

Research on fertility Policy under the background of three-child Policy

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Abstract. The number and structure of population are important factors affecting social and economic development. The implementation of the three-child policy is a family planning policy implemented by China to actively cope with the aging population. In this paper, by referring to the statistical yearbook and other relevant data and combining the current national conditions of China, the Leslie matrix population model and a variety of evaluation models and machine learning classification algorithm were established to complete the analysis and discussion of the influencing factors under the three-child policy, as well as the prediction of the future population situation and suggestions for the future related policies.

Keywords: Leslie matrix population model; TOPSIS; Grey correlation analysis.

1. Background of the problem

The number and structure of population are important factors affecting social and economic development. China has experienced "family planning", "universal two-child policy", and then the implementation of "three-child policy", which are all adjustments to the trend of China's population development and change. The three-child policy is a family planning policy implemented by China to actively cope with the aging population., to form a complete set of support measures how to implement after birth is currently one of the most concern of the people of childbearing age[1], in this paper, combined with China's population age structure, establish mathematical model of predicting after three children open the population of the next 10 years in China, and analyzes the policy of "ShuangJian" after landing impact on whether there will be new born population of our country[2].

2. Leslie matrix population model

2.1 Model establishment

The Leslie model is a population growth model grouped by age, which is different from the exponential growth model and the retarded growth model. In this paper, we need to consider factors such as age structure, sex ratio and fertility policy, and only the Leslie model can meet this requirement[3]. Therefore, we establish the population prediction model according to the following steps[4].

Step1. Set the ratio of birth population to school-age females

$x_i(t)$ Represents the total number of people in the t year, the number of babies born in year t + 1 satisfies formula (1) :

$$x_0(t+1) = \sum_{i=1}^n b_i(t) k_i x_i(t) \quad (1)$$

When the age is I years old and not within the range of childbearing age, let $B_i = 0$, the ith year old is not going to have children[5]. And then we introduce the symbol h_i To represent the proportion of the number of babies born by females at the age of I to females of childbearing age, as shown in Formula (2).

$$h_i = \frac{b_i(t)}{\beta(t)} \tag{2}$$

In addition, the logical relationship as shown in Formula (3) is satisfied, that is, the sum of the number of babies born by women of all ages in the proportion of women of childbearing age is 1. h_i

$$\sum_{i=1}^n h_i = 1 \tag{3}$$

Assume that the symbol is the average number of babies born to all women of reproductive age in year $t+1$, and assume that fertility patterns are only related to age. $\beta(t)$ To make. $r_i = h_i k_i$ Formula (4) can be obtained from the above two equations.

$$x_0(t+1) = \beta(t) \sum_{i=0}^n r_i x_i(t) \quad , \quad \beta(t) = \sum_{i=0}^n b_i(t) \tag{4}$$

Step2. Set the mortality rate and the number of deaths

The total death rate in t year is shown in Formula (5). $d_i(t)$

$$y(t+1) = \sum_{i=0}^n d_i(t) x_i(t) \tag{5}$$

Then the symbol $GI[6]$, which represents the mortality rate of the population at the age of I , is introduced to represent the proportion of the mortality rate among all age groups, as shown in formulas (6) and (7).

$$g_i = \frac{d_i(t)}{\alpha(t)} \tag{6}$$

$$\alpha(t) = \sum_{i=0}^n d_i(t) \tag{7}$$

Assuming that the proportion of deaths is related only to age, we assume that the survival rate satisfies formula (8). $s_i(t)$

$$s_i(t) = 1 - \alpha(t) g_i \tag{8}$$

The number of people who are less than n years old in year $T + 1$ $I + 1$ that is, the number of people who are alive in year T at the i th year is shown in Formula (9).

$$x_{i+1}(t+1) = s_i(t) x_i(t) \tag{9}$$

We assume that when $I + 1$ equals n represents all people older than $n-1$, then we have Formula (10) as follows.

$$x_n(t+1) = s_{n-1}(t) x_{n-1}(t) + s_n(t) x_n(t) \tag{10}$$

Where is the number of people aged $n-1$ who survived in t years, and is the number of people aged n or greater who survived in t years. $s_{n-1}(t) x_{n-1}(t) \quad s_n(t) x_n(t)$

Step3. Set the column vectors of each age group of the population

From the above, a recursive relationship can be calculated for the population size of all age groups. Then, the population can be grouped by age into column vectors as shown in Formula (11).

$$x(t) = [x_0(t), x_1(t), x_2(t), \dots, x_n(t)]^T, t = 0, 1, 2, \dots \tag{11}$$

Then, constant matrix C , death matrix D and birth matrix B are introduced as shown in Formula (12).

$$C = \begin{bmatrix} 0 & 0 & L & 0 & 0 \\ 1 & 0 & L & 0 & 0 \\ 0 & 1 & L & 0 & 0 \\ M & M & & M & 0 \\ 0 & 0 & L & 1 & 1 \end{bmatrix}, D = \begin{bmatrix} 0 & 0 & L & 0 & 0 \\ g_0 & 0 & L & 0 & 0 \\ 0 & g_1 & L & 0 & 0 \\ M & M & & M & 0 \\ 0 & 0 & L & g_{n-1} & g_n \end{bmatrix}, B = \begin{bmatrix} r_0 & r_1 & L & r_{n-1} & r_n \\ 0 & 0 & L & 0 & 0 \\ 0 & 0 & L & 0 & 0 \\ M & M & & M & 0 \\ 0 & 0 & L & 0 & 0 \end{bmatrix} \quad (12)$$

Then, the recursion relation of population grouping vector by age can be expressed as Formula (13).

$$x(t+1) = [C - \alpha(t)D]x(t) + \beta(t)Bx(t) \quad (13)$$

Where $x(t)$ is the number of surviving population at all ages in t year, and $\beta(t)Bx(t)$ is the number of newborns in $T + 1$ year.

Step4. Set the total population

The most basic demographic indicator is the total population: $N(t) = \sum_{i=1}^n x_i(t)$

Step5. Set the average age

The mathematical expression is shown in Formula (14).

$$R(t) = \frac{1}{N(t)} \sum_{i=1}^n ix_i(t) \quad (14)$$

Step6. Set the dependency ratio for the elderly

The mathematical logic relation is shown in Formula (15).

$$\alpha(t) = \frac{\sum_{i=0}^{15} x_i(t)}{\sum_{i=16}^{64} x_i(t)} + \frac{\sum_{i=65}^n x_i(t)}{\sum_{i=16}^{64} x_i(t)} \quad (15)$$

Step7. Set birth policy regulatory factors

We define the regulatory effect γ , and assume that the future TFR does not exceed 3 and meets the growth law as expressed in Formula (16), where TFR is the TFR in the initial year ($T_0 = 2020$). β_0

$$\beta(t) = \frac{3}{1 + (3/\beta_0 - 1)\exp\left\{-\frac{\gamma}{10}(t - t_0)\right\}} \quad (16)$$

2.2 Solving the model

Next, we use MATLAB programming to solve[7].According to the mathematical logic relationship established above, the changes in the number and structure of China's population, as well as the corresponding aging degree and social support burden are predicted. As shown in figure 1 and figure 2, figure 1 shows our country population over the next 10 years compared with more than 65 - year - old population, it can be seen in the next ten years is still the continuation of the trend since 1995, the country's population rise in small scope first, and then began to slowly fall in 2024, and the quantity is more than 65 - year - old population is constantly rising even rising velocity increases gradually[8].As can be seen from Figure 2, the average age of China's population rose at first, and then was 41.277 years old in 2032, and then continued to decline.

Figure Comparison of total population and population over 65 Figure2 Prediction of change in average age[9].In 2032, as shown in figure 3 represents the age of population accounted for more than a prediction results, as shown in the 20 to 48, 2032 accounted for the vast majority of the population, and as the increase of age, the age, the proportion of each more and more small[10], in percentage of the population is between 0 to 20 years old has been in a steady state, at an average.

Step2. Calculate range

Assuming that α Is the minimum difference between two poles, β Is the maximum difference between the two poles, then their mathematical logic relation formula is shown in (17).

$$\begin{aligned}\alpha &= \min(i) \min(k) |y_0(k) - x_i(k)| \\ \beta &= \max(i) \max(k) |y_0(k) - x_i(k)|\end{aligned}\quad (17)$$

The mathematical logic relation of the correlation coefficient (Gamma value) is shown in Formula (18). Y

$$Y(y_0(k), x_i(k)) = \frac{\alpha + \beta * \rho}{|y_0(k), x_i(k)| + \beta * \rho} \quad (\rho \text{取} 0.5) \quad (18)$$

Then we assume that the grey correlation degree is used $Y(y_0(k), x_i(k))$ Formula (19) is shown as follows.

$$Y(y_0(k), x_i(k)) = \frac{1}{n} \sum_{k=1}^{43} Y(y_0(k), x_i(k)) \quad (19)$$

4. Model improvement

Step1. Introduce new models for improvement

Aiming at the shortcomings of traditional grey relational analysis model, this paper introduces dynamic resolution coefficient and TOPSIS method to improve it. It can be seen that the advantage of TOPSIS method is to represent the distance between the data of different sequences, which can just make up for the disadvantage that the traditional grey correlation analysis model cannot well reflect the difference between the data. The mathematical expression of the judgment coefficient is shown in (20).

$$\rho_{\Delta_i} = \frac{\frac{1}{n} \sum_{j=1}^n \Delta_{ij}}{\Delta_{\max}} \quad (20)$$

Step2. Determine the judgment coefficient

If 0.5 is taken as the boundary value, when the coefficient is judged, it indicates that the sequence of influencing factors is relatively stable, and any choice can enhance the difference between the correlation degrees. $\rho_{\Delta_i} > 0.5$ $\rho \in [0.8, 1]$ When, it indicates that the sequence of influencing factors fluctuates greatly, and a smaller value should be taken to reduce the influence on the calculation results. In this paper $\rho_{\Delta_i} < 0.5$ $\rho \Delta_{\max} \rho = 4\rho_{\Delta_i}^2$

Step3. Improved expression method of correlation degree

The core idea of grey correlation analysis can be understood as evaluating the pros and cons by comparing the distance between different sequences to be evaluated and positive ideal sequences. When the distance between the sequence to be evaluated and the forward ideal sequence is the same, it is impossible to judge whether the sequence is good or bad. X_i, X_j, X_0, X_i, X_j By introducing the idea of TOPSIS method and assuming that the sequence of negative reasoning is, a superior judgment can be made by observing the distance relative to. $X_0^- = [X_{0,1}^-, X_{0,2}^-, \dots, X_{0,m}^-]$ $X_i, X_j, X_0^-, X_i, X_j$ By introducing this idea into grey correlation analysis, the mathematical expression of the overall grey correlation degree between the influencing factors of the first newborn population and the negative ideal sequence is shown in Formula (21). i, X_0^-

$$\varphi_i^- = \frac{1}{n} \sum_{j=1}^n \beta_{ij}^- \quad (i = 1, 2, \dots, m) \quad (21)$$

The influence degree of each influencing factor on the new-born population was characterized by comprehensive grey correlation degree I, and the formula is shown in (22).

$$\varepsilon = \frac{\varphi_i}{\varphi_i + \varphi_i^-} \tag{22}$$

5. Solution of the model

Step1. Solve the negative ideal solution distance

The idea of TOPSIS method is introduced, and the negative ideal sequence is set as, then the superior judgment can be made by observing the distance relative to. $X_0^- = [X_{0,1}^-, X_{0,2}^-, \dots, X_{0,m}^-]$ X_i, X_j $X_0^- X_i X_j$ Using Topsis, the negative ideal solution distance (D-) was calculated as:

[0.11743786,0.11075296,0.13350543,0.15756338,0.20676654...

0.28310455,0.33635035,0.40910271,0.48723234,0.53897814,]

Step2. Solve index weights and positive and negative ideal solution values

At the same time, I calculated the information entropy value and information utility value, as well as the weight of each indicator to the parent sequence and the positive and negative ideal solution value according to the correlation of each indicator through MATLAB programming. The calculation results are shown in Table 1.

Table 1 Index weights solved by entropy weight method and Topsis positive and negative ideal solution results

| indicators | Information entropy e | Information utility d | The weight | Is the ideal solution | The negative ideal solution |
|--|-----------------------|-----------------------|------------|-----------------------|-----------------------------|
| Number of New Births (ten thousand) | 0.928 | 0.072 | 0.043 | 0.436 | 6.00 e-08 |
| Number of people with maternity insurance at year-end (10,000) | 0.877 | 0.123 | 0.073 | 0.554 | 1.00 e-08 |
| Number of people enjoying maternity insurance benefits (10,000) | 0.907 | 0.093 | 0.055 | 0.437 | 5.00 e-08 |
| Number of Medical and Health Institutions | 0.92 | 0.08 | 0.047 | 0.540 | 0 |
| Number of medical Insurance participants at the end of the year (ten thousand) | 0.82 | 0.18 | 0.107 | 0.466 | 0 |
| Per capita disposable income of residents (YUAN) | 0.882 | 0.118 | 0.07 | 0.556 | 0 |
| Per capita Disposable income growth rate (%) | 0.942 | 0.058 | 0.034 | 0.504 | 5.92 e-06 |
| Median per capita disposable income (yuan) | 0.848 | 0.152 | 0.09 | 0.569 | 0 |
| Education funds (ten thousand yuan) | 0.859 | 0.141 | 0.083 | 0.561 | 0 |
| National financial funds for education (ten thousand yuan) | 0.873 | 0.127 | 0.075 | 0.507 | 0 |
| Graduate Enrollment (ten thousand) | 0.788 | 0.212 | 0.125 | 0.638 | 1.09 e-06 |
| Enrollment of General Specialty (ten thousand) | 0.801 | 0.199 | 0.118 | 0.626 | 2.00 e-07 |
| Regular Undergraduate enrollment (ten thousand) | 0.865 | 0.135 | 0.08 | 0.539 | 7.40 e-07 |

Step3. Calculate the overall gray correlation degree and visualize the correlation coefficient

By introducing this idea into grey correlation analysis, the mathematical logic relation between the influence factor of the first newborn population and the overall grey correlation degree of the negative ideal sequence is shown in Formula (23). φ_i^-

$$\varphi_i^- = \frac{1}{n} \sum_{j=1}^n \beta_{ij}^- \quad (i = 1, 2, L, m) \quad (23)$$

The result of the negative ideal solution distance as the parent sequence, the other indicators as the sub-sequence, the grey relational degree results of each indicator are obtained. Similarly, we calculated the grey correlation coefficient between the number of newborn population and other indicators, and the results of visual analysis are shown in Figure 4.

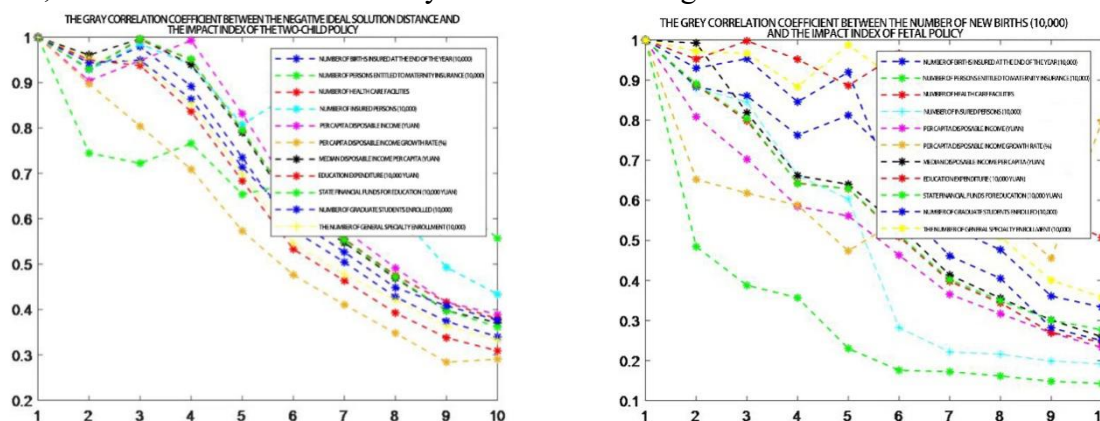


Figure 4 Visual results of grey correlation analysis

Step4. Solve the correlation coefficient of each indicator

Then we characterize the degree of influence of each influencing factor on the new-born population by integrating grey correlation degree I, and the improved index correlation coefficient can be expressed as formula (24). The calculation results of correlation coefficient are shown in Table 2.

$$\varphi_i^- = \frac{1}{n} \sum_{j=1}^n \beta_{ij}^- \quad (i = 1, 2, L, m) \quad (24)$$

Table2 Correlation coefficient results

| indicators | φ_i | φ_i^- | ε | ranki ng |
|--|-------------|---------------|---------------|-------------|
| Number of medical Insurance participants at the end of the year (ten thousand) | 0.492 | 0.809 | 0.621829 | 1 |
| Number of people enjoying maternity insurance benefits (10,000) | 0.534 | 0.775 | 0.592055 | 2 |
| Graduate Enrollment (ten thousand) | 0.588 | 0.752 | 0.561194 | 3 |
| Education funds (ten thousand yuan) | 0.591 | 0.745 | 0.557635 | 4 |
| Per capita disposable income of residents (YUAN) | 0.593 | 0.744 | 0.55647 | 5 |
| Median per capita disposable income (yuan) | 0.6 | 0.737 | 0.551234 | 6 |
| National financial funds for education (ten thousand yuan) | 0.608 | 0.73 | 0.54559 | 7 |
| Number of people with maternity insurance at year-end (10,000) | 0.656 | 0.694 | 0.514074 | 8 |
| Enrollment of General Specialty (ten thousand) | 0.667 | 0.68 | 0.504826 | 9 |
| Regular Undergraduate enrollment (ten thousand) | 0.726 | 0.661 | 0.476568 | 10 |
| Per capita Disposable income growth rate (%) | 0.718 | 0.589 | 0.45065 | 10 |
| Number of Medical and Health Institutions | 0.774 | 0.642 | 0.45339 | 11 |

According to the calculation results, among the 11 indicators with the largest correlation coefficient, education expenditure occupies the fourth position. After the issuance of the double reduction policy, education expenditure, residents' per capita disposable income and median per capita disposable income will definitely be effectively improved due to the renovation of after-school training institutions for children.

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