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Impact analysis of government investment on water projects in the arid Gansu Province of China

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ABSTRACT

In this paper, we introduced three-nested Constant Elasticity of Substitution (CES) production function into a static Computable General Equilibrium (CGE) Model. Through four levels of factor productivity, we constructed three nested production function of land use productivity in the conceptual modeling frameworks. The first level of factor productivity is generated by the basic value-added land. On the second level, factor productivity in each sector is generated by human activities that presents human intervention to the first level of factor productivity. On the third level of factor productivity, water allocation reshapes the non-linear structure of transaction among first and second levels. From the perspective of resource utilization, we examined the economic efficiency of water allocation. The scenario-based empirical analysis results show that the three-nested CES production function within CGE model is well-behaved to present the economy system of the case study area. Firstly, water scarcity harmed economic production. Government investment on water projects in Gansu thereby had impacts on economic outcomes. Secondly, huge governmental financing on water projects bring depreciation of present value of social welfare. Moreover, water use for environment adaptation pressures on water supply. The theoretical water price can be sharply increased due to the increasing costs of factor inputs. Thirdly, water use efficiency can be improved by water projects, typically can be benefited from the expansion of water-saving irrigation areas even in those expanding dry area in Gansu. Therefore, increasing governmental financing on water projects can depreciate present value of social welfare but benefit economic efficiency for future generation.

1. Introduction

Water and land are scarce natural resource. On the one hand, water supply are mainly influenced by natural environmental changes with the constraint of geographical conditions (Grossmann and Dietrich, 2012). Unique regional climatic adaptation reveals interrelationships between implication of climate changes and potentials of water supply changes (Stroup, 2011). Regional climate changes constantly have impacts on the increase of temperature and the decrease of precipitation, especially on arid land and semi-arid land, study water allocation has to be based on a comprehensive model (Lioubimtseva et al., 2005). But under growing human pressure of production and living, quantity of precipitation and runoff on the surface continually are affected by land use and cover changes (Pianosi and Ravazzani, 2010; Singh et al., 2014). Sequentially, in order to preserve water and soil resource for defending severe natural disasters such as floods and droughts (Sivakumar, 2011), large water projects in the hydrological system therefore are invested and built up.

On the other hand, water demand is increasing with climate-driven human intervention. Cultivation and ecological construction aiming to sustainable agriculture have consumed large amount of water resource. It has been proved that interaction among land use and cover changes and climate changes affect crop yields no matter how much technology changes in agricultural facilities (Ciscar et al., 2011; Seto et al., 2000; Veldkamp and Verburg, 2004). Worldwide researchers discussed huge plans of integrated water management from the water supply side to

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enhance water use efficiency. For instance, increase of water storage capacity and decrease of drainage of rainfall for agricultural irrigation, simultaneously, strictly prohibiting exploitation and occupancy of riverbed (Moss, 2004), making innovative water policies at both administrative level and jurisdictional level (Christian-Smith et al., 2011), and so forth. However, water use for environmental adaptation are increasing sharply in arid and semi-arid area, which mainly come from water engineering that exclude natural water supply from precipitation and runoffs. For instance, in urban area, water demands are for building public green, supplementing rivers and artificial lakes; while in rural area, for supplementing swamps and low-lying lakes. Consequently, when facing water demand of expansion of urbanization and cultivated land irrigation, the shrinking water supply has led to severe regional water scarcity (Tekken and Kropp, 2012). Furthermore, population growth is determinate to increase of water demand in all urban–rural regions (Watson and Davies, 2011), and it may have impacts on living standard (Shi et al., 2010).

Public attention then have been drawn on how to value water and how to economically use water. Natural water resource, thereby as externalities of the economic system, has to be marketized with proper economic value (Dudu and Chumi, 2008). Coase (1960) mentioned that markets are considered to be the most efficient way of allocating scarce resources by economic theory even though complete valuation of natural resource is impossible (Coase, 1960; Arrow, 1969). However, impact of water allocation on social welfare has spatial heterogeneity to physical water allocation due to partial economic valuation issues. Partial valuation of natural resource hence leads to Pareto efficiency failed by market failure with asymmetric information. Thereafter, administrative policies always plays uncertain roles to the practical results of welfare allocation mechanism.

Computable General Equilibrium (CGE) modeling from both water supply side and demand side provides insights of policy-oriented impact of water resource allocation (Seung et al., 1997, 1998, 1999; Harris and Mapp, 1986, 1980). It is a systematic-equilibrium-based research on water allocation from both water supply side and water demand side, which indicates sustainable adaptation of a regional integrated water system for both ecological and economic development under water scarcity condition (Rosegrant et al., 2000). Based on SAM (Social Accounting Matrix), CGE modeling water allocation will present the allocation of economic value of water consumption. In addition, the distribution of economic value is derived because economic value of resource utilization can be marketized through factor mobility and sectoral interdependence (Griffith, 2012).

Closure condition of factor mobility in CGE modeling presents systematic changes due to the changes of supply and demand of water. Factor mobility among capital, labor, and natural resource which need to be realized and analyzed for efficiently instructing government investment (Tirado et al., 2010). Especially, direct government investment on large water conservancy project has huge impacts on local economic development. For instance, large water transfer project like the Three Gorges Hydraulic Power Station in China cost 5.19 billion in 1993 USD for 1.13 million people migration, and the Hoover Dam in US made great economic contribution of power generation for 8 million people in Arizona, Nevada and California. Furthermore, partial valuation of natural land use results in heterogeneously proportional changes between land price and the price of other normal commodities which is caused by hysteretic price on continual utilization without market transfer (van Heerden et al., 2008). Therefore, modeling water allocation needs to consider more complex structure of the factor inputs from the demand side. It will provide economic insights for policy-oriented analysis of the efficiency of government investment on large water projects (Rosegrant et al., 2000). More importantly, macro-view economic valuation of natural water resource through entire engineered economic system can be also assessed by social welfare implication of relative changes through microeconomic approach (Diao et al., 2008).

In the rest of paper, we will introduce the conceptual model design and its specification with introduction of the three-nested CES production function and its relevant semiparametric demand function will be discussed in the Section 2. Thereafter, the information of case study region and the question list will be given before the end of Section 3. In the next following Section 4, we will give the data description and closure condition of each testing model. In this part, specific model description with different conditions of factor mobility are examined. Sequentially, empirical analysis and comparing results based on Scenario I, II, III will be given in the Section 5. This paper ends with a conclusion of research findings and a brief discussion of further research issues.

2. Methodology

2.1. Conceptual model design

The conceptual model designed three-nested CES production function in the regional CGE model. It means the non-linear relationship among factors are designed instead of traditional linear relationships of CES production function. Intuitively, evolutionary civilization is nonlinear process. It covers endogenous nonlinear technology improvement, nonlinear resource utilization, and nonlinear human activities. Thereafter, researchers have to recognize economic scale are based on different levels of productivity. Therefore, we designed three levels of additional factor input of the nested CES production function in the CGE model as shown in Fig. 1.

Land and capital are designed in the first level of economic scale in this modeling framework. Theoretically, land is irreplaceable resources on the earth. When human being hunt for food in ‘‘pristine’’ environment in ancient time, we have started to learn from natural environment (Jørgensen, 1996). After human learned how to use stone to make fire, our agricultural activities started to rely on how to use land. According to different land utilization, capital has been accumulated through the ‘‘learning-by-doing’’ process to support human sustainable living. With advanced technology, human have constantly created and improved adaptive environment, and built numerous skyscrapers for saving land use, but total available land is still fixed.

Labor as a production factor is designed in the second level of economic scale in this modeling framework. From ancient times to modern times, labor-intensive jobs are gradually substituted by advanced machines. Although endogenous capital growth is attributed to technology improvement, labor contributes to both aspects of capital accumulation and research development. Thus, the substitution of additional labor input is designed at the second level productivity. Human activities brought industrialization and civilization. Our living standard and environment have been improved, but simultaneously polluting the natural environment. Particularly, in recent two hundred years, human-dominated ecosystem (HDE) has been pressured by rapid growth of urbanization expansion (Collins et al., 2000). In the past several decades, ‘‘urban fringe’’ has been paid much attention because ecosystem beside urban area is bearing much pressure of increasing human activities (Müller and Lenz, 2006; Patten, 1995). Moreover, with increasing individual’s and public’s utility level, government policy becomes easily distorting ecosystem and economic system (Wang et al., 2011). Globally water demand for environmental adaptation and conservation are sharply increasing with downhill climate changes.