Prediction of Population Structure in China based on Difference Equation Model

Bohan Mu

School of Beijing No.156 Middle School, Beijing 100000, China

mbh20041002@163.com

Abstract. Population is the core issue of the development of human society, and predicting the future population changes is an important basis for a country or region to formulate corresponding policies. The theoretical basis of the prediction of population development process is the population development equation, that is, the mathematical model of population development. Aiming at the problem of population structure in China, based on the collection, calculation, collation and analysis of relevant population data, this paper builds a prediction model of population structure in China based on the difference equation method, so as to predict the population of China, and compare it with the original population data to verify and improve the model. The results show that if the current family planning policy remains unchanged, the population structure of China will be aging seriously by 2050. If the two-child family planning policy is implemented, the aging trend of China's population structure will be obviously improved, and it will be an adult population structure after 2030. If the family planning program that is looser than the two-child policy is implemented, the population structure of China will change fundamentally, and the population structure will be in line with the characteristics of younger population structure. In order to provide some reference for the formulation of relevant policies.

Keywords: Difference Equation Model; China; Population Structure Forecast.

1. Introduction

China is a populous country in the world, and the population problem is one of the key issues in China's social and economic development. After the founding of the People's Republic of China, the population of China increased rapidly [1]. The 1990s is the critical moment for China to control population growth. As the population base continues to increase and the birth peak will continue to exist in the late 1980s, the situation of population growth in China will remain very severe in the future [2]. At present, building a well-off society in an all-round way puts the development goal of China at a new level. Looking back, the development of China has been groping forward, and different development stages have different main themes. It has completed the transformation from planned economy to market economy step by step, joined in promoting international trade and exchanges, put forward the transformation and upgrading of industrial structure, and established medical insurance and old-age insurance system. Along the way, the pace of development has been steady and rapid, and the world has made remarkable achievements [3]. At present, the rapid population growth provides sufficient labor for the economic development of China. However, with the change of the age structure of the population and the disappearance of the first demographic dividend, the huge population scale has gradually evolved into a population burden [4]. Therefore, it is an important issue to analyze and forecast the population of China by using mathematical modeling method according to the existing data.

The goal of building a well-off society in an all-round way marks a new stage in the development of China. The aging of population is one of the topics that we are more concerned about. Since the implementation of the family planning policy, the main focus has been population control [5]. With the development of the times, more and more people now notice the change of population structure. The population problem has its unique development law, which is essentially different from other economic problems. The population problem is a progressive problem year by year. The current born population not only affects the total population at this stage, but also affects the future population structure [6]. The prediction of the total population is one of the most important and basic parts of

population prediction, which can provide an important basis for the government's decision-making and is the basis of other kinds of population prediction [7]. In addition, with the same total population, different age structures have different impacts on economy, society, resources and environment. Therefore, the population problem is not only a problem of quantity, but also a problem of population structure. Based on the difference equation method, this paper constructs a population structure prediction model of China [8]. At the same time, this model is used to forecast the population in the future, and the influence of the corresponding policies on the population structure changes is found by using the queue element prediction method. By establishing a prediction model of marriageable groups, the number of men and women in China's marriageable population is quantitatively analyzed, and then the population structure problems in China are summarized as a whole.

2. Difference Equation Model Establishment

Comparing the results of the fifth and sixth censuses, it is found that the aging trend of population age structure in China is strengthened [9]. After the arrival of the aging society, how to maintain the rapid economic development has become the focus of the government and academic circles. Whether it is the understanding of China's current economic situation or the grasp of its future development trend, accurate population forecast is crucial [10]. The age structure of population is mainly measured from three aspects: natural structure, economic and social structure and regional structure. These three structures are mutually infiltrated, influenced and developed together. In peacetime, it is assumed that the death rate of men and women at all ages is fixed, and that women of childbearing age are 15 to 49 years old, and the fertility rate of women of childbearing age at all ages remains unchanged. If we know the female population of all ages in the nth year, the birth and death status of women of all ages, we can deduce the female population of all age groups in the nth+1st year according to the law of population development and change.

According to the basic principle and idea of population prediction by the queue element method, this paper sets the change rate of each age group in a certain period in the future. According to this, the number of deaths and net migration in the future will be calculated, and the population at the beginning of the period will be added and subtracted to calculate the population change. So as to get the impact of the policy on the population structure. It is assumed that China's family planning policy from 2023 to 2050 will have the following three situations: maintaining the existing family planning policy, appropriately relaxing the family planning policy and relaxing the family planning policy. According to these three policies, different fertility rates are set, so as to make low, medium and high programs. Table 1 shows the age group fertility rate and total fertility rate of women of childbearing age.

Table 1. Age group fertility rate and total fertility rate of women of childbearing age

Age group	Pre-adjustment fertility rate	Adjusted fertility rate
15-19	5.92	6.10
20-24	69.48	71.58
25-29	84.07	86.60
30-34	45.85	47.23
35-39	18.72	19.28
40-44	7.52	7.75
45-59	4.67	4.81
Total fertility rate	1181.11	1213.74

Considering that the population of zero years old is the total number of babies born to women in all age groups from 15 to 49, and considering that the natural ratio of girls to boys is about 100:107. Therefore:

$$v_0(n+1)=\frac{100}{207}\sum_{k=15}^{49}b_k v_k(n) \tag{1}$$

Where b_k is the fertility rate of k-year-old women. The survival rate of male population whose q_i is i years old. The following recurrence formula can be used for the variation law of male population in each age group with time:

$$m_{i+1}(n+1)=q_i m_i(n) \tag{2}$$

$$m_0(n+1)=\frac{107}{207}\sum_{k=15}^{49}b_k v_k(n) \tag{3}$$

Although the average growth method, the average growth rate method and the exponential smoothing method are simple, convenient and fast in calculation, it is unrealistic to assume that a fixed number of people will be added every year because of many factors that affect the population growth. Therefore, the accuracy of the prediction results of this model is questioned by many people. Therefore, based on the difference equation method, this paper constructs the population structure prediction model of China. In this paper, a mathematical model for predicting the total population and the population by age and a mathematical model for controlling the birth rate so that the population can reach the predetermined target are put forward. Like other forecasting methods, this method can achieve considerable accuracy in the period of social stability. This model is characterized by considering the fertility rate of women of childbearing age at all ages.

3. Prediction and Analysis of Population Structure in China

In a country or region, if the age structure shows that children account for a large proportion, then although the social support burden is heavy, it is unfavorable to the current social production; However, with the growth of children, the overall social labor supply will continue to increase, and then the social output will continue to increase, and the overall social capital accumulation will accelerate. Therefore, this type of structure is developmental. If the proportion of adults is high, the available labor resources are abundant, and the economic development comes from the so-called demographic window. This period is a good period of development opportunities for the society. If the elderly group accounts for a large proportion, it means that the burden of social support is aggravated, and the relative overall labor supply is insufficient, resulting in a decline in productivity; There will be problems in the supply and distribution of social resources. Any country or region is bound to go through these three stages, and with the change of age structure, the economic and social structure is bound to change. Only by controlling fertility, or even taking a negative natural growth rate in a certain period, can the population be controlled in a moderate range. According to some collected data, this paper gives the survival rate of women and men at all ages, the proportion of men, the proportion of women and the fertility rate of women of childbearing age by weighted average method. Using the mathematical software Matlab, the population development of China was predicted according to different fertility rates. The base period data is the starting point of the model operation, and the selection of accurate base period data has an important influence on the accuracy of the model prediction results. In this paper, the data of the sixth census in China in 2010 is selected as the base data. The total population is divided into 16 groups, and the population aged 0-79 is divided into one group, and the population aged 80 and above.

At the beginning of the establishment of the model, this paper makes a detailed analysis of the relevant population data, including the total population, the number of people of all ages, the number of men and women, the average annual population growth rate, the birth rate, the mortality rate, the census population data, the sample survey population data, etc. At the same time, combined with the current population situation of China, the difference equation model is used to forecast. Predicting

fertility rate is the most difficult part in parameter setting, and it is also the key link in program formulation. The possibility of changing the family planning policy will have a crucial impact on the fertility rate in China. The influence of the total fertility rate of women on the dependency ratio is shown in Table 2.

Table 2. Influence of overall fertility rate of women on dependency ratio

Particular year	2025	2035	2045
B=1	0.66	0.92	0.97
B=1.5	0.65	0.69	0.71
B=1.8	0.63	0.66	0.68

It can be seen from the table that too high a fertility rate will lead to too fast population growth, while too low a fertility rate will lead to an increase in dependency ratio. When the birth control constant fluctuates around 1.8, the population increases slowly to 1.4 billion, and then the population begins to decline gradually. This not only prevents the population from growing too fast, but also controls the aging of the population, which is conducive to the development of the country and the progress of the society. Therefore, this paper holds that the total fertility rate in China should be controlled at about 1.8 in recent years. If the future fertility rate remains unchanged at the level of the current policy fertility rate, it is expected that the median age of the population in China will continue to rise by the end of the 21st century, and the aging degree will become more serious. In addition, from the change of the median age, it can be seen that in the next 20 years, the number and proportion of women of childbearing age and young labor force in China will decrease. Table 3 shows the trend of China's total population.

Table 3. Trend of total population in China

Particular year	Low scheme	Medium scheme	High scheme
2025	13.72	14.01	14.52
2030	13.63	14.17	14.82
2035	13.42	14.21	15.01
2040	13.10	14.11	15.09
2045	12.64	13.90	15.16
2050	12.05	13.63	15.22

By comparing the changing trends of population structure under three different birth plans, this paper concludes that maintaining the current family planning policy will seriously age the population structure of China, so it is imperative to adjust the family planning policy. The implementation of a more relaxed family planning policy than the two-child policy will make the population structure younger in the future, but this will bring China back to the old road of rapid population growth similar to that in 1960s and 1970s, so the high fertility rate scheme is not advisable. However, the moderate fertility rate scheme, that is, the implementation of the two-child family planning policy, can obviously improve the problem of aging population structure in China, without bringing too many new populations. At the same time, the research shows that when the fertility rate is controlled around 1.8, the population growth will increase slowly in the first 30 years or so, and then the population will gradually decrease. This not only prevents the population from growing too fast, but also controls the aging of the population, which meets the development requirements.

4. Conclusion

China is a populous country, and the population problem has always been one of the key factors restricting the development of China. At present, the aging of the population is a topic that we are more concerned about. Since the implementation of the family planning policy, the main focus has been population control. With the development of the times, more and more people now notice the

change of population structure. On the basis of collecting, calculating, sorting out and analyzing relevant population data, this paper builds a prediction model of population structure in China based on the difference equation method. At the same time, this model is used to forecast the population in the future, and the influence of the corresponding policies on the population structure changes is found by using the queue element prediction method. By establishing a prediction model of marriageable groups, the number of men and women in China's marriageable population is quantitatively analyzed, and then the population structure problems in China are summarized as a whole.

The results show that if the low fertility rate scheme is implemented, that is, the current family planning policy remains unchanged, the population structure of China will be in a very serious aging state by 2050. If the medium fertility rate scheme is implemented, that is, the two-child family planning policy is implemented, the aging trend of China's population structure will be obviously improved, and it will become an adult population structure after 2030. If a higher fertility rate scheme is implemented, that is, a family planning scheme that is looser than the two-child policy is implemented, the population structure of China will change fundamentally, and the population structure conforms to the characteristics of the younger population structure, but it will bring a large number of new populations. This paper holds that the long-term low fertility rate and aging population age structure will not only affect the overall labor productivity and economic competitiveness of China, but also bring great pressure to the social security system and medical and health system of China. The population should not grow too fast, resulting in excessive pressure on the economic, social, resources and environment; At the same time, it can't be cut quickly, which is not conducive to the optimization of population structure. However, this paper does not consider the birth rate, and the death rate changes with the development of science and technology. The influence of population mobility on the model is not considered; No consideration was given to the change in the ratio of men to women. These aspects will be discussed in depth in the follow-up.

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