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The Model Analysis of Water Resource Policy Based On CGE Model

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Water resources must exist in the forms of water factors and water commodities. Based on this feature as well as the actual situation of water resource remuneration collection of our country, this thesis has included water production and supply industry, factors reward of water resources and the computable general equilibrium model of water resources of production water supply subsidy. Three scenes have been established, they are the rise in price of water factors, adjustment of production water supply subsidy and technical progress. Setting Jiangxi Province as an example, this thesis has manufactured SAM form, utilized CGE model to simulate the impacts possessed by various scenes on the economy and society and conducted comparable analysis of the simulation results of these three scenes under the same water-saving target. The research result indicates: Raising the price of water factors, cutting down the production water supply subsidy as well as the technical progress can all promote the improvement of water-use efficiency and decrease the total demand of water-use. However, whether analysed from indexes like the total output, GDP, employment, price level or the income of residents or enterprises, the former two scenes will definitely generate negative impact on economy, besides, the negative impact will be larger if cutting down the production water supply subsidy. Technical progress can promote economic development when reaching the water-saving target at the same time.

1. Introduction

Under the background of global climate changes and the fast development of economy and society, the imbalance between water supply and demand and water conflicts are gradually intensified. The sustainable utilization of water resources becomes an essential factor which influences the harmonious development of Chinese economy and society (Chen and Cao, 2010). The primary condition to reach the target of efficient water-saving is to formulate reasonable policy design of water resource management and policy selection. However, water resource management is not only a problem of natural science, it is even more a matter of social science. The management policy of water resources will generate various complicated impact on the macro economy, resource environment as well as interest-related persons involved in the policy (Feng and Tian, 2013). According to the adaptive management of water resources, only based on the consideration of the comprehensive impact of system vulnerability and water resource management policy, reasonably conducting institutional arrangement and policy selection and balancing the conflicts of interest among various subjects of the heterogeneity of water resource management can effectively lead and inspire subjects change their low-efficient behaviours of water consumption and realize the harmony between human and water (Gao and Zhang, 2013).

Since it can quantitatively simulate both direct and indirect impacts brought by policy changes on the whole national economy, CGE model has been widely applied in the assessments of trade policies, financial and monetary policies as well as energy polices (Kucukmehmetoglu and Geymen, 2010). In recent years, various scholars begin to analyse matters concerning water resources through CGE model. The range of research includes policy of water price, water resource allocation, water market, etc. Based on the analysis of current researches, the following problems exist in the CGE model of our country now: 1. When water factors are brought into production function and the factor value of water resource is indicated in CGE model, the variation changes of factor price is available for simulation. While the measurement on factor price of water resource is not uniform in present models, there exist engineering water price measurement and shadow price measurement (Liu and Zhang, 2012). Among that, factor price based on shadow price measurement is more reasonable. However, the actual remuneration of water resource factors collected by our country is much less than that of theoretical value. The effects of model will be influenced if this situation is not taken into account. 2. If only bringing water-related enterprises into the model as an industry and only adopting data in input-output table (IO table) to count the total value of water consumption, then it is equal to set the total volume of goods(water supply) of water production and supply as the total water consumption in production and life. At this moment, the water quantity counted in model is smaller than that in actual economic activities, besides, the water price adopted is actually the price of water commodities containing the interest of water supply enterprises and the influence simulation conducted of water price variation is actually the influence possessed by water commodity on the national economy (Shrestha et al, 2004). This method has ignored the nature of water that water is a kind of factor with paid utilization and not conforms with the reality. The macro closure of new classicism is adopted by most CGE models of domestic water resources, while there exists a wide phenomenon of idle labour force in our country (Mirchi and Watkins, 2014).

2. Construct Water Resource CGE Models

(1) Production Module

The production module in this thesis has simplified the economic system as the production process of four departments, they are agriculture, manufacture, tertiary industry and water production and supply industry. It has also selected three factors of capital (Su and Tung, 2014), labour and water resource as the basic production factors. The production activities of each department can be represented by the production function with three-layer nesting. The structure is shown in Pic1. Firstly, there exists a substitutional relation among capital, water resource and labour force which can be represented by a 2-layer nesting CES function; Through the matching of parameter estimation, it is found that it will be more practical to firstly compound capital and water resources, then compound with labour force to generate the two-layer CES nesting. Therefore, compound these two factors into capital-water resource bunch first in the first layer; in the middle layer, compound labour force and capital-water resource bunch into factor bunch. The factor bunch (value added) in the top layer will form the sectional total output through Leontif function along with intermediate input and other costs; Among that, the intermediate input includes non-water commodities as well as water commodities, water commodities are produced by the water production and supply industry by making water resource as the main production factor. Therefore, we can find that water resources are put into production simultaneously in the forms of water commodities, intermediate input goods as well as water factors.

The equation can be simplified as:

$$Min\sum_{a} PQ_c \bullet QINT_{ca} + PVA_a \bullet QVA_a \tag{1}$$

$$=Min\left\{\frac{QVA_a}{f_a},\frac{QINT_{1a}}{a_{1a}},\frac{QINT_{2a}}{a_{2a}},\frac{QINT_{3a}}{a_{3a}},\frac{QINT_{wa}}{a_{wa}}\right\} \tag{2}$$

$$QVA_a = CES\left(QLD_a, QKD_a\right) \tag{3}$$

$$QKA_a = CES\left(QKD_a, QKW_a\right) \tag{4}$$

In the equation, a belongs to active subset; c belongs to commercial subset; PQ· is the commodity price; $QINTA_a$ represents intermediate input quantity; PVA_a is the price of value added; QVA_a is the quantity of value added; QA_a is the quantity of sectional output; QINT1a,…, $QINT_{wa}$ is the individual amount of intermediate input; fa is the quantity needed in the total output of value added from each unit; a1a, a2a, a3a respectively represent the quantity of the intermediate input of non-water commodity needed by the total amount from each unit; Awa is the quantity of intermediate input of water commodity which is needed by the total amount from each unit; The quantity demanded of capital, labour force and water resource factors is respectively represented by QKD_a, QLD_a, QWD_a; QKW_a is the compounded capital-water resource bunch.

(2) Trade and Investment Module

In open economy, regional self-produced commodities are sold in the regional market and exported to foreign markets; commodities sold inside regions not only include self-produced commodities, but also imported commodities. This thesis sets the exchange rate as fixed exchange rate. According to Armington condition and small-country hypothesis, the import equation can be represented by CES function and the exported export equation can be represented by CET function. Commodities sold in regional market are purchased by enterprises, government and residents for consumption or investment. Among that, commodities purchased by enterprises can serve as the intermediate input goods provided for sectional production. A commodity circulation has been formed through trade and investing consumption link as well as production. (Pic2) Among that, all commodities include water products generated by the water production and supply of non-water commodities in agriculture, manufacture and service industry.

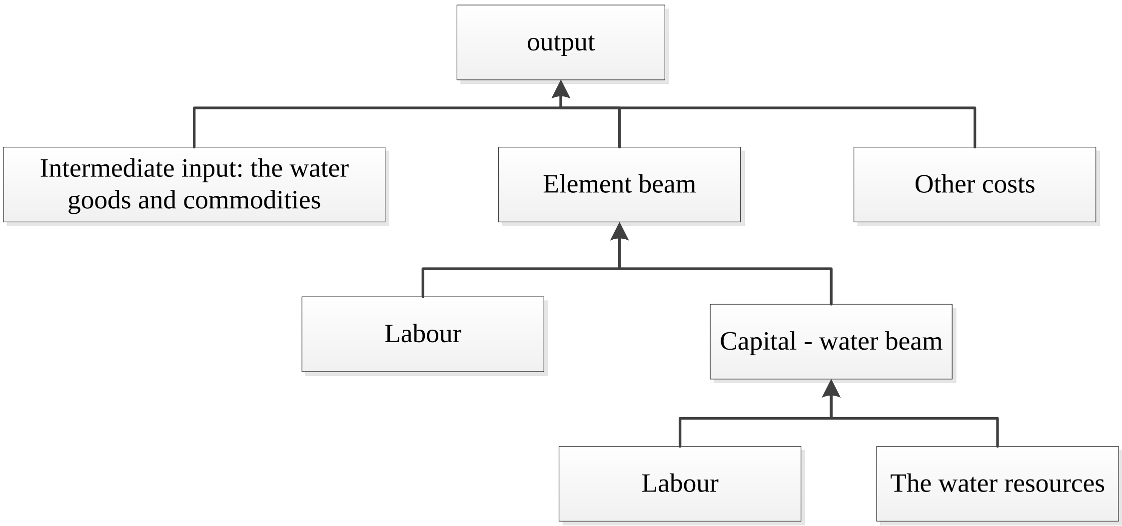

Figure 1: Production structure of water CGE model

(3) Income and Expenditure Module

The income and expenditure module has described factor income, income and expenses of economic subjects(enterprise, resident, government) and national income. Factor income is the remuneration of capital, labour force and water resource from each sector. Suppose the remuneration of labour force is obtained by residents, capital remuneration is obtained by both enterprise and resident and water resource remuneration is possessed by the government. The income of enterprises and residents comes from the relevant factor remuneration as well as the transfer payment obtained by the government and other districts. The expenditure includes commodity consumption, tax payment, relevant transfer payment and deposit. Government income includes indirect production tax, tariff, individual income tax, corporate income tax and the factor remuneration of water resource. Expenditure includes various transfer payment, subsidy of production water and commodity consumption. All deposit of economic subject can be obtained by income subtracting expenditure.

(4) Macro Closure and Balance

The economic system in CGE model has to strike the balance between the commodity market and factor market, realize investment and saving balance and the balance of foreign exchange receipts and expenditures. In Keynes closure, factor demand determines the practical supply. Factor market clearing as well as the closure equation has been shown in equation(6)-equation(12):

$$\sum_a QLD_a = QLSAGG \tag{5}$$

$$\sum_a QKD_a = QKSAGG \tag{6}$$

$$\sum_a QWD_a = QWSAGG \tag{7}$$

$$EXR = \overline{EXR} \tag{8}$$

$$WL = \overline{WL} = 1 \tag{9}$$

$$WK = \overline{WK} = 1 \tag{10}$$

$$WW = \overline{WW} = 1 \tag{11}$$

In this equation, QLSAGG, QKSAGG and QWSAGG are the actually total demands of labour force, capital and water resource factors. WL, WK, WW are the average price of labour force, capital and water resource factor. EXR is the exchange rate, variables underlined are the exogenous variables.

3. Analysis of Simulation Results

Three basic scenes are set according to the analysis and two sub-scenes are simulated in each scene to be compared with the equilibrium solution of reference period, thus respectively analyzing the influence possessed by the factor price adjustment of water resource, production water subsidy variation and technical progress on the sector as well as macro economy. (Shown in table 1). CGE model and scenarios simulation adopt GAMS software to realize the program expression and model solution.

In general, the rise in factor price of water resource will generate negative impact on both sectional output and the macro economy, decrease the each sectional output, GDP and the income of residents as well as enterprises, cause rising prices, decrease employment and decrease resident consumption capability. However, since the cost of water consumption has been raised, the water demand will decrease, the unit quantity of GDP water consumption will decrease and the water-use efficiency will be improved. Although the decrease in income of residents and enterprises will influence government revenue, the price rise in 10% of water resource will improve 0.618% government income if the subsidy rate remains the same and the excess factor remuneration of water resource is granted into the national treasury.

Table 1: Single scene simulation results

	Scene 1 Compared with base year price adjustment factors of water resources		Scene 2 Compared with base year production water subsidies		Scene 3 Compared with base year technical progress rate adjustment	
	10%	15%	-10%	10%	5%	10%
The agricultural water demand	-3.437	-5.014	-0.811	0.833	-0.439	-0.818
The industrial Water demand	-2.554	-3.725	-0.086	0.085	0.050	0.092
The third industry water demand	-2.471	-3.602	-0.002	0.009	0.083	0.153
Water production and supply industry	-5.493	-8.030	-1.320	1.341	0.407	0.744
Total water demand	-3.181	-4.641	-0.530	0.543	-0.179	-0.335
The agricultural water output	-0.750	-1.111	-0.833	0.857	0.463	0.864
The industrial Water output	-0.057	-0.085	-0.060	0.058	0.147	0.271
The third industry water output	-0.024	-0.035	-0.053	0.054	0.103	0.191
Water production and supply industry	-1.272	-1.883	-1.467	1.493	0.727	1.361
Total water output	-0.120	-0.178	-0.138	0.139	0.169	0.312
Enterprise income	-0.374	-0.556	-0.395	0.399	0.133	0.247
Government revenue	0.618	0.918	0.979	-0.991	0.081	0.149
People's income	-0.179	-0.265	-0.301	0.307	0.166	0.309
Residents' consumption	-0.234	-0.347	-0.354	0.360	0.208	0.387
employment	-0.211	-0.313	-0.358	0.365	0.199	0.370
The CPI Price index	0.056	0.083	0.054	-0.055	-0.043	-0.079
GDP	-0.166	-0.247	-0.192	0.194	0.187	0.348
Water consumption per unit of GDP	-3.02	-4.40	-0.333	0.341	-0.36	-0.680

(1) The comparison of simulation results of 10% and 15% factor price has indicated that, the larger the price rise is, the worse influence is generated on the economy, while it will have more obvious effect on decreasing water consumption and improving water-use efficiency.

(2)Besides the water production and supply industry, in the three main industries of national economy, agriculture is the most sensitive part to the factor price variation of water resources. Setting the rise in 10% of factor price as an example, the total output declines 0.12% at this time, and the total water consumption declines 3.181%; the total agricultural output declines 0.75% and the water demand declines 3.437%. The reasons lie in that the water-use efficiency in agricultural sector is quite low and the quantity of water consumption is the largest. In 2007, agricultural water consumption has occupied 71.45% of the total water consumption. The agricultural sector will be greatly influenced as long as the factor price of water resources rises.

The income and expenditure module has described factor income, income and expenses of economic subjects(enterprise, resident, government) and national income. Factor income is the remuneration of capital, labour force and water resource from each sector. Suppose the remuneration of labour force is obtained by residents, capital remuneration is obtained by both enterprise and resident and water resource remuneration is possessed by the government. The income of enterprises and residents comes from the relevant factor remuneration as well as the transfer payment obtained by the government and other districts. The expenditure includes commodity consumption, tax payment, relevant transfer payment and deposit. Government income includes indirect production tax, tariff, individual income tax, corporate income tax and the factor remuneration of water resource. Expenditure includes various transfer payment, subsidy of production water and commodity consumption. All deposit of economic subject can be obtained by income subtracting expenditure.

4. Conclusion and Expectation

The thesis has combined the situation of Chinese actual water resource management and consumption and constructed a water resource CGE model which simultaneously includes water resource factors and water production and supply industry. Shadow price has been adopted to calculate the factor remuneration of water resources and the production water subsidy has been brought into this mode. Based on the improved CGE model of water resources, the thesis has also analysed the influences of three policy and non-policy scenes which respectively are the factor price adjustment of water resources, production water subsidy and technical progress. Jiangxi Province has been selected as the sample for simulation, the main conclusions as well as suggestions are listed below:

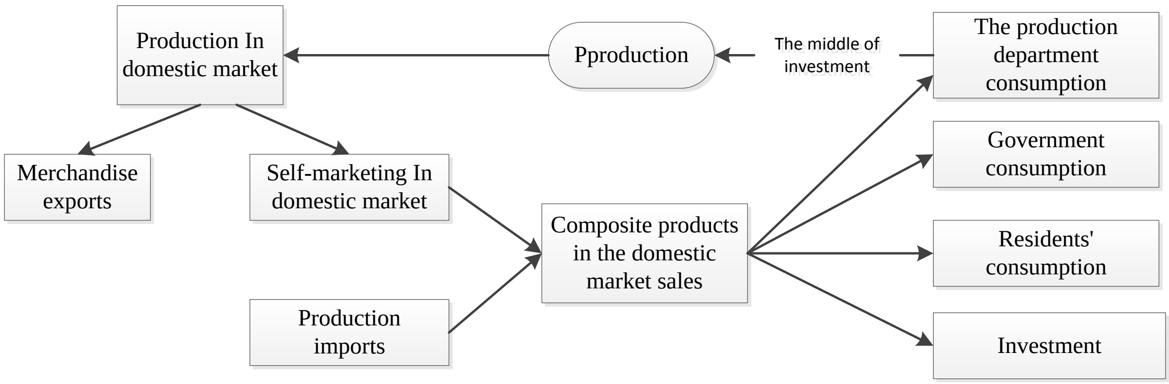

Figure 2: Trade and investment module

(1) Design policies scientifically, select implementations carefully. So as to accommodate the global climate changes and alleviate water-consumption contradictions, low-efficient water consumption should be changed and the water-saving society should be built. It is necessary for the water resource managing departments to scientifically conduct policy design and selection according to realistic conditions as well as full quantitative policy assessment. Changes in three scenes are supposed to be simulated to prove that raising the factor price of water resources, decreasing production water subsidy and promoting technical progress can all improve the water-use efficiency and decrease the total water consumption, thus they can all be utilized as policies and measurements for water saving. Three different policies can achieve certain water-saving targets, but they all have different interest impacts on the development of national economy and subjects of water consumption. Jiangxi province is required to fully consider the possible impacts on GDP, employment, water consumption, income of economic subjects and conduct comparisons as well as researches on specific advantages and disadvantages of different policies to make careful decisions when selecting water resource managing policies in order to avoid social inequality and intensified contradictions.

(2) Comprehensively promote water-saving technologies and popularize water-saving concepts through various means in the long term. Technical progress can comprehensively promote economic development and benefit all social members (government, enterprise, resident). It is the sustainable water-saving means which conforms to the social economy and natural environment the most. However, the short-term effects may be limited due to the restraints by realistic conditions. In addition, the water yield is quite abundant during the wet seasons in Jiangxi province, most consumers possess quite weak water-saving awareness, thus impeding the promotion of water-saving technologies. The government should adopt various methods such as legal restrictions, administrative promotions, economic encouragements, technical supports and education popularization to fully promote water-saving technologies as well as the environmentally protective styles of production and life.

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