

Study on Jilin Province's Population Growth Trend Model

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Abstract

With the population data of Jilin Province from the year 1949 to 2009 and valid population growth change rates, this paper intends to predict the population growth trend of Jilin province by a comparative study conducted under the Malthusian Population Model and Logistic Model and to explore the accuracy of these two models. It then comes to the conclusion that the population of Jilin province will reach the peak when it amounts to 33 million, that is to say, the net population growth rate tends to be a stable one, namely to be zero.

Key words: Malthusian population model; Logistic model; Population growth rate; Comparison

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INTRODUCTION

According to *Jilin Statistical Yearbook*^[1], the population of Jilin province has increased by 17.303 million during the 61 years since the founding of our country. Its variation tendency mainly showed that while the total population kept growing, the growth rate was on

a decline. Despite this trend, the growth rate in every 6 years was relatively stable. Besides, the gender ratio is heading toward balance. Moreover, on the one hand, agricultural population of Jilin province maintained a rapid and sustainable growth between the year 1949 and 1974, rising from 8.282 million to 14.198 million. However, the agricultural population rose slowly from the year 1974 to 2010, with a population of 14.198 million and 14.817 million respectively. On the other hand, the nonagricultural population is in constant increase, from 1.803 million in 1949 to 12.421 million in 2010. As the population increases, the nonagricultural trend is gaining momentum and presents a trend of linear growth.

METHODOLOGY

Malthusian Population Model

The population growth rate is a constant, which means that the population increases exponentially with time passing by. The growth model is $y = x_0(i+r)^k$, in which x_0 stands for the initial population, r the growth rate, k the year range, and y represents the total population in the final year k ^[2]. Considering the development tendency of Jilin province as well as its population goal, this paper suggests that, by the year 2010, Jilin's total population scale will development be $y = x_0 \times (1+r)^k$, $r = 0.37\%$, $k = 1, 2, \dots$. This model conforms to the dynamic trend of Jilin's future population development in a large extent. Therefore, it is able to predict the population of Jilin province between the year 2001 and 2020 and it is estimated that the total population of Jilin province will have reached 28.288 billion by the year 2020 (See Table 1).

Table 1
The Prediction of Jilin's Population Between the Year 2001 and 2020 (10 Thousand)

Year	Total population	Year	Total population	Year	Total population	Year	Total population
2001	2637.1	2006	2686.2	2011	2736.3	2016	2787.3
2002	2646.9	2007	2696.2	2012	2746.4	2017	2797.6
2003	2656.7	2008	2706.2	2013	2756.6	2018	2808.0
2004	2666.5	2009	2716.2	2014	2766.8	2019	2818.4
2005	2676.3	2010	2726.2	2015	2777.0	2020	2828.8

Logistic Model

Logistic Model assumes that the function $r(x)$, $r(x) = r - sx$, $s > 0$ is the decreasing function of the function $x(t)$, and the linear function of x . Here r is tantamount to the growth rate $r(x) < r$ when $x(t = 0)$, namely the inherent population growth rate when the population is free from the constraint of the environment and resources, which is apparently the actual growth rate. In order to clarify the physical significance of the parameter s , this paper introduces the concept of maximum population. When $x = x_m$, the growth rate becomes 0, namely $0 = r - sx_m$, $s = \frac{r}{x_m}$. Under the linear hypothesis of the Logistic, there exist the following models: $\frac{dx}{dt} = r \left[1 - \frac{x}{x_m} \right] x$, $x(0) = x_0$. According to Logistic Model, as long as we estimate the parameters x_m , a and b , we then can determine the concrete form of the population model^[3]. By using this method, we draw the conclusion that $a = 1.83$ and $b = -0.06$.

COMPARISON AND ANALYSIS OF MODELS

It can be observed that there is only a comparatively small error between Malthusian Population Model's predicted outcome of population and the actual population. The minimum error is 0.1 ten thousand people (in 2007), the maximum of the relative error is 0.26% (in 2005), and most of the relative errors are lower than 0.5%; therefore the actual predicted outcome is good^[4]. During population's natural growth, the net relative growth rate is a constant and the Logistic Population Model was accordingly established: if at the time t the population is $x(t)$ from t to $(t + \Delta t)$, the population growth is: $x(t + \Delta t) - x(t) = rx(t)\Delta t$, if $x_0 = x(0)$, $\Delta t \rightarrow 0$, the solution: $x = \frac{k}{1 + (\frac{k}{x_0} - 1)e^n}$ is got by solving a system of equations.

Table 2
Comparison of All Models' Prediction Outcomes

Year	Unit (Ten thousand)		Malthusian model		Logistic model	
	Actual population	Predicted population	Relative error	Predicted population	Relative error	
2001	2637.1	2637.1	0.00%	2710.0	2.76%	
2002	2649.4	2646.9	0.13%	2714.0	2.44%	
2003	2658.6	2656.7	0.08%	2729.0	2.65%	
2004	2661.9	2666.5	0.17%	2733.0	2.67%	
2005	2669.4	2676.3	0.26%	2788.0	4.44%	
2006	2679.5	2686.2	0.25%	2790.0	4.12%	
2007	2696.1	2696.2	0.1%	2804.0	4.00%	
2008	2710.5	2706.2	0.16%	2819.0	4.00%	
2009	2719.5	2716.2	0.12%	2822.0	3.77%	
2010	2723.8	2726.2	0.08%	2835.0	4.08%	

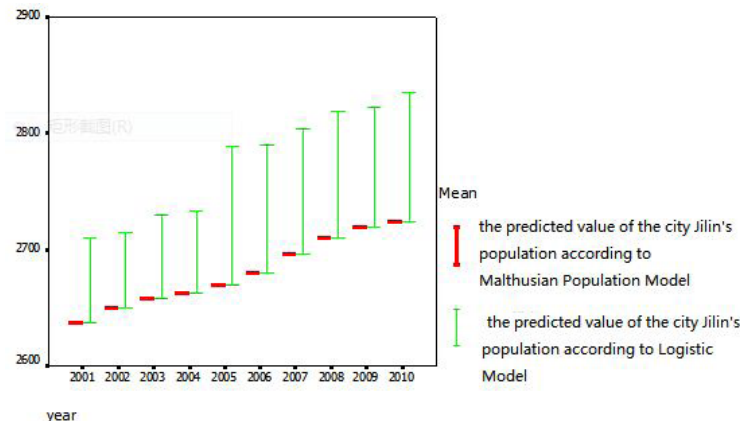


Chart 1
Comparison of All Models' Prediction Outcomes

A population system is a non-linear, open system, with the characteristic of dissipation structure; therefore stability criteria can be used to judge the stability of a population system. According to the dissipation structure theory, the stability of a system in a non-equilibrium linear region can be judged by the generation principle of minimum entropy $\frac{dp}{dt} \leq 0$.^[5] Therefore, if the population stability range of Jilin province can be controlled within 33 million, the net population growth rate can be stable, tending to be a zero population growth rate.

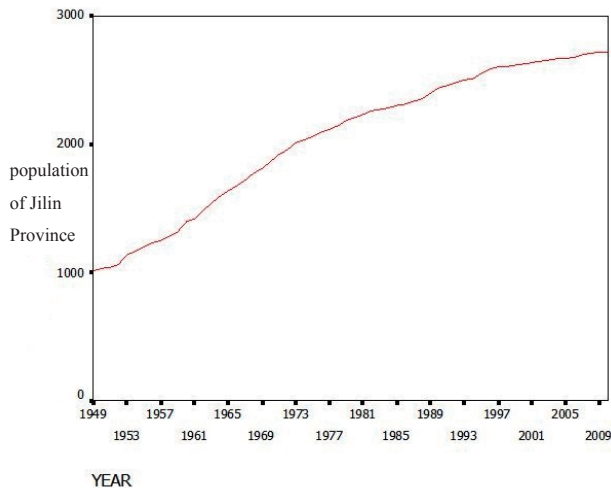


Chart 2
Population Growth in Jilin Province

CONCLUSIONS

Observed from the separate trends and proportions of Jilin Province's agricultural and non-agricultural population, the trend of non-agriculturalization in Jilin province is enlarging, which means that the urbanization process in Jilin is speeding up. Until 2004, non-agricultural population growth trend had been almost the same with years before. Known from Jilin Province's gender ratio, male population and female population are balancing, both towards a proportion of 50%.

As population growth and population prediction are influenced by multi-aspects, the real population growth process can never be embodied or predicted by a specific model. The model depends on the specific situation. Both Malthusian Population Model and Logistic Model can meet requirement of precision in predicting the population growth of Jilin province. Malthusian Population Model and Logistic Model are applied in this article to predict population growth of Jilin province. Therefore, the population stability range of Jilin province is within 33 million. After the year 1950, Jilin province witnesses a zero net population growth rate which is quite stable.

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