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Analysis of the Tax System of China by Means of Computable General Equilibrium Model

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Abstract: This work analyzes CGE model for the analysis of the impact of changes caused by the tax policy in China. A model that demonstrates the effectiveness of the tax system applied in China is developed. It is proved that the municipal economies are experiencing greater tax burden than rural economies, and that the capital is experiencing the largest tax burden which means a decrease in the income of the households. Consequently, the tax burden is shifted to the households. It is argued that the income tax system and factors of the taxes are the most suitable for the Chinese economy.

Key words: Taxation · Factors · Computable General Equilibrium · Households · Municipal economies · Rural economies · Tax schemes · Tax burden · Capital · Consumption · Demand · Equilibrium system · The equality of supply and demand · Consumption price

INTRODUCTION

Since the beginning of 1980, computable general equilibrium models, known in foreign literature as Computable General Equilibrium models (CGE models) [1, 2], have become more and more popular in the analysis of the consequences of the selection of macroeconomic policies and resources allocation in both developing and developed countries. Many countries have developed CGE models for the analysis of the impact of changes caused by the tax policy.

J.B. Shoven, J. Whalley (1972, 1973) [3, p. 281; 4, p. 475] were the first who used a general equilibrium model for the analysis of the tax system. Their last work was used in some models created by J. Whalley (1977) for England [5, p. 342], J. Piggott, J., Whalley (1976) for Australia [6, p. 118] and M., Karadag, T. Westaway (1999) for Turkey [7, 187]. In recent years, well-known CGE models that have been developed for the U.S. tax system analysis are often used in the other countries. A number of CGE models have been developed for the Chinese economy, such as Shantong Li [8] and Hongsong Li, Liangguo Wu. (2000) [9].

As it's known that, after the tax reform in 1994, Chinese tax system consists of sales tax (value added tax, business tax, and consumption tax), income taxes, customs duties, resource taxes, taxes on transactions (operations),taxes on property, and others. Turnover taxes are considered to be the main and fundamental taxes in China as they account for over 65% of the government revenues. With the growth of the tax revenue from the other types of taxes, the share of these three types of turnover taxes fell slightly, but they still retain a leading position. Turnover taxes exist in the most tax systems of the countries of the world, and the earnings from them are usually much less than from income taxes, especially in developed countries.

Our objective is to develop a model which is able to demonstrate the degree of effectiveness of the taxes system applied in China.

MATERIALS AND METHODS

CGE model is a static double-factor model, and it examines three groups of goods in accordance with the three sectors of the Chinese economy which are primary, secondary, and tertiary sectors. In this model, households, according to their geographical location, are divided into two groups - urban and rural. The model consists of two types of basic functions - production and consumption. On their basis, we may obtain three groups of equilibrium equations.

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To develop the model we choose functional forms. The first limitation includes selected functions which meet the law of Walras, which is considered to be an important basis for the consumption functions in any equilibrium system. The second limitation requires that the changes of the supply and demand in the economy to be applied and suitable for the calculation of any price vector used in the equilibrium in the economy.

The main functional forms used in CGE model is Cobb-Douglas production function, constant elasticity of the production factor (CES), the linear expenses system (LES) and others. We give a production function:

$$Q_i = A_i K_i^{\alpha_i} L_i^{\beta_i} \text{ (i = 1, 2, 3)} \tag{1}$$

where Qi - the quantity of good "i", Ai - efficiency parameter; K_i and L_i - invested capital and labor, α_i and β_i - capital capacity and labor productivity; i = 1, 2,3 - primary, secondary, and tertiary sectors.

Since the requirements, brought by the Cobb-Douglas utility function, are easier to work with, we may write down our utility function as follows:

$$U^c = \prod \left(X_i^c \right)^{\delta_i^c} \text{ (i = 1, 2)} \tag{2}$$

where U^c - the utility, c - different consumers, c = 1 - urban households, c = 2 - rural households; X_i^c - good "i" consumed by each costumer "c"; δ_i^c - the share of expenses of the "c" consumers, $\delta_i^c > 0$ and $\sum_{i=1}^{3} \delta_i^c = 1$ (c = 1, 2).

Functions of the factors, derived from the cost minimization for the production function (1), take the form:

$$K_i = \frac{\alpha_i * \alpha_i^{-\alpha_i} * \beta_i^{-\beta_i} * Q_i * P_K^{\alpha_i} * P_L^{\beta_i}}{A_i * P_K} \tag{3}$$

and

$$L_i = \frac{\beta_i * \alpha_i^{-\alpha_i} * \beta_i^{-\beta_i} * Q_i * P_K^{\alpha_i} * P_L^{\beta_i}}{A_i * P_L} \tag{4}$$

where P_K and P_L - price factors of production.

Equation of the customer budget may be written as:

$$P_1 . X_1^c + P_2 . X_2^c + P_3 . X_3^c = P_L . W_L^c + P_k . W_k^c = I^c \tag{5}$$

where Pi - consumer price for the good "i", W_L^c and W_K^c - labor and capital costs of the consumer "c", I^c - income of the consumer "c".

If we maximize the utility function, on the condition that the budget of the customer is limited, it gets possible to develop individual functions of demand on the goods:

$$X_i^c = \frac{\delta_i^c}{\sum \delta_i^c} \times \frac{I^c}{P_i} \text{ (i = 1, 2, 3; c = 1, 2)} \tag{6}$$

In the CGE model there are 15 parameters which need to be accurately determined. There are 9 parameters of the production function which influence the supply of the goods (i.e. A_i, α_i and β_i for i = 1, 2, 3) and 6 parameters of the utility function that determine the demand of each customer on each good (i.e. δ_i^c for i=1, 2, 3; c = 1, 2). There are also 4 exogenous variables the values of which should be determined: labor costs (W_L) and capital costs of each consumer (W_K).

Solution of the model is characterized by 17 variables: 5 price variables P_1, P_2, P_3, P_K, P_L, and 12 values X^1_1, X^1_2, X^1_3, X^2_1, X^2_2, X^2_3 and K_1, K_2, K_3, L_1, L_2, L_3, which meet all the requirements of the equilibrium.

The conditions of the equilibrium in this model consist in the market demand equaling to the market supply for all the labor costs, capital costs, and output of the goods, while every sector has zero profit. It may be written more fully as:

Equality of supply and demand for the factors:

$$\sum_{i=1}^{3} K_i \left(p_L, p_K, Q_L \right) = \bar{K} \tag{7}$$

$$\sum_{i=1}^{3} K_i \left(p_L, p_K, Q_L \right) = \bar{L} \left(i = 1,2,3 : c = 1,2 \right) \tag{8}$$

where $K_i(P_i, P_i, Q_i)$ and $L_i(P_i, P_i, Q_i)$ are set by the functions (3) and (4); $\bar{K}$ and $\bar{L}$ - aggregate supply of capital and labor.

Equality of supply and demand for the goods:

$$\sum_{c=1}^{3} X_i^c \left(P_1, P_2, P_3 P_L, P_K \right) = Q_i \text{(i = 1, 2, 3)} \tag{9}$$

where X^c_i - set by the maximization of the utility function (2), on the condition that the budget of the consumer is limited; Q_i - set by the function (1).

Condition of zero profitability for all the sectors:

$$P_K.K_i\left(P_L,P_K,Q_i\right)+P_L.L_L\left(P_L,P_K,Q_i\right)=P_iQ_i \ (i = 1, 2, 3) \quad (10)$$

Since the price factor determines consumers income (which take its position when limiting the budget of each customer) and the price of goods provide distortion of the budget limitation, customers demand on goods may be calculated. Conditions of the factor, which meet the demand on goods, are set by the functions (3) and (4). Consequently, the equilibrium is characterized by 5 price parameters P_1, P_2, P_3, P_K, P_L as it's shown in equations (7) - (10).

Thus, we have the complete model of general equilibrium. On the next stage, we include tax variables in the model. Three alternative tax schemes are created in this model to illustrate different situations under the variety of tax systems. We form scheme 1 that reflects taxes levied upon finished products. Theoretically, in the value added tax system, the price of the product is a total added value of the entire process and this tax is price included. Although only the certain number of goods of industrial output are subjected to consumption tax, it is reasonable that we assume the production of these goods to use the single production process and the consumption tax is considered as a part of the price. Business tax is subjected to services, and it is clear that its price includes the tax. For the same reasons other taxes could be substituted by the tax levied on the finished products. Now the profit maximization problem of i-th sector is the next:

$$\begin{aligned} &\max\ \pi_i = P_iQ_i - T_iP_iQ_i - P_KK_i - P_LL_i \\ &s.t.\ A_iK_i^{\alpha_i}L_i^{\beta_i} = Q_i \end{aligned} \quad (11)$$

where π_i is a profit of i-th sector, Ti - tax rates for the finished product of i-th sector.

Now we move to the formation of the schemes 2 and 3 that reflects taxes levied upon expended production factors. In the schemes 2 and 3 we replaced the taxes by those which are subjected to expended factors. Then the profit minimization problem of i-th sector is the next:

$$\begin{aligned} &\min C(K_i,L_i) = (1+T_{ki})P_kK_i + (1+T_{li})P_lL_i \quad (i = 1, 2, 3) \\ &s.t.\ A_iK_i^{\alpha_i}L_i^{\beta_i} = Q_i \end{aligned} \quad (12)$$

where TKi и TLi are tax rates for the capital and labor in I-th sector.

In scheme 2 Tk1= Tk2= Tk3, and Tl1= Tl2= Tl3, while in scheme 3 Tk1 ≠ Tk2 ≠ Tk3, и Tl1 ≠ Tl2 ≠ Tl3.

The most part of the current Chinese tax system is considered in the CGE model. The total sum of all tax proceeds is 867.21 billion, which equals 93.63% of the total national income.

Suppose that in Scheme 1 the agricultural tax and contract tax are applied to the primary sector, value added tax and consumption - to the secondary sector, business tax and property transfer tax - to the tertiary sector, and other taxes are distributed between secondary and tertiary sectors according to its production. On this basis, we calculate mixed tax rates in three economy sectors (Table 1).

In schemes 2 and 3 it is quite difficult to determine which factor, capital or labor, includes these taxes other than income tax on individuals. To solve the problem we suppose that all taxes, excluding income tax on individuals, are subjected to the capital and only personal income tax is subjected to the labor. In scheme 2 both capital and labor in different economy sectors are taxed by the same mixed rates (Table 2).

However, in practice the same factors in different economy sectors are taxed to different rates. With scheme 3 we calculate tax rates in different sectors (Table 3).

Note that farmers who work in the primary sector have less income, and so we take into account that they do not pay tax on individuals. This also means that all income taxes on individuals are distributed on labor in secondary and tertiary sectors.

It is obvious that tax rates on capital in the primary sector are too high and they conflict with reality. This is because the primary sector, in whole, is invested by the Government, and capital is concentrated in base sectors which could not make a profit directly, e. g., irrigation operations. That is why, in fact, agricultural tax and contract tax are not subjected to the capital in the primary sector, so we do not take into account the capital tax in the primary sector.

The next problem that requires to be solved is redistribution of income. Based on sum of all tax revenues it is discovered that urban households have gotten 9.388%, rural households - 0.798%, and the remaining amount was directed to the Government funds.

It is also determined the operating parameters (i.e., A, α and β) (Table 4).

The consumers' budget distribution parameters are necessary to determine factors (i.e., δ_i^c for i = 1, 2, 3; c=1, 2). We determined the consumers' budget distribution parameters. They are proportional to the costs of benefits in each sector (Table 5).

Table 1: Tax rates in economy sectors

Economy sector	Primary sector	Secondary sector	Tertiary sector
Tax rate	0,027316	0,146478	0,099822

Table 2: Mixed tax rates

Capital	Labor
0,29337	0.007495

Table 3: Mixed tax rates in different economy sectors

	Primary sector	Secondary sector	Tertiary sector
Capital	1,071789	0,606598	0,129802
Labor	-	0,017642	0,017642

Table 4: Operating parameters

	Primary sector	Secondary sector	Tertiary sector
A	0,2418	0,0841	0,0473
α	0,6998	0,8408	0,5579
β	0,6742	0,5628	0,8338

Table 5: Distribution parameters

	Urban households	Rural households
Primary sector	0,1844	0,2906
Secondary sector	0,4843	0,5282
Tertiary sector	0,3313	0,1812

Table 6: Cost factors

	Capital (100 million Yuans)	Труд (10,000 persons)
Urban households	3236,904	20678
Rural households	809,976	49279
Total	4046,88	69957

When model is created, it indicates that with supported growth of the Chinese economy, households' savings are rising rapidly. In the CGE model savings are considered to be exogenous variables in order to balance budgets both of consumers and the Government. Households' savings are constant proportion of its net income. We evaluated savings' rates both of urban and rural households, in other words, 0.2971 for urban and 0.05486 for rural. It means that 29.71% of urban income and 5.486% of rural households' income are transferred into savings.

Data processing and information updating which used in the model. The problem arises because of different data classification. For example, in the yearbook annual costs on food products per capita are classified by the characteristics of these products, not by the economy sector. It is essential to regroup them according with three economy sectors. Major adjustments is this data cluster could be summarized as follows.

If any production does not have a need in further technical processing, it refers to the primary sector; in other way "-" to the secondary one; and the rest refers to the tertiary sector.

Similarly, we have made updating of other data. First, we use urban and rural households' savings data. Then, we evaluate the exchange rate in relation of households' savings to investments. All the data obtained we put into Table 6.

Table 7: Initial model - without taking tax inflows

	Output, Yuan.	Capital, units.	Labor, 10 000 people.	Tax inflows, Yuan.
		Initial model - without taking tax inflows		
		Production		
Primary sector	20344,55	567,88	9367,1	0
Secondary sector	42938,43	2008,72	23020,2	0
Tertiary sector	21337,37	1468,4	37569,7	0
Total	84620,35	4045,0	69957	0
Price Unit	-	17,12	1	-
		Consumption		
	City	Countryside	Government	Total
Primary sector	7376,06	12968,49	0	20344,55
Secondary sector	19369,71	23568,72	0	42938,43
Tertiary sector	13249,92	8087,46	0	21337,37
Income factor	56901,92	47214,98	0	104116,9
Transfers	0	0	0	0
General income	56901,92	47214,98	0	104116,9
Savings	16906,24	2590,31	0	19496,55
Expenditures	39995,68	44627,67	0	84620,35
	Output, Yuan.	Capital, units.	Labor, 10,000 people.	Tax inflows, Yuan.

Table 7: Continue

Scheme 1 - sectors output taxes				
Production				
Primary sector	18790,82	1130,52	11995,4	507,352
Secondary sector	34238,67	2125,46	15668,76	5012,541
Tertiary sector	18009,82	789,03	12986,1	1797,281
Total	71038,31	4045,0	40650,26	7317,174
Price unit	-	11,014	1	-
Consumption				
	City	Countryside	Government	Total
Primary sector	5502,556	11973,66	0	18790,82
Secondary sector	14449,85	21760,73	0	34238,67
Tertiary sector	9884,47	7467,05	0	18008,82
Income factor	41762,62	43535,23	0	85297,85
Transfers	686,35	57,81	-744,16	0
General income	42448,98	43593,04	7317,174	93359,19
Savings	12612,10	2391,60	0	15003,70
Expenditures	29836,88	41201,44	0	71038,31

Table 8: Scheme 2– expended factors taxes (tax rates are identical for the same factors in all the sectors)

Production					
	Primary sector	Secondary sector	Tertiary sector	Total	Price unit
Output, Yuan.	17030,76	35226,57	16820,74	69078,07	-
Capital, units.	678,832	1603,76	1762,41	4045,0	14,103
Labor, 10 000 people.	9222,96	15138,83	37141,86	61503,65	1
Tax inflows, Yuan.	2124,64	4984,71	5585,15	12694,5	-
Capital tax	12372,51	Labor tax	321,99	Total taxes	12694,5
Consumption					
	City	Countryside	Government	Total	
Primary sector	5286,828	11743,93	0	17030,76	
Secondary sector	13883,34	21343,23	0	35226,57	
Tertiary sector	9496,948	7323,791	0	16820,74	
Income factor after tax	39589,87	42656,03	0	82245,9	
Transfers	1194,89	100,64	-1295,53	0	
General income	407,84	42756,67	12694,5	96280,09	
Savings	12117,64	2345,716	0	14463,36	
Expenditures	28667,12	40410,95	0	69078,07	

Table 9: Tables to scheme 3. - expended factors taxes (different tax rates in different sectors)

Production					
	Primary sector	Secondary sector	Tertiary sector	Total	Price Unit
Output, Yuan.	17604,84	36605,93	17666,09	71876,86	-
Capital, units.	843,83	1083,85	2117,32	4045,0	14,88
Labor, 10 000 people.	12093,89	10792,65	47070,45	69957	1
Tax inflows, Yuan.	0	7456,76	3677,42	11134,18	-
Capital tax	10372,53	Labor tax	761,65	Total taxes	11134,18
Consumption					
	City	Countryside	Government	Total	
Primary sector	5702,39	11902,45	0	17604,84	
Secondary sector	14974,63	21631,30	0	36605,93	
Tertiary sector	10243,45	7422,64	0	17666,09	
Income factor after tax	42946,22	43245,81	0	86192,03	
Transfers	1044,386	87,960	-1132,346	0	
General income	43990,61	43333,77	11134,18	98458,56	
Savings	13070,14	2377,377	0	15447,51	
Expenditures	30920,47	40956,39	0	71876,86	

Table 10: Prosperity estimation.

	Scheme 1		Scheme 2		Scheme 3	
	CV	EV	CV	EV	CV	EV
City households	-14452,97	-14452,97	-16117,17	-16117,17	-12911,33	-12911,33
Countryside households	-3621,85	-3621,85	-4458,30	-4458,30	-3881,20	-3881,20
Total	-18074,92	-18074,92	-20575,47	-20575,47	-16792,53	-16792,53
National income losses	-19,36%	-19,36%	-21,37%	-21,37%	-17,06%	-17,06%

Now that parameters of production and consumption functions are determined and expended factors are known, CGE model is built. According to the accepted solution practice, we took labor price as the standard one. Then we solved this general equilibrium model and found the series of net market prices of products and factors for the initial model and each tax model respectively. All the results are presented in the tables below (Table 7-9).

CONCLUSIONS

Equilibrium solutions provide the data about tax inflows from all the schemes. Tax inflows in schemes 1, 2 and 3 make up 731,7174 bil., 1 269,45 bil. and 1 113,418 bil., which is 84,38%, 146,38% and 128,39% of all the tax inflows in China, respectively.

Obviously, more tax inflows may be gathered by using schemes 2 and 3, which means that income taxes are more appropriate for the Chinese economy, from the point of view of taxes accumulation in government's favor.

In the scheme 1 (final output taxes), employed population is 406,5026 mil., which makes 41,89% of all unemployed population in China. This result is close to the achieved result in Li Hongsong work [8], where the percent of unemployed population in China is 46,2%. On the other side, in scheme 2 unemployment rate declined to 7,8%, and in scheme 3 - drops to zero.

From the point of view of providing a bigger number of the working places, income taxes (factor taxes) are more appropriate for China, especially, in accordance with the scheme 3.

The most widely used means are compensation and equivalent deviations (variants), connected with equilibrium comparison. Compensation and equivalent variants may be written as:

$$CV = \frac{(U_n - U_o)}{U_n} I_n, EV = \frac{(U_n - U_o)}{U_o} I_o \quad (13)$$

where U_n, U_o and I_n, I_o - are the new and the previous utility and income levels, respectively.

Compensation and equivalent variants, referring to all the schemes, are presented in Table 10.

But the fact that these taxes are distorting points out to gross welfare losses. And city households lose more than the countryside ones. The results show that the losses of the overall society's prosperity are estimated to be 20% of the national income in each of the schemes, and distortion of taxes by the scheme 3 is lower than by the other two schemes. From the point of view of economic prosperity, scheme 3 (different taxes in different sectors) is the most appropriate for China.

In CGE model, labor price is determined as 1 price unit, as the standard price, which gives a relative equilibrium of capital prices. In tables, the relative capital price in the initial model, in schemes 1, 2, and 3 is 17,12, 11,014, 14,103 and 14,88 price units, respectively. This result, in which the capital price declines while taxation, is related to one of the conclusions that were made by Herman K. Harberger [10, p. 223], who discovered that taxation of factors leads to the drop of the relative capital price.

The result that the capital price in scheme 1 is lower than in scheme 2 shows that although all the tax schemes hold in public demand on capital, taxes from turnover, taxes on final output will have a bigger effect than others. Taxation leads to changes in income and consumption of the households. Changes in income (consumption) of the city households in schemes 1, 2, and 3 show that city households lose much more income than countryside households. The reason is that more taxes are imposed on capital, while only the part in all of the tax schemes is imposed on labor. That's why city households suffer from a bigger tax burden than the countryside ones. In other words, the biggest tax burden is imposed on capital, which means the decline of the net income of the households. Therefore, the tax burden shifts onto the households.

All of the adduced arguments show that the system of the income taxes, factor taxes, is the most appropriate for the Chinese economy.

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