New Energy Price Policy CGE Model Analysis

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Abstract: New energy is an important energy development trend in China in the future, and plays an important role in production and energy consumption. Based on the production module function, trade function module, institutional module function, closure and market clearing module function, social welfare function and dynamic module function, this paper constructs a CGE model of electricity price policy for new energy substitution, and uses CGE model to study the impact of the change of new energy price on electricity output and structure.

1. New Energy Price Policy CGE Model Building

A CGE model of short-term new energy tariff policy mainly includes production function module [1-3], trade function module and three main function modules (enterprise function module, resident function module and government function module, equilibrium and closure function module, social welfare function and dynamic function module) [4-5]. The detailed model structure is as follows.

(1) In the production module, this paper divides the production function into six levels of nesting, the highest level contains two inputs, the rest are nested, and the input synthesis of production function elements is in the form of function. The first level of CET production portfolio function (the combination of intermediate input and labor-capital-energy input) is

$$\begin{aligned} &\min PKEL_i \cdot KEL_i + PND_i \cdot ND_i \\ &s.t.QX_i = (\beta_{keli} KEL_i^{\rho_i^q} + \beta_{ndi} ND_i^{\rho_i^q})^{\frac{1}{\rho_i^q}} \end{aligned} \tag{1}$$

$$\begin{aligned} E_{clepi} = (&\beta_{hyepi} \cdot E_{hyepi}^{\rho_i^{clep}} + \beta_{nuepi} \cdot E_{nuepi}^{\rho_i^{clep}} \\ &+ \beta_{wiepi} \cdot E_{wiepi}^{\rho_i^{clep}} + \beta_{soepi} \cdot E_{soepi}^{\rho_i^{clep}})^{\frac{1}{\rho_i^{clep}}} \end{aligned} \tag{2}$$

(2) The substitution relationship of trade function module is in the form of constant elasticity transformation function. Under certain technical constraints, producers determine the optimal strategy of product distribution. Domestic production consists of domestic sales and exports, and domestic products are composed of domestic output and imports.

$$QX_i = \gamma_{ei}(\xi d_i \cdot QD_{si}^{\rho ei} + \xi e_i \cdot QE_i^{\rho ei})^{\frac{1}{\rho ei}} \tag{3}$$

(3) Institutional module function is composed of government income and expenditure, enterprise income and expenditure, and resident income and expenditure function. Stone-Gayley utility function is used in resident part, and the other function is linear function with equal proportion.

$$\begin{aligned} YGT = &\sum_i GINDTAX_i + \sum_i GTRIFM_i + \\ &GHTAX + GETAX + GWY \end{aligned} \tag{4}$$

(4) The function of closure and market clearing module includes balance of payments, government balance of payments and investment-savings balance.

$$\begin{aligned} &\sum_i PM_i \cdot QM_i + YMK + YMG = \\ &\sum_i PE_i \cdot QE_i + YHW + GWY + \overline{SF} \cdot EXR \end{aligned} \tag{5}$$

$$RGDP = \sum_i HD_i + \sum_i GD_i + \sum_i INV_i + \sum_i STO_i + \sum_i [QE_i - (1 + tm_i)QM_i] \tag{6}$$

$$GDP_i = R_i \cdot K_i + W \cdot L_i + t_{indi} \cdot PX_i \cdot QX_i \tag{7}$$

$$GDP = \sum_i GDP_i \tag{8}$$

$$PGDP = \frac{GDP}{RGDP} \tag{9}$$

(5) The social welfare function uses commodity prices before the implementation of the policy to calculate the impact of external policy shocks on the welfare of residents, and uses Hicks equivalence to change to

$$\begin{aligned} EV &= E(U^s, PQ^b) - E(U^b, PQ^b) \\ &= \sum_i PQ_i^b \cdot HD_i^s - \sum_i PQ_i^b \cdot Hd_i^b \end{aligned} \tag{10}$$

(6) Dynamic modular functions include the equilibrium of labor market, commodity market and capital market to optimize the combination and minimize the cost.

$$KS_{t+1} = KS_t - \sum_i K_{i,t} \cdot depr_i + TINV_t \tag{11}$$

$$\min PKEL_i \cdot KEL_i + PND_i \cdot ND_i \tag{12}$$

2. New Energy Price Policy CGE Model Basic Data and Parameter Settings

Based on the national input-output extension table issued in 2018, this section adjusts the input-output table to 23 departments according to the needs of the study and the characteristics of the corresponding industrial structure. According to the adjusted input-output table of 2015, the theory of social accounting matrix and the basic structure of social accounting matrix, and referring to the relevant basic data of China Statistical Yearbook 2017 and China Financial Yearbook 2017, the paper compiles the basic data, and the micro-social accounting matrix of China in 2015.

In the model, the setting of production function and the meaning of trade module instead of the setting of elasticity coefficient refer to the research results of previous scholars, which mainly refer to the value of Guo Zhengquan and other relevant scholars [6-7].

The share parameters of production function, Armington function and CET function in the model are calibrated by the base year social accounting data, and the relevant share parameters are calibrated in the model program according to the basic data. According to the established model, the CGE model was used to evaluate and analyze the impact effect.

3. New Energy Price Policy CGE Analysis of Model Impact Effect

3.1 Scenario Setting

Taking the new energy price as an exogenous parameter, the influence of the change of the new energy price on the total output and structure of electricity in four different situations is analyzed.

3.1.1 Scenario 1

Assuming that the price of new energy increases by 10% while other energy prices remain unchanged; Scenario 2: Assuming that the price of new energy increases by 20%; Scenario 3: Assuming that the price of new energy decreases by 10% when other energy prices remain unchanged; Scenario 4: Assuming that the price of new energy decreases when other energy prices remain unchanged, scenario 2: Assuming that the price of new energy decreases by 10%.20%.

3.2 Model Results

The analysis of the impact of new energy tariff changes on power output and structure is shown in the table below. As can be seen from the table, scenario 1 and scenario 2 will lead to an increase in total power generation, wind power and solar power generation, and little change in hydropower and nuclear power generation, but a decrease in thermal power generation. With the increase of the strength of the rise, the effect is enhanced. In scenario 3 and scenario 4, the price of new energy power declines, resulting in a basically unchanged total power generation, an increase in demand for thermal power, hydropower and nuclear power, and a significant decrease in wind and solar power generation. With the increase of policy intensity, the impact effect is enhanced. The reasons are as follows: under scenario 1 and scenario 2, the speed of new energy installations is accelerating, and the proportion of new energy generation is increasing. At the same time, the proportion of thermal power generation will decrease due to little change in demand. In scenario 3 and scenario 4, as the price of new energy decreases, the proportion of new energy generation will decrease, and the proportion of thermal power generation will increase due to the substitution effect. The total power generation is consistent with the demand. Because the demand is not sensitive to the change of new energy price, the total power generation has little change. Also need to fall to

Table 1. The impact of different scenarios of new energy tariff changes on power output and structure (unit: %)

project	Situation 1	Situation 2	Situation 3	Situation 4
Total power generation	0.102	0.156	0.024	0.023
Thermal power	-0.1598	-0.3279	0.2199	0.3476
hydropower	0.056	0.065	0.2322	0.3665
nuclear power	0.089	0.114	0.2264	0.3575
Wind power	2.4526	4.9431	-12.2051	-19.0155
Solar energy and other electricity	2.4756	4.245	-12.3235	-19.1885

4. Summary

New energy is an important energy development trend in China in the future, and plays an important role in production and energy consumption. Based on the production module function, trade function module, institutional module function, closure and market clearing module function, social welfare function and dynamic module function, this paper constructs a new energy price policy CGE model, and studies the impact of the change of new energy price on power output and structure by using CGE model.

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