

Population, Education, Economic Growth and Structural Change: the Dynamic Extended Input-Output Framework on Education Considering Population

Zhang Hongxia

School of Economics, Renmin University of China, Beijing, China, 100872

ABSTRACT

This paper builds a dynamic model system—the extended input-output model with assets on education considering population, to investigate the relations of population, education, economic growth and structural change. The framework is based on the extended input-output model on education (Zhang Hongxia & Chen Xikang, ESR, 2008). The extended IO model on education shows the relation of the production and distribution of human capital with the economic growth. But the model doesn't take the population change into consideration, which is very important for the development of education and economy. Therefore, the model system in this paper investigates the population system, the education and the economic systems in detail, to analyze the relations of population change, the education development, the economic growth and economic structural change. The framework includes five parts: the population developing equations, education developing equations, consumption determination equations, investment determination equations and output determination equations. The framework can be used to analyze the required education scale, the economic growth and structural change, with certain population system movement and technology development.

Keywords: population; education; input-output technique; Songjian population model

1 Introduction

The three systems, population, education and economy, have close relations with each other. To investigate the relations of the three systems quantitatively is very important for solving the macro practical problems of education, such as “the optimal public input in education” and “the rational proportions of physical capital and human capital input”. Input-output model is good method for analyzing such problems, which should consider the economic structure. Analyzing human capital in an input-output model was first done by Bródy (1970), who included the reproduction of labor in the production process in his dynamic input-output model. Aulin-Ahmavaara (1987, 1989, 2003, 2004) built a complete dynamic input-output model including human time and the production of human capital. The Bródy and Aulin-Ahmavaara models aimed at investigating the growth potential,

Zhang Hongxia, School of Economics, Renmin University of China, Beijing, China, 100872; Email: zhanghx_c@126.com

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productivity, and price proportions of an economy. Liu (1996) combined an input-output model extended with assets and education.

Based on the former research work (Hongxia Zhang, Xikang Chen, 2008), by using the idea of system science, this paper builds model system of the extended input-output model with assets on education considering population, to study the dynamic relations of population, education and economy.

In our former paper, we built the extended input-output model with assets on education to analyze the relations of each sub sectors of education with other industries of the economy. But this model doesn't consider the factors of population systems, and can't study the relations of population growth, education development , economic growth and economic structure change. Based on the former work, this paper construct a framework of the extended input-output model with assets on education considering population, in order to investigate the relations of population, education and economy.

2 The brief introduction of the Framework of the Extended Input-Output Table on Education

This part gives a brief introduction of the extended input-output table on education. Please see the detailed model in Hongxia Zhang & Xikang Chen (2008).

In classical input-output (IO) tables, the education sector is a tertiary industry, a kind of service. Its income is recorded in the rows (i.e. the output in an IO table) refers to the sources of educational funds, while its outlays are recorded in the columns (i.e. inputs in an IO table) are the uses of educational funds. These monetary flows are reflected in the “monetary IO table”, i.e. the upper part in Table 1. Yet, if we look at this sector as producing human capital, the output of education is students acquiring knowledge and skills. We reflect this in the middle part of Table 1 by a separate table termed “student input table”. Educational funds and students are two sides of the same production process of education. For educational funds, the rows corresponding to the education sector in the monetary IO table 1 account for the sources of the funds; while its corresponding columns account for the use of the funds. For student flows, the rows in the student input table show the distribution or output of students, while the columns represent the sources or input of students that will be educated. The purpose of the extended IO table on education is to show the production and distribution of human capital and its relation with the growth and development of sectors. It should be noted that human capital here refers to students at different educational levels.

Table 1. The extended input-output table on education

Monetary input-output table							
	Intermediate demand		Final demand				Total output
	Non-education sectors 1,...,k	Education sectors k+1,...,n	Consumption	Fixed capital & inventories		Other	
				Non-edu sectors	Edu sectors		
Non-education sectors 1,...,k	W^{PP}	W^{PE}	c^P	I^{PP}	I^{PE}	Y^P	X^P
Education sectors k+1,...,n	W^{EP}	W^{EE}	c^E	0	0	0	X^E
Primary inputs							
Total input	$(X^P)^t$	$(X^E)^t$					
Student input table							
	Intermediate demand		Final demand				Total output
	Non-education sectors 1,...,k	Education sectors k+1,...,n	Consumption	Human capital		Other	
				Non-edu sectors	Edu sectors		
Education sectors k+1,...,n		W^Q		F^{EP}	F^{EE}		X^Q
Primary inputs		s'_{t+1}					
Total input		X^Q					
Asset holding table							
	Intermediate demand		Final demand				Total assets
	Non-education sectors 1,...,k	Education sectors k+1,...,n					
Fixed assets 1,...,k	K^{PP}	K^{PE}					
Human capital k+1,...,n	H^{EP}	H^{EE}					

In the extended IO table and model on education, the economy is divided into two subsystems. These are, non-education sectors. The upper part in table 1 shows that other sectors send the students to the education sector in order to increase their human capital to the education sector. Consequently, the education sector obtains the funds, buys products and equipment from other sectors, and performs the educational process in order to make the students more qualified. Next, when students graduate, they will enter industries and become an important factor of production.

3 The model system of the extended input-output model on education considering population

3.1 The relations of population, education and economy

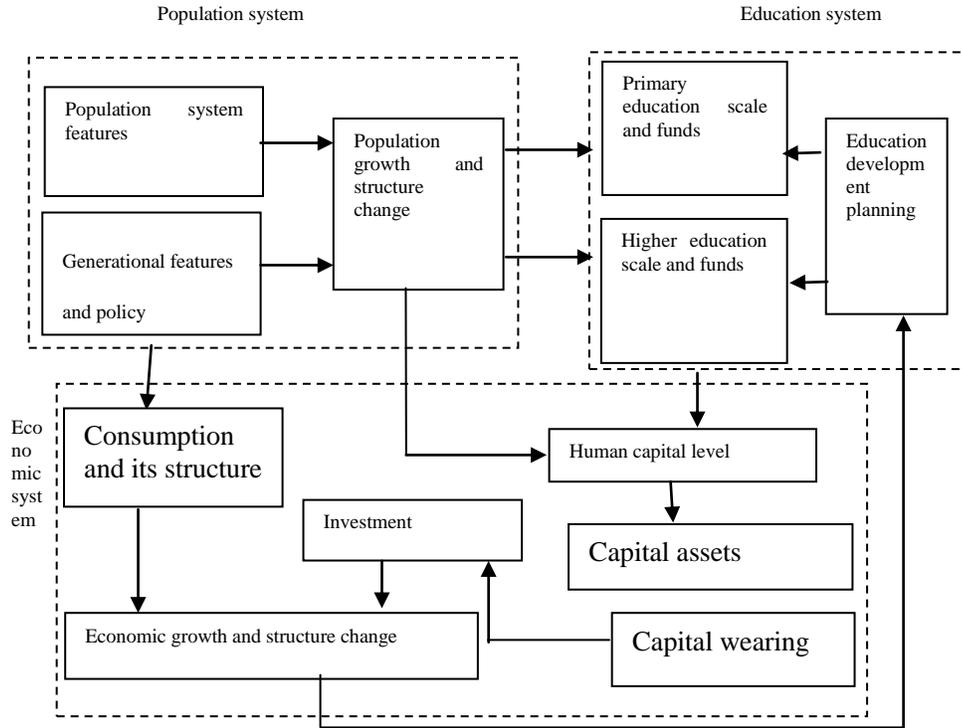


Figure 1 the relations of population, education and economy

First, investigate the relations of population system, education system and economic system, shown in figure 1. The population motion is determined by the initial population features, the generational features and the population development policy. The population growth and structural change will affect the education demand firstly, and then affect the fundamental education scale and financial funds requirement. The higher education is influenced by the fundamental education and the population growth and its structural change. Meanwhile, the fundamental education and higher education is affected by the national education development plan, and the national education development plan is restricted by the population and the development of industries in the economy. It means that the education should keep coordinated with the economic development. The population development causes the consumption increase and consumption structure change, and consumption is the motivation of economic growth and industrial development. At the same time, the situations of population and education determine the human capital level of an economy, and then have a big effect on economic growth. In order to get the full employment, a certain amount of investment is required. The investment demand is also determined by the degree of capital wearing. The economic growth and structural change is determined by the consumption and investment through input-output model.

Here we don't take the international factors into consideration, that is, the international trade is outside the model. This assumption is to make the model system focusing on the relations of education, population and economy.

3.2 Construction of the model system

The model system is composed by population development equation, education development equation, consumption determination equation, investment determination equation and the output determination equation.

3.2.1 The population development equation

There are many kinds of population prediction models, but most of them are only used to predict the population totally, but can't be used to predict the population structure. However, we not only need the population, but its age structure. The Songjian population prediction model can meet all our demand. Therefore, we choose this model to build the population development equations. Here, the discrete Songjian population motion equation is as follows.

$$\psi(t) = \beta(t) \sum_{i=a_1}^{a_2} k_i(t) h_i(t) N_i(t) \quad (1)$$

$$N_0(t) = (1 - \mu_{00}(t)) \psi(t) \quad (2)$$

$$N_i(t) = (1 - \mu_{i-1}(t-1)) N_{i-1}(t-1) + g_i(t), \quad i = 1, \dots, m \quad (3)$$

Here, $\psi(t)$ is the actual enfant amount in the t th year; $k_i(t)$ is the proportion of female population at age i in the t th year; $h_i(t)$ is the generational mode of the women at age i ; $N_i(t)$ is the total population at age i in the t th year; $\mu_{00}(t)$ is the enfant mortality rate in the t th year; $\mu_i(t)$ is the mortality rate of population at age i in the t th year; $g_i(t)$ is the net immigration population at age i in the t th year; m is the highest age.

The population development, including total amount and age structure, affect the education demand directly, and determines the labor supply along with the education development. Meanwhile, the consumption and its structure are constrained by the total amount and age structure of population and economic development level.

3.2.2 Education development equations

The education development is restricted by population development, and affected by the economic development level and the national long term education plan at the same time, especially the national education plan.

For the compulsory education, according to the education development plan of our country, assume all the children at school age can enter the primary school, and all the youngers graduated

from primary school can enter the junior high school.

For the senior high school education, determine the education scale (here refer to the student amount) by the education development plan of our country. Other graduates of junior high school enter the production system new labors.

For the higher education, determine the education scale by the education development plan of our country. Other graduates of senior high school enter the production system as new labors.

According to the relations of the compulsory education and the population development, we get

$$S_1^Q(t) = N_{i0}(t) \quad (4)$$

Here, $S_1^Q(t)$ is the amount of the children registered in primary school latest, that is the amount of children at grade 1; $i0$ is the entrance age of primary school.

By using the student flowing matrix in the extended input-output table on education, define the distribution coefficient, and build the student distribution model by the distribution coefficients. The student distribution coefficient is: $e_{ij}^Q(t) = w_{ij}^Q / x_i^Q(t)$, and it means proportion of the student in the i th grade at year t entering the j th grade as the intermediate products, that is, the ratio of the students continuing their schooling. The matrix form of the student distribution coefficients is $E^Q = (\hat{X}_i^Q)^{-1}W^Q$, here E^Q is the student distribution coefficient matrix.

Then the education scale equation is

$$\sum e_{ij}^Q(t)X_i^Q(t) + F_i(t) = X_i^Q(t) \quad (5)$$

$$(1 - \sum_{j=1}^n e_{ij}^Q(t))X_i^Q(t) = F_i(t) \quad (6)$$

Here, we assume F is the amount of students withdrawing from school and entering the production system as new labor. Obviously, the student distribution coefficients are determined by the education development plan of the country. For example, if the nine year compulsory education implemented, all the primary school students and all the junior high school students except for the graduate will go on their schooling, the corresponding distribution coefficient is 1; a large part of the graduates of junior high school will enter the senior high school, and the rest will be new labors and enter the production system, thus the distribution coefficient will be determined by the education development plan.

The education scale of the students amount is determined by the vertical model, that is

$$X^Q(t+1) = E^Q(t)^T X^Q(t) + S(t+1)^T \quad (7)$$

We assume that the education funds of each education level is computed by the education funds per student. The education funds per student is influenced by the economic growth and the amount of students. To be simplified, we can suppose the education fund per student increase as the fixed growth rate.

3.2.3 The consumption determination equations

First determine the consumption level per capita and the total consumption. the consumption level per capita is affected by many factors, such as the historic consumption level, the actual income per capita, the expected income per capita, etc. In order to make it convenient for policy simulation, here we simply suppose the consumption level per capita increase at a fixed growth rate in average. The total consumption is the mutilation of the population and the consumption level per capita.

$$c(t+1) = pc(t) \quad (8)$$

Here, $c(t)$ is the consumption level per capita at year t ; p is the average growth rate of the consumption level per capita.

The vector of consumption sectoral structure is determined by the commodity-specific Engel curves, which was introduced by Pasinetti (1981). Here we use the model proposed by Verspagen(1993).

$$b(t+1) = b(t) + [\hat{b}(t)T(b(t) - b^*) - (\hat{b}(t) - \hat{b}^*)T^T](c(t) - c(t-1)) \quad (9)$$

Here, b is the vector of consumption sectoral structure, b^* represents the consumption shares that prevail at infinitely high consumption per capita levels. The elements of matrix T indicate how quick current consumption shares adapt to b^* in the presence of consumption growth.

The consumption vector is

$$C(t) = c(t)N(t)b(t) \quad (10)$$

Here, $C(t)$ represents the consumption vector, $N(t)$ is the population at year t , that is the sum of the population at all ages.

3.3.4 Investment determination equations

Every new labor entering the production system should use certain amount of fixed assets and circulating capital. Therefore, in order to provide enough occupations, certain amount of investment is required. The investment determination equations are affected by the situation of labors or human capital. Here we assume the object is full employment. Otherwise, investment should also take the assets wearing into consideration.

Define the capital using per capita

$$k_i(t) = K_i(t) / H_i(t) \quad (11)$$

Here, $K_i(t)$ is the assets used in the i th sector at year t , $H_i(t)$ is the amount of labor used in the production of the i th sector at year t . $k_i(t)$ represents the capital using per capita. Here, for each sector, we can also separate the labors into different groups by their educational level.

The human capital motion equation is

$$H(t) = H(t-1) + F(t) - \hat{\alpha}H(t-1) \quad (12)$$

Here, $H(t)$ is the labor used matrix at t year. $F(t)$ is the new labors matrix of sectors, and α is

the retirement rate vector at each education level.

The assets used motion equation can be introduced by the human capital used matrix and capital used matrix per labor.

$$K(t) = H(t)\hat{k}(t) \quad (13)$$

Investment is used to build new assets and assets wearing compensation. Thus investment motion equation is

$$I(t) = K(t) - K(t-1) + K(t-1)\hat{\beta} \quad (14)$$

Here, $\hat{\beta}$ is the assets wearing rate vector. From the view of statistics, investment has some differences with capital formation, but at the long term analysis, we can ignore the difference. Let the sector structure of capital formation is $l(t)$. $l(t)$ also can be computed by the commodity-specific Engel curve as the method to get sector structure of consumption. Let $i = (1,1,\dots,1)^T$, the capital formation vector is

$$I_f(t) = I(t)\hat{i}l(t) \quad (15)$$

3.3.5 The output determination equation

The output vector is determined by input-output model. Here we use the “sequential” or “two-stage” model (Bart Los, 2001). That is

$$X(t+1) = (I - A(t))^{-1}(C(t+1) + I_f(t+1)) \quad (16)$$

Up to now, we build the model system of the extended input-output model with assets on education considering population development. The model system is used to investigate the education scale and structure, the corresponding economic growth and economic structure dynamically, to meet the population’s consumption demand and to get full employment under certain technological development.

The five parts of the model system relate with each other, and are all difference equations, and can be solved by iteration method. To be specific, we can solve them by forward recurrence method, or backward recurrence method. The development of population system is the most fundamental part among the five modules, and is the important factor to determine the development of education and economy. Therefore, we should predict the development of population system, by forward recurrence method, given the initial features and the generational mode. Next is to predict the scales and education funds of compulsory education and non compulsory education, and determine the consumption and investment vectors. Then we can predict the outputs of each sectors, all by forward recurrence method. Alternatively, we can solve the education and economic systems by backward recurrence method. That is, we can give the long term objectives of education and economy, and compute the economic growth and structure and education scale and input from backward direction, in order to attain the objectives.

4. The simulation results

4.1 Data resources

The data used in this paper include the 2002 Chinese input-output table compiled by NBS, Chinese Economic Census Yearbook 2004, Chinese Yearbook 2005, Chinese Education Yearbook, Educational funds yearbook, Population yearbook, and the population census data in 2000. First the 2002 Chinese extended input-output on education with assets is compiled, by using the aboved data. There are 28 sectors in the table, shown in the appendix 1.

The main parameters are setted as follows: the average growth rate of consumption per capita is 7%; the fixed assets holding and labors holding are attained from the 2002 Chinese extended input-output on education with assets; the enrolment rates of every class in every year are determined by the education development plan in China; the educational funds per student determined by the history data and the economic growth rate. The input coefficients matrix is revised by RAS method; the average growth rate of capital holding per capita is estimated by the history information.

4.2 The simulation results

First, based on the population census data in 2000, by using the Songjian population model, this paper predicts the population and the age structure in 2001-2020. The main results are in table 2.

Table 2 The population prediction results in 2001-2020 in China unit: 10,000 persons

Year	Prediction results	Actual population	Predict error
2001	128002.5	127627	0.0029
2002	128866.5	128453	0.0032
2003	129661.5	129227	0.0034
2004	130424.9	129988	0.0034
2005	131187.3	130756	0.0033
2006	131889.9		
2007	132613		
2008	133328.1		
2009	134045.8		
2010	134772.9		
2011	135511.3		
2012	135908.2		
2013	136293.8		
2014	136653.5		
2015	136968.7		
2016	137210.9		
2017	137372.3		
2018	137461.8		
2019	137443.3		

2020	137276		
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From Table 5.2, the predicted error of population prediction is about 0.3%, in 2001-2005. Based on the population prediction results, the 2005 Chinese input-output table and the 2002 Chinese extended input-output on education with assets , by using the model system and the above assumptions, this paper simulated the economic growth and economic structure change. First is final demand prediction, including consumption and capital formation. Table 3 shows the final consumption of each sectors, and table 4 is the fixed capital formation prediction results.

From table 3, we can see that the average growth rate of total consumption is about 8%. From the structure changes, it shows that in the main sectors of final consumption, the proportion of agriculture products decreases from 15% in 2006 to 10% in 2020. in secondary industry, Food products and tobacco processing decreased from 10% to 9%; the proportion of chemical products maintains at 3%; the industry of Textile, Wearing apparel, leather, furs,down and others increased from 5% to 6%; Manufacture of transport equipment increased from 1% to 2.5%; Electric machinery and equipment increases from 1.5% to 2%; Electronic and Telecommunication Equipment increases from 2% to 3%; the industry of Electricity, Steam and Hot Water Production and Supply maintains at 2.5%. In service industry, the industry of Freight transportation, post and communications maintains at 3%; commerce and catering service keeps at 9%. Finance and insurance service grows from 3% to 6%; Real estate industry falls down from 6.5% to 5.5%. Services of health care, sports and social welfare keeps at 8%; other services remains at 6%. To be simplified, in the simulation, the industrial structure of fixed capital formation keeps stable. From table 4, the growth rate of total fixed capital formation is about 7%.

Table 5 is the simulation results of outputs for industries. On the whole, under the current trend of population and technology development, if the growth rate of consumption per capita is 7%, to meet the consumption demand and get full employment, the output growth rate should keep at 7%-9%. The proportion of agriculture decreases, from 10% in 2006 to 8% in 2020; the ratio of industry grows from 49% in 2006 to 50% to 2020; the industry of Construction keeps stable, and decreases from 7% in 2006 to 6.4% in 2020. The industry of services grows from 33% in 2006 to 35% in 2020.

The simulation results of educational funds are shown in table 6. Totally speaking, under the trend of population and the educational long term plan, the growth rate of educational funds in total should be 7%-12%, and 9% in average. The growth rates of educational funds for junior and senior high school fluctuate great, from -1% to 14%, and -2% to 16% separately, and their average growth rates are 6% and 5% separately. The reason of great fluctuation of the growth rate in high school educational funds lies in the trends of population development and the parameters setting in the paper. The growth rate of higher educational funds is 4% to 20%, and 10% in average.

Table 7 gives the simulation results of new labors in 2006-2020. According to the education development plan in China, all the graduates of primary school should enter the high school, and all the junior high school graduates should enter the senior high school from nearly 2014. Therefore, we just assume there are no primary school graduates in the new labors, and the new labors from junior high school decrease fast. The quantity of new labors of higher education grows greatly.

Table 3 The simulation results of final consumption in 2006-2020 in China Unit: 10000yuan

	2006	2007	2008	2009	2010	2011	2012
Agriculture, forestry and fishing	147452434.4	155401635.9	163627637.5	172147584.0	180978651.1	190135678.9	199119079.4
mining	3937675.1	4142573.9	4353595.2	4571064.0	4795298.4	5026549.1	5251497.4
Food, beverages and tobacco	102825848.1	109679866.6	116952252.8	124678587.3	132895788.2	141640027.5	150558937.7
Textile, Wearing apparel, leather, furs, down and others industry	48721406.2	52894343.7	57424608.1	62345737.7	67692833.6	73501266.7	79601266.4
Sawmills and manufacture of furniture	5544302.9	5842762.0	6151554.1	6471316.0	6802685.1	7146210.9	7483109.8
Paper products, printing and record medium reproduction	5981374.7	6344692.1	6726262.9	7127519.2	7549935.1	7994918	8442077
Petroleum refineries and coke-making	2255975.3	2527867.5	2829831.1	3164837.1	3536007.9	3946531.1	4388307.0
Chemical industry	20990413.6	22479917.4	24070359.6	25770632.4	27589991.2	29537600.5	31541254.9
Non-metal mineral products	7866414.1	8330124.5	8815415.3	9323915.7	9857296.1	10417129.0	10976641.5
Smelting and pressing of metals	327872.3	346745.0	366439.0	387014.1	408531.1	431046.6	453446.2
Metal products	5042132.2	5279548.7	5520514.9	5764996.8	6012927.1	6264135.3	6501642.5
Machinery industry	1048209.9	1133479.3	1225661.2	1325395.9	1433352.7	1550204	1672310
Manufacture of transport equipment	12326197.0	14144392.4	16184081.5	18467492.9	21018016.1	23859622.5	26947045.6
Electric machinery and equipment	14145531.4	15575318.8	17146372.4	18872363.5	20767636.0	22846759.1	25059779.9
Electronic and Telecommunication Equipment	20091672.4	22425233.1	25011495.2	27875333.7	31042883.4	34540802.9	38297221.7
Manufacture of instrument, meters and other measuring equipment	1333149.5	1474130.5	1629496.4	1800647.9	1989055.4	2196214.7	2417399.2
Other manufacturing Products	7520252.8	8137864.1	8806075.1	9529584.9	10313307.4	11162180.2	12050079.4
Electricity, steam, hot water and gas production and supply	21657158.5	23541949.3	25590712.5	27818894.6	30242667.2	32878341	35650362
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Freight transportation and storage	32543907.2	35778511.3	39328691.9	43224913.0	47499131.4	52183785.7	57164117.7
Post and telecommunication services	14130109.9	15214806.7	16381552.0	17637809.7	18991371.1	20450021.1	21964904.2
Commerce and catering service	91778173.6	98631730.9	105985237.1	113883715.4	122374121.7	131503241.7	140954331.5
Finance and insurance	26106926.7	29724881.3	33771902.0	38290869.6	43326889.3	48926142.3	54993461.6
Real estate industry	62494533.6	66572421.6	70889488.4	75465776.7	80322053.7	85478574	90721446

Scientific research and Polytechnic services	25446935.1	27400367.1	29501560.3	31763956.6	34201587.3	36828472.1	39556627.2
Services of health care, sports and social welfare	74019632.5	79701743.8	85813660.6	92394482.5	99485023.0	107126062.9	115061676.4
Government agencies and others	151583549.0	163219848.2	175736338.9	189213092.4	203733690.0	219381645.9	235632853.9
Other services	54600288.6	58791675.4	63300106.7	68154423.9	73384733.0	79021115.8	84874789.6

Table 3 Continuing

	2013	2014	2015	2016	2017	2018	2019	2020
Agriculture, forestry and fishing	208388988.1	217945091.8	227784424.0	237890567.9	248285793.6	259032486.3	270118135.9	281520693.4
mining	5482209.3	5718561.3	5960376.7	6207151.9	6459424.4	6718803.7	6984987.7	7257483.5
Food, beverages and tobacco	160012744.2	170021675.8	180600955.8	191750751.7	203496694.9	215892357.0	228923342.6	242557203.6
Textile, Wearing apparel, leather, furs, down and others industry	86191298.3	93295383.1	100932942.6	109112256.8	117852602.3	127186470.3	137103035.7	147574870.7
Sawmills and manufacture of furniture	7830670.3	8188873.6	8557602.6	8936236.0	9325607.9	9728060.6	10143125.8	10569979.8
Paper products, printing and record medium reproduction	8911306	9403228	9918263	10456106	11017976	11606718	12221647	12861336
Petroleum refineries and coke-making	4872887.2	5402611.2	5979416.3	6604383.1	7279010.4	8005407.1	8782731.4	9608688.7
Chemical industry	33677202.2	35950981.3	38366891.9	40925769.1	43633541.4	46501838.8	49527331.7	52702219.3
Non-metal mineral products	11561571.3	12172519.8	12809851.7	13473042.3	14163585.3	14885113.0	15636786.8	16416914.0
Smelting and pressing of metals	476789.0	501092.8	526367.0	552585.5	579807.2	608180.0	637670.9	668215.2
Metal products	6740150.1	6979110.5	7217968.4	7455857.4	7693274.0	7932087.1	8172017.8	8412760.3
Machinery industry	1803807	1945140	2096668	2258529	2431102	2615054	2810169	3015916
Manufacture of transport equipment	30353388.0	34096622.1	38191720.8	42647536.6	47474822.6	52687655.6	58279997.7	64234977.9
Electric machinery and equipment	27470871.9	30090414.1	32926924.4	35984741.1	39271142.8	42797239.1	46558942.8	50545447.9
Electronic and Telecommunication Equipment	42412379.0	46905739.7	51793396.7	57084195.1	62790806.5	68931336.0	75498668.2	82473511.2
Manufacture of instrument, meters and other measuring equipment	2658843.8	2921624.0	3206624.8	3514310.2	3845414.2	4201031.8	4580750.6	4983471.3
Other manufacturing Products	13006843.1	14035765.8	15139495.6	16319076.0	17577278.1	18918913.6	20342426.1	21843927.2
Electricity, steam, hot water and gas production and supply	38647846	41881937	45361661	49090966	53078649	57339383	61868226	66652597
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Freight transportation and storage	62586122.4	68472822.3	74843091.0	81706423.2	89079141.8	96986384.9	105418986.7	114352800.6
Post and telecommunication services	23589810.2	25329747.2	27188691.7	29167932.4	31272092.4	33509630.6	35877950.6	38370733.2
Commerce and catering service	151071009.2	161882811.4	173413035.4	185668353.0	198677313.9	212493386.5	227100537.6	242460219.5
Finance and insurance	61676683.5	69010238.4	77022765.7	85730949.6	95155769.9	105325251.5	116227614.0	127830160.0
Real estate industry	96266968	102126065	108306832	114808592	121646247	128851681	136416525	144322202
Scientific research and Polytechnic services	42482922.8	45616377.8	48964153.5	52528570.9	56317955.7	60347541.4	64612652.3	69101907.9
Services of health care, sports and social welfare	123573637.5	132688180.8	142426136.4	152794256.0	163816757.1	175537950.6	187944236.2	201002510.1
Government agencies and others	253064354.6	271729873.1	291672067.1	312904763.3	335477556.3	359481189.5	384887811.2	411629628.6
Other services	91153604.0	97876910.7	105060075.1	112708077.4	120838781.7	129484873.6	138636321.0	148268705.0

Table 4 The simulation results of the fixed capital formation Unit:10000yuan

	2006	2007	2008	2009	2010	2011	2012	2013	2014
Agriculture, forestry and fishing	6052344.1	6573220.4	7376369.9	7945441.3	8296716.4	8768459.7	9275876.1	9778407.3	10330608.2
mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Food, beverages and tobacco	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Textile, Wearing apparel, leather, furs, down and others industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sawmills and manufacture of furniture	955452.3	1037680.3	1164469.4	1254305.7	1309759.7	1384231.4	1464334.6	1543666.6	1630839.7
Paper products, printing and record medium reproduction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum refineries and coke-making	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chemical industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-metal mineral products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smelting and pressing of metals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metal products	2518794.2	2735566.4	3069811.9	3306641.4	3452831.0	3649155.6	3860326.2	4069463.8	4299272.4
Machinery industry	48941605.3	53153612.8	59648192.4	64249924.5	67090471.5	70905170.9	75008336.9	79071999.2	83537310.5
Manufacture of transport	21752619.0	23624690.8	26511276.0	28556565.0	29819076.4	31514560.3	33338256.3	35144394.3	37129049.6

equipment									
Electric machinery and equipment	5380542.4	5843602.1	6557603.2	7063508.4	7375792.5	7795172.9	8246266.8	8693017.7	9183925.1
Electronic and Telecommunication Equipment	20629064.3	22404440.8	25141929.7	27081576.5	28278877.3	29886787.0	31616286.4	33329134.8	35211279.7
Manufacture of instrument, meters and other measuring equipment	1841405.4	1999880.2	2244235.8	2417373.9	2524248.1	2667774.5	2822154.2	2975047.6	3143052.9
Other manufacturing Products	1077088.7	1169785.0	1312715.3	1413988.5	1476502.2	1560454.7	1650755.6	1740187.2	1838458.1
Electricity, steam, hot water and gas production and supply	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	213630883.1	232016362.8	260365305.5	280451939.2	292850971.9	309502195.1	327412580.1	345150530.3	364641684.7
Freight transportation and storage	1547405.3	1680578.0	1885919.6	2031414.3	2121224.9	2241835.7	2371567.1	2500049.4	2641230.9
Post and telecommunication services	1995597.6	2167342.5	2432159.5	2619795.4	2735619.0	2891163.6	3058470.5	3224166.6	3406240.0
Commerce and catering service	7478204.5	8121792.9	9114155.0	9817292.9	10251324.2	10834204.6	11461162.3	12082083.8	12764376.7
Finance and insurance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real estate industry	6954251.6	7552747.7	8475580.9	9129454.1	9533075.4	10075116.9	10658147.4	11235564.7	11870053.5
Scientific research and Polytechnic services	987777.6	1072787.7	1203866.3	1296742.1	1354072.2	1431063.4	1513876.7	1595892.7	1686015.1
Services of health care, sports and social welfare	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Government agencies and others	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4 continuing

	2015	2016	2017	2018	2019	2020
Agriculture, forestry and fishing	10936591.8	11564148.6	12074069.5	12662840.7	13874597.1	14827596.5
mining	0.0	0.0	0.0	0.0	0.0	0.0
Food, beverages and tobacco	0.0	0.0	0.0	0.0	0.0	0.0
Textile, Wearing apparel, leather, furs, down and others industry	0.0	0.0	0.0	0.0	0.0	0.0
Sawmills and manufacture of furniture	1726503.2	1825572.3	1906070.9	1999017.2	2190310.9	2340756.0
Paper products, printing and record medium reproduction	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum refineries and coke-making	0.0	0.0	0.0	0.0	0.0	0.0

Chemical industry	0.0	0.0	0.0	0.0	0.0	0.0
Non-metal mineral products	0.0	0.0	0.0	0.0	0.0	0.0
Smelting and pressing of metals	0.0	0.0	0.0	0.0	0.0	0.0
Metal products	4551463.6	4812632.9	5024845.8	5269873.8	5774168.4	6170776.7
Machinery industry	88437528.8	93512196.8	97635616.0	102396648.2	112195380.7	119901704.8
Manufacture of transport equipment	39307004.0	41562494.4	43395192.0	45511283.6	49866434.9	53291592.9
Electric machinery and equipment	9722645.4	10280544.2	10733864.7	11257283.1	12334536.2	13181754.1
Electronic and Telecommunication Equipment	37276739.5	39415730.5	41153766.6	43160559.0	47290760.3	50539003.9
Manufacture of instrument, meters and other measuring equipment	3327421.4	3518353.4	3673495.2	3852626.8	4221299.6	4511246.5
Other manufacturing Products	1946300.3	2057981.7	2148728.4	2253507.4	2469154.3	2638752.2
Electricity, steam, hot water and gas production and supply	0.0	0.0	0.0	0.0	0.0	0.0
Construction	386031215.5	408182221.9	426181011.7	446962993.0	489734615.9	523372842.4
Freight transportation and storage	2796162.9	2956610.7	3086982.4	3237513.7	3547324.0	3790977.8
Post and telecommunication services	3606046.8	3812966.8	3981099.5	4175230.9	4574775.0	4889000.9
Commerce and catering service	13513122.8	14288524.5	14918576.8	15646055.5	17143287.2	18320802.1
Finance and insurance	0.0	0.0	0.0	0.0	0.0	0.0
Real estate industry	12566339.4	13287413.4	13873321.7	14549830.3	15942160.0	17037173.4
Scientific research and Polytechnic services	1784915.2	1887336.1	1970558.1	2066649.0	2264414.7	2419949.7
Services of health care, sports and social welfare	0.0	0.0	0.0	0.0	0.0	0.0
Government agencies and others						

Table 5 The simulation results of output Unit: 10000yuan

	2006	2007	2008	2009	2010	2011	2012	2013
Agriculture, forestry and fishing	320151293.1	340377086.6	363392393.8	385698656.3	407559707.2	431345683.9	455481773.2	480650394.8
mining	109459854.0	118122424.5	129301600.6	139160548.8	147976726.4	158285072.3	169170685.2	180631101.6
Food, beverages and tobacco	167165994.0	178487672.3	190873041.3	203662400.5	216986900.2	231358170.8	246090266.3	261709633.2
Textile, Wearing apparel, leather, furs, down and others industry	117094861.3	126795134.2	137681654.7	149031896.7	160985639.9	174121690.3	187914824.5	202754088.6
Sawmills and manufacture of furniture	32006156.4	34292930.9	37289635.4	39860392.6	42107604.6	44767282.2	47559262.9	50487209.7

Paper products, printing and record medium reproduction	58129109.5	62262571.2	67180468.8	71982765.7	76890735.3	82479084.0	88351848.9	94692331.0
Petroleum refineries and coke-making	62593086.0	67686504.8	74117471.8	79958502.3	85353902.3	91589446.7	98179065.6	105153124.1
Chemical industry	240133508.6	258524622.8	280836615.9	301831687.7	321950001.8	344715832.6	368554260.7	393799252.0
Non-metal mineral products	54061670.4	58322460.0	64202468.4	68953102.7	72709325.2	77275303.7	82104884.0	87078620.7
Smelting and pressing of metals	153151075.4	165976731.2	183653913.9	198107665.0	209734721.7	223856436.6	238889609.7	254477196.2
Metal products	54283889.6	58543770.6	64259778.6	69036721.8	73001288.8	77730655.0	82721215.8	87898186.4
Machinery industry	133164044.6	144305857.9	160023688.3	172491786.1	182057067.8	193866162.3	206451777.3	219394108.2
Manufacture of transport equipment	94651577.1	103506706.8	114918895.3	125223261.7	134644495.3	145652350.1	157429660.3	169943610.5
Electric machinery and equipment	70140069.6	76258311.3	84073340.6	91134502.4	97599616.9	105113446.1	113102367.1	121566017.2
Electronic and Telecommunication Equipment	137600191.8	150122328.6	166069740.7	180616030.9	194069397.7	209687770.1	226346474.6	244050856.7
Manufacture of instrument, meters and other measuring equipment	16502473.3	17855963.8	19642348.6	21196891.6	22576217.5	24216320.8	25962808.8	27811805.5
Other manufacturing Products	25748760.9	27836810.1	30465079.9	32855171.6	35061517.5	37604638.3	40288511.3	43124999.3
Electricity, steam, hot water and gas production and supply	93192254.0	100570030.3	109658699.2	118178224.5	126380543.6	135781671.1	145705257.1	156292245.0
Construction	226387958.7	245545042.3	274849129.1	295879504.5	309335793.0	327258121.5	346530048.7	365796602.1
Freight transportation and storage	139773373.0	151426151.4	165674672.1	179195052.5	192305080.3	207252903.9	223065666.7	239948153.9
Post and telecommunication services	57202695.2	61766149.2	67456683.9	72687008.1	77584609.5	83209626.9	89138999.8	95420474.9
Commerce and catering service	238189178.0	256469903.8	278257757.4	299212216.8	319753279.2	342829145.6	366981031.0	392649564.5
Finance and insurance	93320244.0	102225304.2	112668371.3	123255456.4	134156232.7	146389136.5	159421344.2	173501359.1
Real estate industry	94851541.6	101535721.6	109066949.6	116630967.8	124308636.9	132682688.9	141312822.5	150445437.3
Scientific research and Polytechnic services	37089662.8	39931892.2	43210135.5	46477270.9	49782785.3	53441593.9	57259595.7	61328626.3
Services of health care, sports and social welfare	83004322.0	89348729.5	96272525.5	103628761.3	111499770.5	120044534.4	128937308.2	138485881.0
Government agencies and others	151583549.0	163219848.2	175736338.9	189213092.4	203733690.0	219381645.9	235632853.9	253064354.6
Other services	112855330.0	121579908.7	131654415.8	141716713.9	151937574.8	163273956.3	175125783.7	187783814.3
Total	3173487723.8	3422896569.2	3732487815.0	4016876253.1	4282042861.8	4585210370.7	4903710007.8	5239939048.8

Table 5 continuing

产出	2014	2015	2016	2017	2018	2019	2020
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Agriculture, forestry and fishing	507146099.9	534930345.2	563830869.1	592970167.5	623927375.8	660135628.8	695486199.9
mining	192946639.4	206048471.3	219792509.4	233194499.6	247894811.7	267556054.2	285593829.0
Food, beverages and tobacco	278261473.7	295727111.2	314100963.3	333246127.0	353572210.9	375642906.0	398206584.6
Textile, Wearing apparel, leather, furs, down and others industry	218718570.4	235812376.4	254034301.2	273224939.9	293800937.5	316431105.6	339725331.5
Sawmills and manufacture of furniture	53599161.1	56847636.0	60207090.1	63393332.5	66915101.8	71770390.6	76030826.9
Paper products, printing and record medium reproduction	101397325.1	108318277.6	115529775.6	122851577.1	130843822.6	139897097.0	148495798.1
Petroleum refineries and coke-making	112661214.3	120675286.8	129122780.1	137510313.3	146667655.3	158447819.5	169525080.6
Chemical industry	420841738.7	449591277.4	479866880.6	510346104.5	543353804.7	583858878.7	622775453.7
Non-metal mineral products	92444714.0	98191552.9	104177337.4	109677000.1	115793386.3	125298867.0	133493915.8
Smelting and pressing of metals	271372279.8	289559333.2	308618878.9	326418352.1	346192155.3	376129812.9	402395903.0
Metal products	93474547.0	99437368.9	105667314.4	111535455.7	118013931.2	127504570.8	135904599.7
Machinery industry	233446967.4	248614493.3	264468267.4	278930007.3	295092016.0	320970934.3	343173633.3
Manufacture of transport equipment	183554565.1	198268786.1	213912623.0	229528734.4	246630473.5	268930717.2	290071975.2
Electric machinery and equipment	130730253.9	140587369.6	151026713.8	161411640.5	172765608.5	187536122.6	201480983.4
Electronic and Telecommunication Equipment	263269275.8	284004748.5	306034023.5	328100740.5	352214351.7	383242500.5	412804174.0
Manufacture of instrument, meters and other measuring equipment	29800590.1	31908529.4	34117714.8	36260162.0	38628450.8	41827018.2	44720075.7
Other manufacturing Products	46179454.2	49444376.8	52887431.9	56308181.4	60037743.1	64837638.0	69362858.6
Electricity, steam, hot water and gas production and supply	167637660.1	179643984.8	192280336.0	204989160.9	218843093.4	235802036.1	251939152.4
Construction	386862862.1	409765462.6	433442505.6	452965940.7	475475522.9	520000694.4	555126176.5
Freight transportation and storage	258127170.9	277528931.3	298065584.0	318906789.1	341560406.5	369100389.6	395746826.4
Post and telecommunication services	102170292.0	109359775.2	116934060.3	124489820.0	132721108.2	143133052.9	152984735.4
Commerce and catering service	420135967.1	449346285.7	480157532.3	511491328.0	545340538.3	585731572.1	625093617.8
Finance and insurance	188773386.4	205243141.0	222879078.0	241340143.9	261295576.3	284098046.7	307214657.4
Real estate industry	160164680.4	170472920.8	181334377.7	192549690.7	204508409.8	218023401.4	231627613.1
Scientific research and Polytechnic services	65685660.1	70325226.8	75234769.9	80305255.1	85751057.7	91994005.5	98237326.2
Services of health care, sports and social welfare	148698604.1	159568373.8	171115014.1	183324003.1	196350094.9	210270670.1	224740369.4
Government agencies and others	271729873.1	291672067.1	312904763.3	335477556.3	359481189.5	384887811.2	411629628.6

Other services	201339530.3	215759792.6	231020936.2	246796836.3	263761409.8	283140063.2	302509422.6
Total	5601170556.6	5986653302.2	6392764431.5	6797543859.3	7237432243.9	7796199805.0	8326096748.8

Table 6 The simulation results of educational funds Unit: 10000yuan

Year	Primary school	Junior high school	Senior high school	High education	Total
2006	16239893.5	15048560.2	20230035.3	48119080.8	99637569.8
2007	17573430.2	15296980.6	21702820.0	57083904.8	111657135.6
2008	19038098.5	15650081.4	21133600.2	68682968.5	124504748.6
2009	20820533.9	15942900.0	20774154.0	79694234.9	137231822.8
2010	22918110.6	16155170.6	21484588.2	87317068.8	147874938.1
2011	25725247.3	15985649.8	22334901.6	93757098.2	157802896.8
2012	28894153.5	16045892.6	23092434.0	99502998.3	167535478.4
2013	31260909.7	17999250.9	23723174.3	103392974.2	176376309.2
2014	34088115.6	20603490.5	23774068.9	108633326.9	187099001.9
2015	37466835.1	23484291.1	24145163.4	116690340.2	201786629.9
2016	41362633.0	24567570.5	27379488.0	125507598.8	218817290.3
2017	45724396.6	26128698.2	31654729.3	133786542.4	237294366.5
2018	49142489.9	27870511.0	36412195.0	142017292.5	255442488.4
2019	52602382.9	30058115.3	38412846.4	160223479.3	281296824.0
2020	56183142.3	32382387.6	41143626.2	182414018.1	312123174.2

Table 7 The simulation results of new labors Unit: person

year	Junior high school	Senior high school	High education
2006	5768028.7	6015290.9	6341024.5
2007	3884990.5	6421350.9	6901274.2
2008	3102772.1	7894588.4	7617950.9
2009	2379901.7	7726547.5	8109414.9
2010	1797719.8	6887578.6	8151457.4
2011	1236075.2	6742030.8	8190566.6
2012	684890.6	6545856.3	8287530.7
2013	220550.5	6575074.8	8198612.0
2014	0.0	6536470.9	8190266.9
2015	0.0	6221049.1	8354501.4
2016	0.0	6144420.4	8383558.4
2017	0.0	5576873.8	8335331.8
2018	0.0	5380878.7	8250628.7
2019	0.0	7069866.4	8402018.3
2020	0.0	6835295.7	8775849.7

5 Conclusion

On the base of former research results, this paper build a model system of the extended input-output model on assets with education considering population, to analyze the education scale and education funds demand, and the economic growth rate and economic structure change, in order

to meet the population consumption demand and to get full employment.

The 2002 Chinese extended input-output table with assets on education is compiled. Based on the table, we predicted the population and its structure change; analyzed the economic growth and structural change to get full employment under the condition of 7% growth rate in consumption per capita; predicted the education scale and structure, and the corresponding education funds. The simulation requires further investigation to change the parameters setting.

References

- Aulin-Ahmavaara, P. (1987) *A Dynamic Input-Output Model with Nonhomogeneous Labour for Evaluation of Technical Change* (Helsinki: The Finnish Academy for Science and Letters).
- Aulin-Ahmavaara, P. (1989) A complete dynamic input-output model including the production of human capital and labour, *Economic Systems Research*, 1, pp.121–129.
- Aulin-Ahmavaara, P. (2003) The SNA93 values as consistent framework for productivity measurement: unsolved issues, *Review of Income and Wealth*, 49, pp. 117–133.
- Aulin-Ahmavaara, P. (2004) Moving human capital inside the production boundary, *Review of Income and Wealth*, 50, pp. 213–228.
- Bar Los. Endogenous Growth and Structural Changes in a Dynamic Input-Output Model [J]. *Economic Systems Research*, 2001, vol. 13: 3-34
- Bródy, A. (1970) *Proportions, Prices and Planning* (Amsterdam: North Holland).
- Chen, X. (1990) Input-occupancy-output analysis and its application in China, in: M. Chatterji and R.E. Kuenne (Eds), *Dynamics and Conflict in Regional Structural Change*, pp. 267-278 (London: Macmillan).
- Chen, X. (1999) Input-occupancy-output analysis and its application in Chinese economy, in: S.B. Dahiya (Ed.), *The Current State of Economic Science*, pp. 501-514 (Rohttak, India: Spellbound Publications).
- Chen X. (2002) Water conservancy economy input-occupancy-output tables for China and its nine major rivers, Paper presented at the Fourteenth International Conference on Input-Output Techniques, October 10-15, 2002, Montreal, Canada.
- Chen, X., Guo, J. and Yang, C. (2005) Extending the input-output model with assets, *Economic Systems Research*, 17, pp. 211-226.
- Liu, X. (1996) Dynamic input-occupancy-output model for human capital, *Quantitative & Technological Economics*, 3, pp. 40–45.
- Lucas, R. (1988) On the mechanics of economic development, *Journal of Monetary Economics*, 22, pp. 3–42.
- Mincer, J. (1958) Investment in human capital and personal income distribution, *Journal of Political Economy*, pp. 281-302.

Song Jian, Yu Jingyuan (1985), *Population Cybernetics*, Science Press.

Zhang Hongxia & Chen Xikang (2008), An Extended Input-Output Model on Education and the shortfall of Human Capital in China [J], *Economic Systems Research*, Vol. 20(2): 205-221.