A Study on Influence of Family Planning Policy Adjustment on Population Size and Structure of Jilin Province

Wang Liying
Baicheng Normal University, Jilin, Baicheng 137000

ABSTRACT: In this thesis, the mathematical modeling method is used to build Leslie population model so as to predict the development tendency of population size and structure of Jilin province, including the total population, male to female ratio, population age structure, aging of population based on the influences of the changes of total female population and comprehensive fertility rate after implementing the new family planning policy of "second pregnancy of single-child". It is obtained through the Leslie population model solved by the statistical software SPSS18.0 that the population of Jilin Province will reach the peak around 2030 and at that time the male to female ratio will tend to 1, the pace of population aging will become relatively slow and the dependency ratio will tend to be smooth and steady after implementing the new family planning policy of "second pregnancy of single-child".
KEYWORD: Leslie model, Sexual Proportion, Dependency Ratio, Aging

1 INTRODUCTION

After the policy of "second pregnancy of single-child" was put forward in the Third Plenary Session of the Eighteenth Central Committee, many provinces, cities and municipalities have introduced the specific policies in succession since this year. Before and after the introduction of the policy, people from all circles of life have conducted a good deal of studies and reviews on the effect of "second pregnancy of single-child". In this thesis, the Leslie model is built so as to predict the development tendency of population size and structure of Jilin province, including the total population, male and female population, male to female ratio, population age structure and aging of population based on the influences of the changes of total female population and comprehensive fertility rate after implementing the new family planning policy of "second pregnancy of single-child".

2 CONSTRUCTION OF LESLIE MODEL

Given that the number of people who are i years old in year of t and live to the year of $t+1$ and become $i+1$ years old is

$$\begin{cases} x_{i+1}(t+1) = (1-u_i(t))x_i(t) \\ \quad i = 0,1,2,\cdots,m-1 \\ \quad t = 0,1,2\cdots \end{cases} \tag{1}$$

The number of people born in year of t is

$$x_{00}(t) = \sum_{i=i_1}^{i_2} b_i(t)K_i(t)x_i(t)$$

The number of infants survived in year of t is

$$x_0(t) = s_{00}(t)x_{00}(t)$$

The number of people who are 1 year old in year of $t+1$ is

$$x_1(t+1) = s_0(t)s_{00}(t)x_{00}(t) \tag{2}$$

Make the fertility rate as $b_i(t) = \beta(t)h_i(t)$

$h_i(t)$ is fertility pattern (the weighting factor used to control the fertility rate), then it can be obtained

$$\beta(t) = \sum_{i=i_1}^{i_2} b_i(t)$$

It denotes the total fertility number of fertile women in year of t, and then formula (2) is

$$x_1(t+1) = s_0(t)s_{00}(t)\sum_{i=i_1}^{i_2} b_i(t)K_i(t)x_i(t) = \beta(t)\sum_{i=i_1}^{i_2} b_i'(t)x_i(t) \quad (3)$$

Thereinto, $b_i'(t) = s_0(t)s_{00}(t)h_i(t)k_i(t)$

Based on the above discussions, introduce the vector $X(t) = [x_1(t), x_2(t), \cdots, x_m(t)]^T$

The improved discrete type Leslie population model can be obtained through combining formula (1) and formula (3). [4]

$$X(t+1) = A(t)X(t) + \beta(t)B(t)X(t) \quad (4)$$

Thereinto

$$A(t) = \begin{bmatrix} 0 & 0 & \cdots & 0 & 0 \\ s_1(t) & 0 & \cdots & 0 & 0 \\ 0 & s_2(t) & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & s_{m-1}(t) & 0 \end{bmatrix}$$

$$B(t) = \begin{bmatrix} 0 & \cdots & 0 & b_{i_1}' & \cdots & b_{i_2}' & 0 & \cdots & 0 \\ 0 & \cdots & 0 & 0 & \cdots & 0 & 0 & \cdots & 0 \\ 0 & \cdots & 0 & 0 & \cdots & 0 & 0 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & \cdots & 0 & 0 & \cdots & 0 & 0 & \cdots & 0 \end{bmatrix}$$

Table 1: Symbol Description

Symbol	Implication	Symbol	Implication
t	Denoting the year (the initial year is selected as $t=0$)	$\beta(t)$	Denoting the total fertility number of all fertile women in year of t
$x_i(t)$	The number of people who are i years old in year of t	$h_i(t)$	Fertility pattern
$b_i(t)$	The fertility rate of the i age group in the year of t	$s_i(t)$	The survival rate of people who are i years old in year of t
$x_{00}(t)$	The number of people born in year of t	$X(t)$	The distribution vector of each age group
$x_i(t)$	The number of people who are i years old in year of t	$A(t)$	Matrix of survival rate
L	Leslie matrix	$K_i(t)$	The proportion of fertile women who are i years old in the year of t
$s_{00}(t)$	Survival rate of infants in year of t	$k_i(t)$	The proportion of women who are i years old in year of t

3 POPULATION SIZE AND STRUCTURE OF JILIN PROVINCE

According to the data of the sixth population census, the initial data of $x(0)$, the annual average death rate, total female population, the percentage of women in total population and annual fertility rate of female are shown in table 2.

Table 2: Data of Female Population of All Ages in Jilin Province

No.	Age Group	Annual Average Death Rate	Total Population	Female Population	Percentage of Women	Male to Female Ratio	Annual Fertility Rate‰
1	0-4	0.0008333	1079016	509968	0.4726232	2.2282	0
2	5-9	0.0000594	1094295	518509	0.4738293	1.11046	0
3	10-14	0.00005992	1118204	531062	0.4749241	1.1056	0
4	15-19	0.0001081	1684347	823104	0.4886784	1.04634	5.2
5	20-24	0.0001267	2501314	1251262	0.5002419	0.99903	49.7
6	25-29	0.0001554	1956582	977366	0.4995272	1.00189	48.55
7	30-34	0.0001759	2171403	1064799	0.4903737	1.03926	26.67
8	35-39	0.0002971	2557636	1254810	0.4906132	1.03827	12.86
9	40-44	0.0004863	2893132	1410850	0.4876549	1.05063	5.63
10	45-49	0.0007684	2614467	1285549	0.491706	1.03374	3.39
11	50-54	0.0013806	2150509	1061660	0.4936785	1.02561	0
12	55-59	0.0022574	2005362	1004905	0.501109	0.99557	0
13	60-64	0.0040832	1324710	671528	0.5069245	0.97268	0
14	65-69	0.0074135	837251	431830	0.5157713	0.93884	0
15	70-74	0.0127376	680192	344537	0.506529	0.97422	0
16	75-79	0.0203348	429609	220731	0.5137951	0.9463	0
17	80-84	0.0319577	232870	118947	0.5107871	0.95776	0
18	85-89	0.0465096	91293	47523	0.5205547	0.92103	0
19	90-94	0.0649754	23809	12845	0.5395019	0.85356	0
20	95-99	0.0696071	6235	3481	0.5582999	0.79115	0
21	100 +	0.1968912	579	331	0.5716753	0.74924	0

Given that the annual average death rate μ_i in i group and the death toll in unit time dt are in proportion to the total population $X_i(t)$, then it can be obtained

$$\frac{dX_i(t)}{dt} = -\mu_i X_i(t)$$

The vectors of survival rate and average fertility rate in the future 50 years can be calculated [2]

S = [0. 999166674 , 0. 999940601 , 0. 999940082, 0. 999891946 , 0. 999873267 , 0. 999844627, 0. 999824077 , 0. 999702851 , 0. 999513676 , 0. 999231583 , 0. 998619397 , 0. 997742552, 0. 995916842 , 0. 992586453 , 0. 98726242 , 0. 97966523 , 0. 968042255 , 0. 95349041, 0. 935024571 , 0. 930392943 , 0. 803108808]

B = [0 , 0 , 0 , 5. 2 , 49. 7, 48. 55, 26. 67, 12. 86, 5. 63, 3. 39, 0, 0, 0, 0, 0, 0, 0, 0, 0]

Substitute the values of vector S, B and C into the equation (4) and use the SPSS18.0 software to programme according to the different total fertility rate so as to obtain the predicted data of population size and structure in the future 50 years.

Since the value of β can affect the total population and population structure changes, take $\beta = 1.2, 1.8, 2.2$ ($\beta = 1.2$ denotes that each couple has only one child averagely, $\beta = 1.8$ denotes that each couple can have two children, $\beta = 2.2$ denotes that each couple has two children averagely) respectively to make comparative analysis, as shown in figure 1, figure 2 and figure 3.

It can be seen from figure 1 that when $\beta = 1.2$, the population increases slowly and will decline rapidly after reaching the peak and even the negative growth will appear; when $\beta = 2.2$, population increases rapidly and will decline slowly after reaching the peak; however, when $\beta = 1.8$, the population increase is relatively stable.

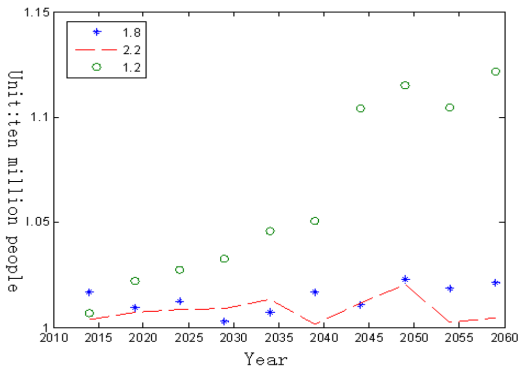

Figure 1: Changes of sexual proportion when different values are taken for β

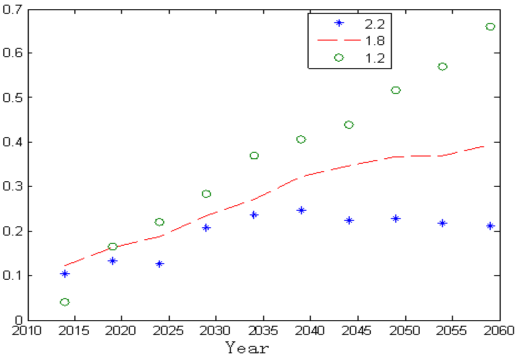

Figure 2: Changes of aging when different values are taken for β

It can be seen from figure 1 and figure 2 that when $\beta=1.2$, the fluctuation range of sexual proportion is large; when $\beta=2.2$, the gender descent rate is slow. However, when $\beta=1.8$, the sexual proportion tends to be stable. Hence, the fertility rate affects the structure of sex ratio. When the value of β is small, the aging pace is fast; when β is large, the aging pace is relatively slow.

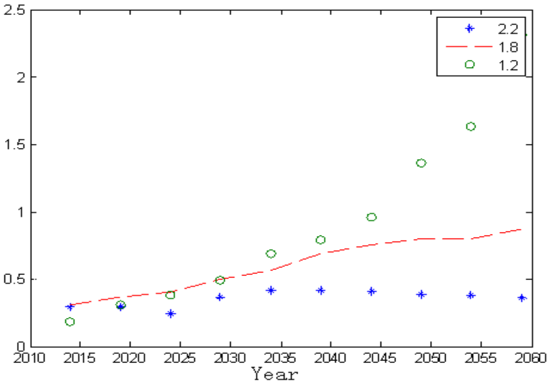

Figure 3: The dependency ratio when different values are taken for β

It can be seen from figure 3 that when the value of β is small, the dependency ratio is large; when the value of β is large, the dependency ratio is small. When β=1.8, the dependency ratio tends to be stable.

It can be seen from the above analyses that after implementing the new family planning policy of "second pregnancy of single-child", the population of Jilin province will reach its peak around 2030 with approximately 28 million people and at that time, the male to female ratio will tend to 1, the pace of population aging will become relatively slow and the dependency ratio will tend to be stable when β=1.8, which is an ideal result.

4 CONCLUSIONS

It should be considered from many aspects to formulate the policies to control population growth; if attention is only paid to total population control, serious aging and manpower shortage can be caused. If the population is allowed to increase freely to avoid social aging, the enormous pressure can be brought to resources and environment due to the overpopulation. Therefore, the correct population policies should be formulated so that the national economy can grow steadily and the living standards can improve continually.

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