) |
|------|--------------------------------------------------|--------------------------|
|      | actual value | fitted value | Relative error (%) | actual value | fitted value | Relative error (%) |
| 1994 | 6.79        | 7.03         | 3.99               | 2481        | 2481         | -               |
| 1995 | 7.32        | 7.03         | 3.99               | 3043        | 3043         | -               |
| 1996 | 7.70        | 7.28         | 5.39               | 3550        | 3549         | 0.03           |
| 1997 | 7.97        | 7.55         | 5.26               | 4032        | 3828         | 5.06           |
| 1998 | 8.24        | 7.82         | 5.06               | 4294        | 4156         | 3.22           |
| 1999 | 8.33        | 8.10         | 2.71               | 4540        | 4544         | -0.09          |
| 2000 | 7.44        | 8.39         | -12.79             | 4956        | 5009         | -1.06          |
| 2001 | 7.56        | 8.68         | -14.89             | 5376        | 5568         | -3.56          |
| 2002 | 8.62        | 8.98         | -4.25              | 5890        | 6245         | -6.02          |
| 2003 | 8.68        | 9.29         | -7.04              | 6623        | 7071         | -6.77          |
| 2004 | 8.76        | 9.60         | -9.59              | 7895        | 8084         | -2.39          |
| 2005 | 10.92       | 9.91         | 9.25               | 9060        | 9331         | -2.98          |
| 2006 | 11.30       | 10.21        | 9.57               | 10613       | 10872        | -2.59          |
| 2007 | 10.99       | 10.52        | 4.27               | 12963       | 12785        | 0.84           |
| 2008 | 11.45       | 10.81        | 5.55               | 15495       | 15164        | 1.39           |
| 2009 | 10.67       | 11.09        | -3.94              | 17339       | 18132        | -4.57          |
| 2010 | 10.95       | 11.34        | -3.61              | 21182       | 21842        | -3.11          |

### Policy Thinking on the Acceleration of Population Aging

Population aging is an objective necessity in the process of world economic and social development. As far as our country is concerned, with the continuous development of economy and society, population aging has a tendency of accelerating continuously. We should try our best to increase the social value of the elderly population. To reduce the burden on society, the following recommendations are made[4-6]:

- To develop the aging industry, clearly the priority areas of the development of aging industry. The huge size of the elderly population is a potentially huge market, the elderly population diverse consumer demand can lead to a broad prospects for development of the aging industry. Now the old people need to do some work, and they live close to the most then, to promote the development of the whole industry of aging.

- Promote healthy aging and tap the potential of human capital. For the elderly who are healthy and have the ability to continue to work, we should actively use their rich experience, skilled technology, play their own strengths, and ensure their re-employment opportunities.

- Good social security system can increase the investment and loan confidence of the elderly, reduce the old people's savings rate, increase the social capital investment, and promote the virtuous circle of economic development.

### Acknowledgement

This research was financially supported by the Scientific Research Fund of China West Normal University(14D015).
This research was financially supported by the Excellence Scientific Research Fund of China West Normal University (17YC395).

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