THE QUANTITATIVE ANALYSIS OF SPATIAL DISTRIBUTION OF POPULATION

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ABSTRACT

According to the theory of dissipative structure and the feature of the evolution of population in China, the evolutionary equations for the population of cities and towns in every province(except Taiwan and Hainan) of China are obtained. By these equations spatial distribution of population from 1980 to 1984 and future evolution are shown. Some natures of population in China are discussed.

I. Introduction

I.prigogine indicated that the nonlinear system in the condition of far from equilibrium should appear steady order structure--dissipative structure, when it exchange matter, energy and information with circumstance [1] The particular form of dissipative structure is determined by the internal interaction of the system and the interaction between system and environment. Theory of dissipative structure is also called the theory of self-organization. It has many applications not only in physics, chemistry and biology , but also in society ,economy and other social science.[2,3]

The population of a country is a open system. There are birth, death, and migration in the system. The population system should appear steady order distribution (dissipative structure) under certain conditions. So we can discuss population by the theory of self-organization. In the second part, evolution model of the population of China is set up, and the physical meaning of each parameter and variable in the model is discussed. In part three, according to the statistical data of China, we correct the numerical value of parameter, calculate and draw some curves about population distribution on the basis of computed result. The final, we discuss some problems simply.

2 The evolutionary model

The population distribution of China has its special feature which is different from other countries.1)The quantity of peasants in China is much more than that of workers, they live in villages and migrate little.The reason for the change of peasants is mainly birth and death. 2) The government do not supply staple food to peasants.The life of peasants depend on themselves.Economical plan worked out by government consider less the quantity of peasants. 3) The statistical data of the quantity of peasants is difficult to obtain. The data of peasants is not complete.So our reseach is concentrated on the population of cities and towns,namely the population with staple food supply by the government planning.

We divide China into 29 regions (29 province, autonomous regions,and municipality directly under the Central Government except province Taiwan and Hainan in China).Let p_i is number of population in cities and towns of ith region(i=1,2,3, ...29). Let x_i is the number of workers and n_i is the number of the unemployed in the region ($n_i+x_i=p_i$)

The evolution of workers is determined by Logistic equation

$$\frac{dx_i}{dt}=\varepsilon n_i\left(1-\frac{x_i}{J_i}\right) \qquad (2.1)$$

where ε is a scalar coefficient (it is the same for every province), J_i is the number of job in ith region. When workers are less than jobs($J_i>x_i$), number of workers increase; when workers are more than jobs ($x_i>J_i$), number of workers decrease.

P_i submit Marsas population evolution equation:

$$\frac{dP_i}{dt} = \alpha_i P_i \qquad (2,2)$$

According to the relation $n_i+x_i=P_i$,the evolution of the unemployed can be obtained by the evolution of P_i and x_i .So

$$\frac{dn_i}{dt} =\alpha_i P_i-\frac{dx_i}{dt} +MG_i^{in} - MG_i^{out} \qquad (2.3)$$

The term MG_i^{in} and MG_i^{out} represent the migration of the unemployed. The migration from other regions into the ith region (MG_i^{in}) is affected by the quantity of the unemployed in other regions and the attraction force of ith region for the unemployed in other regions.

$$MG_i^{in} = \xi \sum_{j\neq i} n_j \frac{v_{ij}}{\sum_k V_{kj}} \qquad (2.4)$$

Same analysis:

$$MG_i^{out} = \xi\, n_i \sum_{j \neq i} \frac{V_{ji}}{\sum_k V_{jk}} \qquad (2.5)$$

where ξ is a scalar coefficient (It is the same for migration in and out, and for different regions). V_{ij} indicate the attraction of ith region for the unemployed in jth region. It is related with the numberof jobs in ith region, and distance between ith and jth region.The function is written as follow

$$V_{ij} = \left(\frac{J_i}{x_i}\right)^{\alpha} P_i\, e^{-\phi d_{ij}} \qquad (2.6)$$

The attraction has negative exponential function for distance. It is result of geography. Living condition is shown by population P_i. (J_i/x_i) shows the relation between the number of jobs and attraction. α shows the understanding level for information. When $\alpha=0$, attraction is constant for any J_i and x_i .It is the situation of no-information. When α is large,the attraction is remakable different even the ratio J_i/x_i has little difference. It is the situation of rich information. Above relations show basically the migrational behavior.

The number of jobs is determined by the latent capacity of the economical evolution. It submits Logistic equation

$$\frac{dJ_i}{dt} = kJ_i\,(J_i - M_i) \qquad (2.7)$$

where k is a scalar coefficient.The latent capacity of economical evolution is affected by many elements, such as natural resources, fund , labor, etc. In order to discuss the relation between population and economics, we analyse only the influence of labor on latent capacity. In China,the number of labor is determined by the government.The quota of increasing labor of every province set by the government determine the number of jobs next year.

The equations (2.1), (2.3) and (2.7) are the mathematical model established for the evolution of the population of China.Let M_i is quota of increasing labor in ith province, it is gotten by the department of labor and planning. α_i is the naturl growth rate of population in ith province, it is getten by the statistical department. Parameters ε ,k ,ξ and α are simulated by statistical data about population, $\phi=0$. The number of population in every regions and year can be computed through above equations and parameters.

3 The computed result

Through the simulation of computer, we get ε=0.00526, ξ=0.0755, k=2.422, α=0.7 . Input the data of the population in 1980, the number of population from 1981 to 1984 can be obtained. The difference between the computed result and the real statistical data is small. The relative errors of every year are less than 1%. Computed result conform to reality,and we can obtain the following table(Table 1).

Table 1 population in 1984

province	computed result	real statistic	relative error
Beijing	573.4	556	3.0
Tianjin	422.6	435	-2.9
Hebei	767.4	713	4.7
Shanxi	521.3	508	2.6
Inner Mongolia	507.8	538	-6.0
Liaoning	1395.0	1419	-1.7
Jilin	750.3	800	-6.6
Heilongjiang	1178.1	1247	-5.9
Shanghai	724.6	766	-5.7
Jiangsu	938.1	943	-0.5
Zhejiang	602.2	586	2.7
Anhui	638.7	639	0.0
Fujian	415.6	428	-3.0
Jiangxi	535.3	548	-2.4
Shandong	881.0	853	3.2
Henan	808.7	797	2.4
Hubei	799.4	806	-0.8
Hunan	671.9	686	-2.1
Guangdong	1168.9	1189	-1.7
Guangxi	423.3	446	-5.4
Sichuan	1248.0	1303	-4.4

We forecast the number of population on every province in 2000, according to the above computed results.

Table 2 spatial distribution of population in 2000

province	population	province	population
Beijing	745.9	Henan	1319.1
Tianjin	532.2	Hubei	1142.9
Hebei	1700.8	Hunan	884.4
Shanxi	938.1	Guangdong	1994.4
Inner Mongolia	598.9	Guangxi	484.1
Liaonin	1818.2	Sichuan	1567.1
Jilin	792.4	Guizhou	372.8
Heilongjiang	1267.9	Yunnan	554.9
Shanghai	854.4	Xizang	62.2
Jiangsu	1433.8	Shaanxi	702.9
Zhejiang	879.3	Gansu	495.9
Anhui	915.4	Qinghai	210.9
Fujian	594.1	Ningxia	138.8
Jiangxi	670.1	Xinjinag	471.1
Shandong	1559.6		

4 Discuss

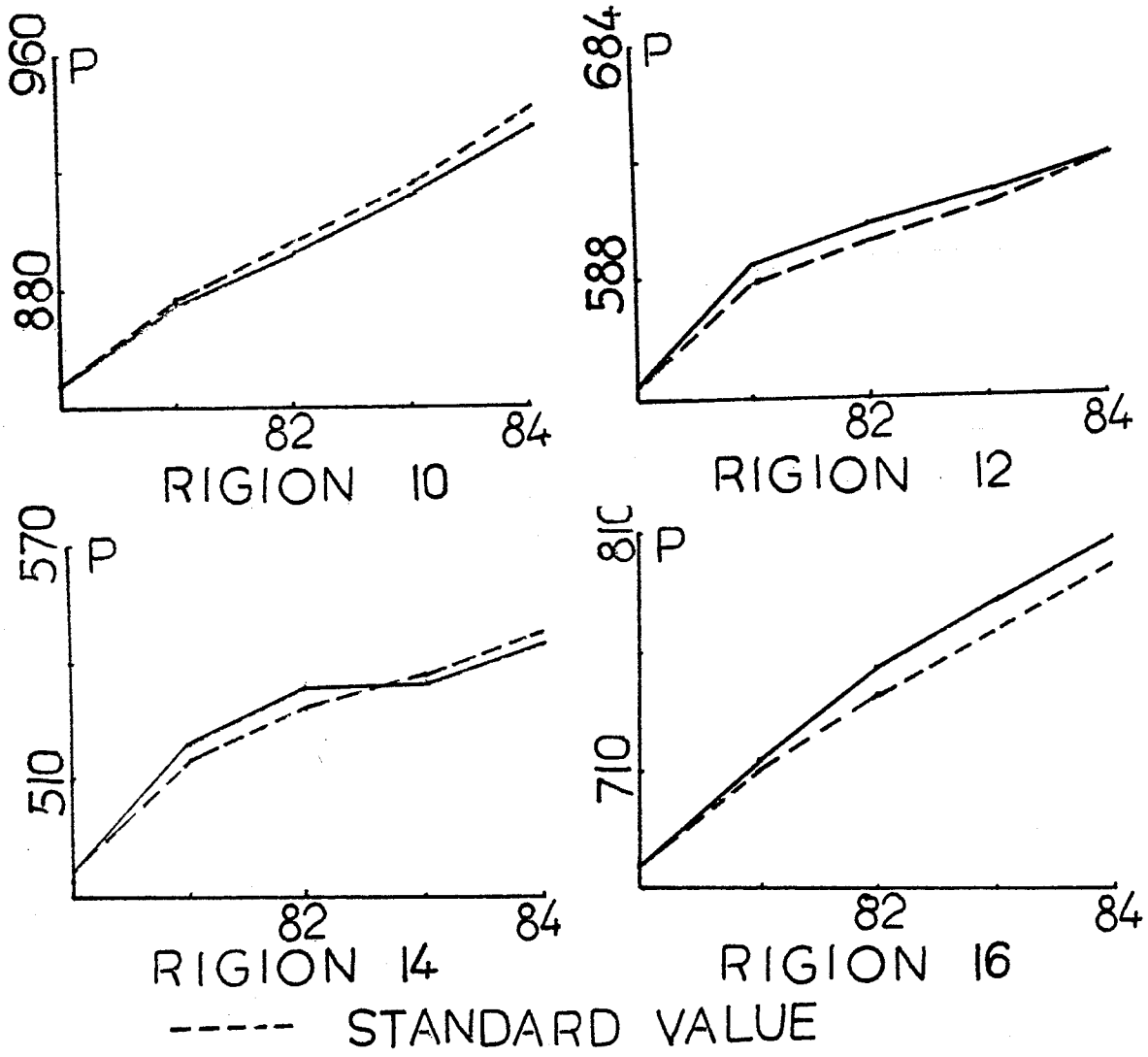
1. The spatial distribution of the population of China can be analysed through the theory of dissipative structure. Population system is a open system. It has nonlinear interaction between population and economy in the system. It has all conditions for dissipative structure. The theory of nonequilibrium statistical physics is correct for the solution to society and economy , and some result can be got.

2.In most countries of the world, the labor of cities and towns can migrate freely, but it could not do in China. In china the population in cities and towns is controlled directly by the quota determined by the government. In the above, the relation between population and economics is discussed.For some counties which adopt the policy of planning economics, this is an useful analytical method.

3. Same method is suitable for a province or a region. We can discuss the migration and the change of population among the cities of a province.

province	computed result	real statistic	relative error
Guizhou	317.5	341	-7.4
Yunnan	366.7	365	0.5
Xizang	27.9	28	-0.5
Shaanxi	484.0	496	-2.5
Gansu	288.8	294	-1.8
Qinghai	95.7	98	-2.4
Ningxia	77.9	78	-0.2
Xinjiang	363.2	360	0.9

The computed result and the real statistic data about number of population in every year on some province is drawn in the following pictures. We can easily find the trend of population evolution in the pictures.



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