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# Effects and mechanism of influence of China's resource tax reform: A regional perspective

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ABSTRACT

China's resource tax reform, beginning with Xinjiang as a pilot area in June 2010, marked a new stage in the progression of China's resource tax system. Based on the 2007 social accounting matrix (SAM) for Xinjiang, constructed by ourselves, this paper takes a regional perspective on China's resource tax reform to quantitatively calculate its degree of influence and qualitatively analyze its mechanism of influence by adopting an energy computable general equilibrium (CGE) model and a SAM price model. The results show that the main significance of the reform lies in bolstering local government finances rather than energy conservation or carbon reduction. This is because revenue will be transferred from resource enterprises and the central government to the local government, while simultaneously the low tax rate, narrow tax scope and unreasonable price mechanism will combine to prevent the reform from reaching its environmental goals. Promoting resource price mechanism reform and deepening resource tax reform will be two key elements of China's future energy strategies. Because resource enterprises will bear the increased burden caused by the reform, the degree of sectoral price increases will be limited; therefore, the fear that resource tax reform will push up inflation is unnecessary and should not be a barrier to reform.



## 1. Introduction

China's resource tax system has been improving gradually over the past thirty years. In 1984, to adjust differential income derived from resources, China began collecting resource taxes by volume on crude oil, natural gas, coal, metal ore and non-metal ore products. Ten years later, the scope of resource taxation was expanded to all mineral resources. This resource tax system was applied for more than a decade without fundamental change until June 2010, when the State Administration of Taxation and the Ministry of Finance jointly issued the "Provisions on Several Issues Concerning the Reform of Resource Tax on Crude Oil and Natural Gas in Xinjiang". It indicated that China's resource tax reform would start with Xinjiang as a pilot area. Why did China first reform resource taxes in Xinjiang rather than in other provinces? First, it is one of a series of central government support policies to promote the development of Xinjiang's economy (Xian, 2010). Second, as an important part of China's energy base (Qian et al., 2012), Xinjiang has conditions that are suitable for reform.

According to its provisions, Xinjiang's resource tax reform involves crude oil and natural gas, and the resource tax will be levied based on price instead of on production volume, with a tax rate of 5%. In December 2010, the resource tax reform was extended to twelve western provinces. In November 2011, China extended the regional resource tax on domestic sales of crude oil and natural gas to the whole country, increased the tax rate to 5–10%, and widened the tax to include coking coal and rare earths. The reform has great significance and indicates that China's resource tax system is entering a new stage. First, the resource tax base is much more reasonable. The traditional volume-based resource tax encourages resource companies to develop and utilize high-quality mineral resources and quite low-grade resources, which results in a waste of state-owned mineral resources (Xu and Wu, 2011; Zhang and Zhou, 2007). Additionally, the volume-based resource tax cannot reflect resource price changes (Sun, 2007), neglecting the relationship between resource taxes and price. Second, the resource tax rate is increased. The traditional low rate of resource taxation cannot reflect the real value of resources, leading to overexploitation and depletion of natural resources (Cao et al., 2011) and contributing little to local public finances (Zhang, 2006). Therefore, it is of great importance to analyze the economic and environmental effects of resource tax reform.

The Chinese government said the reform was mainly for the purpose of resource conservation and environmental damage reduction. For example, on July 19, 2011, Chinese Premier Wen Jiabao chaired a leading group conference on the national response to climate change focused on working toward energy savings and emission reductions, and the conference noted that promoting the reform of resource and environmental taxes would contribute to the improvement of the permanent mechanism for energy savings and emission reductions. Previous research generally also concluded that resource tax reform contributes to energy saving and emission reduction (Barker et al., 1993; Berkhout et al., 2004; Guo et al., 2011; Lin and He, 2008;

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Peretto, 2009; Tarek, 2007; Wei, 2009; Wissema and Dellink, 2007). However, there are few quantitative calculations of the energy conservation and emission reduction effects of China's resource tax reform, especially from the provincial level. In addition, these studies overlook the impact of China's energy price mechanism, which may influence the environmental effects of resource tax reform. It is widely believed that the reform will also cause a larger portion of resource companies' profits to flow to the public finances of local governments. Previous studies mainly analyzed the impacts of resource tax reform from a national perspective (Guo et al., 2011; Lin and He, 2008; Wei, 2009) and failed to present the impact of the reform on local revenue, which has great significance especially for western provinces. With Xinjiang as an example, we developed a regional social accounting matrix (SAM) model and established an energy computable general equilibrium (CGE) model to quantitatively simulate the economic and environmental effects of resource tax reform from a regional perspective. During the reform process, the main concern was that the reform may push up inflation (Zhu, 2011). However, the existing literature on China's resource tax reform (Cao et al., 2011; Guo et al., 2011; Lin and He, 2008; Wei, 2009; Xu, 2011; Xu and Wu, 2011) failed to provide a detailed analysis of the impact of resource tax reform on sectoral price levels or of the tax burden caused by the reform. As an effective supplement to CGE analysis, price multiplier and structural path analysis were adopted in this paper to analyze the resource influence mechanism and discuss why certain sectors will bear the increased tax burden caused by the reform.

The simulation scenarios are determined according to the actual situation and future trend of the resource tax system. First, the tax rate we set is 5–20%, which is larger than the present tax rate (5–10%). China's Ministry of Finance has indicated that the resource tax reforms would be further deepened when appropriate and that the resource tax rate would be further increased, considering that a tax rate between 5 and 10% was still much lower than that of developed countries. For instance, the resource tax rate of Australia reaches as high as 30%. The existing literature also agrees that the resource tax rate will be further increased. For example, the highest tax rate reaches as high as 50% in the research of Wei (2009). Thus, we believe that it is possible that the resource tax rate could be 20% as the reform continues. Second, the resource tax items we analyze are not only crude oil and natural gas but also coal. In September 2012, Minister of Finance Xie Xuren said that the scope of the reform will be further widened, especially the tax on coal, which is the main source of energy for China. At present, only coking coal is in the scope of reform, but it is widely believed that coal resource tax reform will be implemented in the future. For example, Guo et al. (2011) calculate the effects of different rates of ad valorem taxes for coal.

The paper is organized as follows: Section 2 introduces the construction and structure of Xinjiang's SAM of 2007, along with data on energy consumption and carbon emissions. Section 3 mainly describes the simulation models. Simulation results and discussions are given in Section 4, followed by main conclusions and policy implications in Section 5.

## 2. Data

The data used as the basis of this paper are Xinjiang's SAM of 2007, constructed by ourselves, and energy consumption and carbon dioxide emission data. Here, we describe the construction and structure of Xinjiang's SAM and the sources of energy consumption and carbon dioxide emission data.

### 2.1. Social accounting matrix

As the basis for constructing a CGE model, a SAM represents flows of all economic transactions that take place within a regional or national economy. As far as we know, there is no ready-made social accounting matrix of Xinjiang suitable for our research. Therefore, we had to develop Xinjiang's SAM of 2007 according to the research demands and actual situation. There are two approaches to create a SAM: top-down and bottom-up. The former emphasizes data consistency, while the latter emphasizes data accuracy. Due to incomplete data coverage and limited resources, we used the top-down approach, which seems appropriate in the current situation. First, we compiled the macro-SAM, as shown in Table 1. Then, the micro-SAM was compiled according to the macro-SAM and data from multi-purpose surveys such as household income surveys. In the end, the RAS method was used to balance the micro-SAM.[1] Xinjiang's SAM of 2007 was constructed mainly based on input–output tables for Xinjiang and other data from the China statistical yearbook (2008), Xinjiang statistical yearbook (2008), Financial yearbook of China (2008), Financial yearbook of Xinjiang (2008), and Tax year book of China (2008).

The structure of Xinjiang's micro-SAM is determined by the research demands, which comprise a total of 42 accounts, including 30 productive sectors. For example, to reflect the resource tax reform comprehensively, we present the energy industry as specific as possible. There are nine energy sectors in the micro-SAM, including the primary energy sector (coal, crude oil, natural gas, and hydropower) and secondary energy sector (coke, coke gas, petroleum products, heating, and thermal power). Here, we mainly describe the construction of the local and central government accounts. Resource tax reform has a direct influence on the revenues of local and central governments. To analyze the impact of resource tax reform on local and central government revenues, we split the government account into central government and local government mainly through three approaches. For the first type of accounts with detailed data for both local and central governments, we split the government accounts directly. For example, the personal income tax collected by the local governments are taken from the "Xinjiang financial revenue and expenditure balance sheet of 2007", and the personal income tax collected by the central government are taken from the Tax Year Book of China (2008). For the second type of accounts, we split the government accounts indirectly. For instance, the consumption data for the central government are the difference between the government consumption from the IO table and the consumption for local government taken from "Xinjiang's financial revenue and expenditure balance sheet of 2007" and "Xinjiang's final account of revenue and expenditure of extra-budgetary funds of 2007". The third type includes local and central government savings accounts, which are balancing items.

### 2.2. Energy consumption and carbon dioxide emission data

In addition to the economic data provided by Xinjiang's SAM, we need the energy consumption and carbon dioxide emission data of 2007 to analyze the environmental impacts of resource tax reform. There are no direct statistics of $CO_2$ emissions; therefore, we have to calculate $CO_2$ emissions based on the method provided in IPCC (2006). The calculation is based on the final fossil fuel consumption data and fossil fuel transformation data from the energy balance table (National Bureau of Statistics of China, NBS, 2008). With the assumption that all the carbon in the fuel is completely combusted and transformed into carbon dioxide (Guo et al., 2012; Meng et al., 2011), we can obtain the $CO_2$ emissions from each type of energy by multiplying the relative emission factors (IPCC, 2006). The data for final energy consumption and carbon dioxide emissions are presented in Table 2. "Crude oil" in Table 2 represents the crude oil that is used directly, except that transformed into petroleum products. We calculate the $CO_2$ emissions for final crude oil consumption and petroleum

[1] For simplicity, we broadly describe the construction of Xinjiang's SAM in this paper; the detailed construction process and data sources can be provided upon request.

**Table 1**
Xinjiang's macro social accounting matrix of 2007 (millions of Yuan).

| | COM | ACT | FAC | HOU | ENT | GOV | OR | S-I | TOT |
|---|---|---|---|---|---|---|---|---|---|
| Commodities (COM) | – | 4561.62 | – | 1207.92 | – | 708.77 | 2383.69 | 1968.85 | 10830.85 |
| Activities (ACT) | 8158.00 | – | – | – | – | – | – | – | 8158.00 |
| Factors (FAC) | – | 3271.64 | – | – | – | – | – | – | 3271.64 |
| Households (HOU) | – | – | 1844.40 | – | 116.75 | 33.53 | – | – | 1994.68 |
| Enterprise (ENT) | – | – | 1427.24 | – | – | 17.36 | – | – | 1444.60 |
| Government (GOV) | 17.56 | 324.74 | – | 38.31 | 134.00 | – | – | – | 514.61 |
| Other regions (OR) | 2655.28 | – | – | – | – | – | – | – | 2655.31 |
| Saving-Investment (S-I) | – | – | – | 748.45 | 1193.86 | −245.08 | 271.62 | 124.03 | 2092.88 |
| Total (TOT) | 10830.85 | 8158.00 | 3271.64 | 1994.68 | 1444.60 | 514.58 | 2655.31 | 2092.88 | – |

products (gasoline, diesel oil, fuel oil, and so on) by multiplying the relative emission factors while ignoring the $CO_2$ emissions during the process of oil refining. The $CO_2$ emissions of heating and thermal power are calculated by the fossil fuel consumption during the production process. Hydropower is a type of noncarbonic clean energy if the carbon dioxide emissions produced during the process of construction are ignored.

## 3. Simulation models

Since the early work of Debreu (1959) and Johansen (1960), the CGE model has been widely applied in various fields as an effective policy analysis tool. Because an energy CGE model captures interrelationships among economic sectors, it is commonly used to analyze resource tax reforms in different countries (Ferran, 2010; Semboja, 1994; Vásquez Cordano and Balistreri, 2010; Wissema and Dellink, 2007). CGE models can reflect the reform's effects on the macro economy comprehensively, but they fail to explain the mechanism of influence of the reform. Thus, a SAM price model (Roland-Holst and Sancho, 1995), as an effective supplement to CGE analysis, has been widely used in policy evaluation (Akkemik, 2011; Fofana et al., 2009; Parra and Wodon, 2008). In this paper, energy CGE and SAM price models are used to analyze China's resource tax reform from a regional perspective.

### 3.1. Energy CGE model

Based on Xinjiang's SAM of 2007, this paper develops an energy CGE model for Xinjiang to analyze China's resource tax reform from a regional perspective, in which prices and quantities adjust to clear markets for products and factors. The recycle mechanism of the Xinjiang CGE model is presented in the form of a block diagram, and the flows of goods, factors and taxes are summarized graphically in Fig. 1.

The main agents described in the Xinjiang CGE model are the government, households and enterprises, and each agent takes actions under certain constraints. The government, modeled as a tax collector, has the constraint that its expenditures and transfers are equal to the tax revenues. Households select a combination of consumer goods to maximize their utility under budget constraints, and enterprises choose a combination of intermediate inputs and factor inputs to minimize their costs, subject to certain technological constraints. The behavior of each agent is mathematically described in different modules. The Xinjiang CGE model includes a production module, a price module, a government module, consumption and trade modules, and equilibrium and closure modules.

**Table 2**
Xinjiang's final energy consumption and $CO_2$ emissions for 2007.

| | Final energy consumption | Carbon dioxide emission |
|---|---|---|
| Coal | 1821.77 ($10^4$ tn) | 3744.28 ($10^4$ tn) |
| Coke | 284.75 ($10^4$ tn) | 859.74 ($10^4$ tn) |
| Coke gas | 24.85 ($10^8$ $m^3$) | 42.67 ($10^4$ tn) |
| Crude oil | 78.64 ($10^4$ tn) | 243.94 ($10^4$ tn) |
| Petroleum products | 879.75 ($10^4$ tn) | 2128.58 ($10^4$ tn) |
| Natural gas | 55.57 ($10^8$ $m^3$) | 1213.65 ($10^4$ tn) |
| Heating | 14278.32 ($10^{10}$ kJ) | 1732.81 ($10^4$ tn) |
| Thermal power | 358.09 ($10^8$ kW·h) | 3850.27 ($10^4$ tn) |
| Hydropower | 58.78 ($10^8$ kW·h) | – |

#### 3.1.1. Production module

The production module describes the behaviors of producers, adopting a constant elasticity of substitution (CES) production function. Under certain technological constraints, the producer chooses the combination of intermediate inputs and factor inputs to minimize its costs. The mathematical descriptions of producer behaviors are

$$\min_{X_i} TC(X_i) = \sum_{i=1}^{n} P_i X_i \qquad s.t.V = A\left[\sum_{i=1}^{n} a_i(\lambda_i X_i)^{\rho}\right]^{1/\rho} \tag{1}$$

Where $TC$ is the total cost of the producer; $V$ is the output of the producer; $X_i$ is the input of production factor $i$, which includes labor, capital, energy and intermediate inputs; $P_i$ is the price of production factor $i$; $a_i$ is the share parameter of production factor $i$; $A$ is the transfer parameter impacting all production factors; $\lambda_i$ is the transfer parameter of production factor $i$; and $\rho$ is an elasticity parameter. The solutions to Eq. (1) yield the optimal input and the cost of unit output, which are

$$X_i = \alpha_i \lambda_i^{\sigma-1}\left(\frac{PX_i}{P_i}\right)^{\sigma} V \tag{2}$$

$$PX_i = \left[\sum_i \alpha_i \left(\frac{P_i}{\lambda_i}\right)^{1-\sigma}\right]^{1/(1-\sigma)} \tag{3}$$

where $PX_i$ is the cost of unit output $i$ and $\sigma$ is an elasticity parameter. The methods for determining the elasticity parameters can be divided into two types. The first is an econometric approach, which needs the support of a large amount of statistical data. The second is to obtain the elasticity parameters from other studies, which is a critical complement to the first approach. We adopt a combination of both approaches, based on the principles of reliability and applicability. The relationship between capital, labor and energy is important (Lv et al., 2009; Thompson and Taylor, 1995); therefore, we calculate the capital/energy/labor substitution elasticity directly based on the method provided by Li (2000). The estimation results show that Xinjiang's substitution elasticity between energy and capital (0.42) is similar to that (0.47) of China (Lv et al., 2009), and Xinjiang's substitution elasticity between energy and capital aggregation and labor (0.52) is relatively lower than that (0.84) of China (Lv et al., 2009). Compared with studies on capital/energy/labor substitution elasticity, the previous studies on energy substitution elasticity are more systematic with similar conclusions. For example, Stern (2009) has

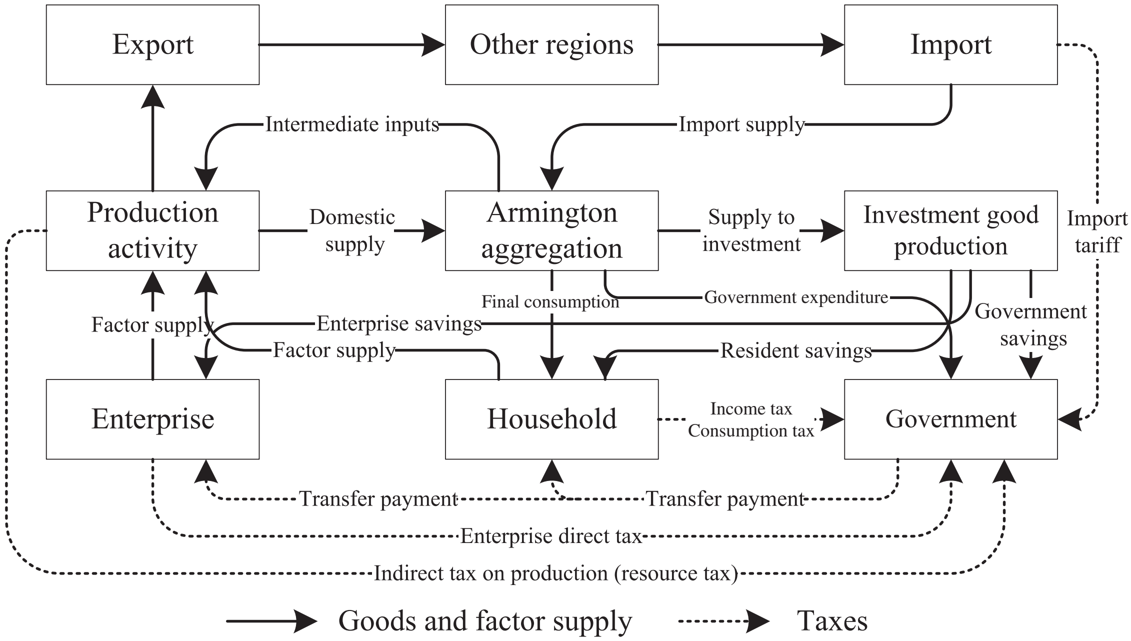


**Fig. 1.** Flow of goods, factors and taxes.

recently conducted a meta-analysis of studies on this topic, and most of the original GTAP-E model-specified parameters were closely aligned with Stern's conclusions (Beckman et al., 2011). In addition, Beckman et al. (2011) undertook a further comprehensive examination of the literature considered by Stern (2009). Therefore, this paper obtains energy substitution elasticity from other sources (Beckman et al., 2011; Stern, 2009; Tan, 2008; Xiao, 2008).

China's resource tax is a type of production tax, and it has been collected on the production base (the resource tax will be integrated into the CGE model in the price module). To illuminate the economic effects of resource tax reform, the production process of each sector is described by a six–stage nested production function, allowing for a flexible treatment of substitution possibilities, and energy is taken out of the intermediate input nest and incorporated into the value-added nest. The nesting structure of production is presented in Fig. 2.

*3.1.2. Price module*

Eq. (3) mathematically describes the price of the general composite intermediate inputs. The price of a particular sector depends on not only the price of a combination of commodities but also production taxes, including resource taxes. Hence, the price of energy intermediate inputs is shown in Eq. (4):

$$PPX_e = PX_e\left(1 + \tau_e^p + \tau_e^r\right) \tag{4}$$

$PX_e$ is the production cost of energy sector $e$; $\tau_e^r$ is the resource tax rate of resource $e$; $\tau_e^p$ is other production taxes and fees for resource $e$; $PPX_e$ is the after-tax price of resource $e$.

The price mechanism described in Eq. (4) is the general form of a market price, which is suitable for sectors with a high degree of marketization, such as the coal industry. However, it fails to capture China's price mechanisms for crude oil, natural gas and electricity.

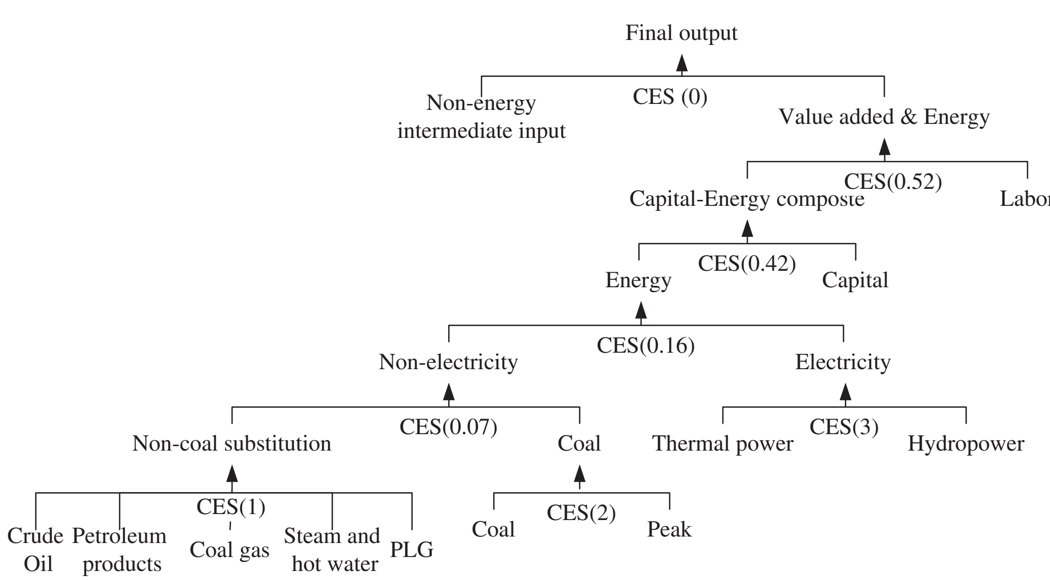


**Fig. 2.** Production structure of the Xinjiang CGE model.

China's crude oil price has been integrated into the international crude oil price; the domestic crude oil price is determined based on the related crude oil price at the international market, and prices of refined petroleum products are still controlled by the government. The price of China's domestic natural gas is made up of three elements: ex-plant price, transportation tariff and end-user price. The first two are under the control of the central government, and the last is under the control of the local government of each province. Thermal power accounts for 80% of China's electricity. Although the coal price is basically no longer under control at present, China still regulates the electricity price. Therefore, administered prices will be much better to describe the price mechanisms of crude oil, natural gas and electricity. In the price module, the prices of crude oil, natural gas and electricity are set as exogenous variables, which are not influenced by the resource tax reform. Furthermore, the factor market is described such that the supply of both labor and capital is not fixed and can flow freely between different sectors, and the factor Price is chosen as numeraire and normalized to unity.

*3.1.3. Government module*

The government module describes the behaviors of the local and central governments, whose incomes are made up of production tax, income tax, resource tax and so on. Described as tax collectors in the model, local and central governments will be influenced through fiscal parameters during the process of resource tax reform. The reform will cause the direct increase of local revenue because all revenues from natural resources, with the exception of offshore oil resource taxes, belong to the local government. With the decrease in profits of resource companies, central government revenue will decrease indirectly. Government expenditure is made up of expenditures on goods and services and transfer payments. The Xinjiang government pledged that the additional tax revenue will be used to improve people's lives. To simplify the analysis, Xinjiang's resource tax reform improves residents' welfare through the government's transfer payments.

*3.1.4. Consumption and trade module*

The consumption module describes the consumption behavior of the representative consumer, whose utility is represented by the Stone–Geary utility function. The consumer earns income from a supply of labor, capital, and transfers from the government. Under budget constraints, the consumer makes consumption decision to maximize its utility. The mathematical descriptions of consumer behaviors are

$$\max_{C_i} U(C_i) = \prod_{i=1}^{n} (C_i - \theta_i)^{\mu_i} \quad s.t. Y = \sum_{i=1}^{n} P_i C_i \tag{5}$$

where $U$ is the utility of the consumer; $C_i$ is the consumption of commodity $i$; $\theta_i$ is the consumption of commodity $i$ as a necessary good; $\mu_i$ is the marginal budget share of commodity $i$; Y is the disposable income of the consumer; and $P_i$ is the price of commodity $i$. The solutions to Eq. (5) yield the percentages of the respective products possessed by consumers, which are shown as follows:

$$C_i = \theta_i + \frac{\mu_i}{P_i}\left(Y - \sum_{j=1}^{n} P_j \theta_j\right) \tag{6}$$

The first part of the sum on the right side of Eq. (6) represents the basic demand of the consumer, and the second part represents extra demand. Eq. (6) shows that consumers will change their consumption plan according to the price of products. With the resource tax reform, resource prices will increase. Hence, consumers will reduce the percentage of energy in their consumption structure in order to maximize their utility under their budget constraints.

The consumption of consumers comprises domestic goods, imported goods and goods brought in from other provinces, and we adopt the Armington hypothesis that products of different regions compete as imperfect substitutes. The elasticity parameters among commodities from different regions are obtained from Tan (2008). The consumption structure is presented in Fig. 3.

*3.1.5. Equilibrium and closure module*

The equilibrium module describes the balance of the goods market and the factor market, which means that the total demand is equal to the supply of each good and factor. For example, total output available for each good covers domestic demand and the trade balance between exports and imports. The closure module mainly describes the balance between savings and investment, the balance of financial revenue and expenditures and the balance of international payments. The Xinjiang CGE model adopts the neoclassical closure principle. First, actual government spending is an exogenous variable, and the tax rate, transfer payments and government consumption are fixed; government savings are adjusted to government revenue to balance the government budget closure. Second, total investment in the economy is adjusted to the gross savings to balance the savings-investment closure. Total savings comprise private savings, government savings, corporate savings, public sector surplus earnings and foreign savings. Third, the net capital inflow from other regions is the difference between the total imports and total exports with net transfers. The exchange rate is endogenously determined, while net capital inflow is fixed.

*3.2. SAM price model*

Based on Xinjiang's SAM of 2007, this paper adopts price-multiplier and structural path analysis to qualitatively discuss the mechanism of influence of Xinjiang's resource tax reform on sectoral price levels and tax burdens. Compared with the CGE model, price multiplier analysis applies a much simpler assumption on the economic structure. It is assumed that different inputs are not substitutable and there is surplus production capacity in each sector. Therefore, the product price changes in the same proportion as costs, having nothing to do with the level of output. Additionally, the accounts of the SAM are divided into endogenous and exogenous ones. Endogenous accounts comprise production accounts, factor accounts and enterprise and resident accounts, and exogenous accounts consist of government accounts, external trade accounts and capital accumulation accounts. The SAM price model can simulate the impact of a shock in exogenous accounts on the endogenous accounts through the multiplier process.

*3.2.1. Price multiplier analysis*

We define the price vector of production accounts $P_1$, the price vector of factor accounts $P_2$, the price vector of enterprise and resident accounts $P_3$ and the price vector of exogenous accounts $\pi_4$. The accounting balance of the SAM matrix can be presented as follows:

$$P_1 = P_1 A_{11} + P_2 A_{21} + \pi_4 A_{41} \tag{7}$$

$$P_2 = P_3 A_{32} + \pi_4 A_{42} \tag{8}$$

$$P_3 = P_1 A_{13} + P_3 A_{33} + \pi_4 A_{43} \tag{9}$$

We define $A = \begin{bmatrix} A_{11} & 0 & A_{13} \\ A_{21} & 0 & 0 \\ 0 & A_{32} & A_{33} \end{bmatrix}$, $P = (P_1, P_2, P_3)$, $v = (\pi_4 A_{41}, \pi_4 A_{42}, \pi_4 A_{43})$, and then the above price equations can be written as follows:

$$P = PA + v = v(I - A)^{-1} = vM \tag{10}$$

The transposed matrix $M$ is the matrix of price multipliers. The element $m'_{ji}$ of $M'$ means the ratio of price change between sector $j$

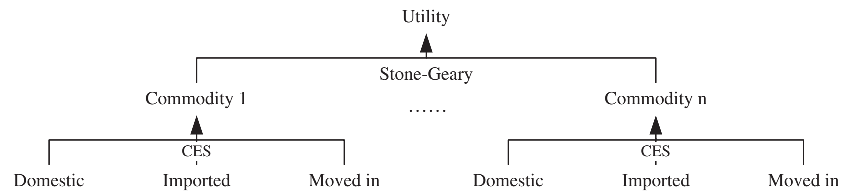


**Fig. 3.** Consumption structure of the Xinjiang CGE model.

and sector $i$ when the price of sector $i$ changes. The impact of resource tax reform is computed by exogenously changing the price level of the resource sector.

*3.2.2. Structural path analysis*

The price multiplier matrix reveals the extent of effects on other endogenous accounts caused by an exogenous shock, and structural path analysis further reveals the cost transmission mechanism, which is important for policy analysis. In other words, the price multiplier matrix reflects global influence ($G$), and structural path analysis clarifies the direct influence ($D$) of each elementary path and the total influence ($T$), which includes both direct and indirect influences.

The direct influence of account $i$ on account $j$ is the element $a_{ji}$ of matrix $A$, and the direct influence of account $i$ on account $j$ along the path $s$:$i \rightarrow x \rightarrow y \rightarrow j$ ($D^p_{(i\rightarrow j)s}$) is equal to the product of direct influences of adjacent accounts, which is shown as follows:

$$D^p_{(i\rightarrow j)s} = a_{xi}a_{yx}a_{jy} \tag{11}$$

There are not only direct influences but also indirect influences for any path. Feedback effects will increase the influence between different accounts. The total influence is the influence transmitted from origin to destination along an elementary path, including all indirect effects within the structure imputable to that path. The mathematical description of the total influence of account $i$ on account $j$ along the path $s$ is

$$T^p_{(i\rightarrow j)s} = D^p_{(i\rightarrow j)s}\mu^p_s \tag{12}$$

where $\mu^p_s$ is the path multiplier (U) of path $s$; the calculation of the $\mu^p_s$ are provided in Defourney and Thorbecke (1984).

The total influence reflects both direct and indirect influences transmitted along an elementary path, and the global influence reflects the sum of all the total influences caused by various elementary paths between origin and destination. Suppose $S = \{s/i, j\}$ is the set of elementary paths between origin $i$ and the destination $j$, then the relationship between three types of influence can be expressed as follows:

$$G^p_{(i\rightarrow j)s} = \sum_{s\in S} T^p_{(i\rightarrow j)s} = \sum_{s\in S} D^p_{(i\rightarrow j)s}\mu^p_s \tag{13}$$

The global influence of account $i$ on account $j$ can also be expressed by the element $m'_{ji}$ of the price multiplier matrix $M'$.

## 4. Simulation results and discussion

Is it reasonable to conclude that resource tax reform will contribute to energy conservation and emission reduction? Is it obvious that resource tax reform will bolster local government finances? Is it necessary to worry that resource tax reform will increase inflationary pressure, and who will then bear the increased burden caused by the reform? These are the three major issues of China's resource tax reform; therefore, we simulate the influence of resource tax reform on energy conservation and emission reduction, fiscal revenues of central and local governments, and sectoral price levels and tax burdens, by means of an energy CGE model and a SAM price model. Moreover, the energy price determination mechanism, resource tax distribution mechanism and energy price transmission mechanism are discussed.

### *4.1. Influence on energy conservation and carbon reduction*

Energy conservation and carbon reduction are substantial challenges faced by Xinjiang. In the Eleventh Five-Year (2006–2010) period, Xinjiang finished only half of its energy conservation targets. In addition, under international pressure to take collaborative action on reducing carbon dioxide emissions, China has set targets to cut carbon dioxide intensity by 17% in the next five years, which will be allocated among China's provinces. To confirm whether resource tax reform can relieve Xinjiang's pressure on energy conservation and carbon reduction, we quantitatively calculate the energy conservation and emission reduction effect of Xinjiang's resource tax reform and analyze the impact of China's energy price determination mechanism on the environmental effects of the reform. According to the energy CGE model, the influences of the reform on energy and carbon intensities are shown in Table 3.

Xinjiang's current oil and gas resource tax reforms have no contribution to energy conservation and emission reduction, and in fact, they lead to higher energy and carbon intensities, especially from oil resource tax reform. Table 3 shows that Xinjiang's oil resource tax reform, with a tax rate of 5–10%, will result in an increase of energy and carbon intensities by 0.19–0.41% and 0.20–0.43%, respectively. Xinjiang's gas resource tax reform, with a tax rate of 5–10%, will result in an increase of energy and carbon intensities by 0.007–0.014% and 0.007–0.015%, respectively. At present, a huge proportion of Xinjiang's energy consumption structure (see Table 2) is occupied by coal, which has a lower utilization efficiency and larger carbon emission factor than oil and gas. Reforms merely on oil and gas not only cannot improve the unreasonable energy consumption structure but also further exacerbate it; hence, it is reasonable that oil and gas resource tax reform will result in an increase of energy and carbon intensities.

**Table 3**
Environmental influence degree of Xinjiang's resource tax reform (%).

| Tax rate (%) | Reform on coal | | Reform on oil | | Reform on gas | | Reform on coal oil & gas | |
|---|---|---|---|---|---|---|---|---|
| | EI | CI | EI | CI | EI | CI | EI | CI |
| 5 | −0.19 | −0.24 | 0.19 | 0.20 | 0.01 | 0.01 | 0.00 | −0.03 |
| 6 | −0.24 | −0.30 | 0.23 | 0.25 | 0.01 | 0.01 | 0.00 | −0.05 |
| 7 | −0.28 | −0.35 | 0.28 | 0.30 | 0.01 | 0.01 | −0.01 | −0.06 |
| 8 | −0.33 | −0.41 | 0.32 | 0.34 | 0.01 | 0.01 | −0.01 | −0.07 |
| 9 | −0.37 | −0.47 | 0.36 | 0.39 | 0.01 | 0.01 | −0.02 | −0.09 |
| 10 | −0.42 | −0.52 | 0.41 | 0.43 | 0.01 | 0.02 | −0.02 | −0.10 |
| 15 | −0.63 | −0.79 | 0.60 | 0.65 | 0.02 | 0.02 | −0.06 | −0.18 |
| 20 | −0.83 | −1.03 | 0.79 | 0.84 | 0.03 | 0.03 | −0.10 | −0.27 |

Notes: EI is the abbreviation of energy intensity; CI is the abbreviation of carbon intensity; the simulation is based on Xinjiang's energy CGE model of 2007, under the administered price mechanism of oil, gas and electricity.

The influence of resource tax reform on energy intensity and carbon dioxide intensity will be much more obvious with an increase of tax rates, and coal resource tax reform will contribute to Xinjiang's energy conservation and carbon reduction. Table 3 shows that coal resource tax reform will result in a decrease of energy and carbon intensities by 0.19–0.42% and 0.24–0.52%, respectively, under the current resource tax rate of 5–10%, and the degree of decrease will reach as much as 0.63–0.83% for energy intensity and 0.79–1.03% for carbon intensity when the tax rate reaches 15% and 20%. At that point, coal, oil and gas resource tax reform with tax rates of 5–20% will result in an overall decrease of energy and carbon intensities of 0.00–0.10% and 0.03–0.27%, respectively. As with oil and gas resource tax reform, constant electricity prices also inhibit the environmental effects of coal resource tax reform. However, some coal is still consumed directly. With an increase of consumption costs, the percentage of coal in the energy structure will be reduced because of the substitution effect. Hence, coal resource tax reform will result in decreases in both energy and carbon intensities.

The simulation results of the energy CGE model, which takes into account China's current resource price determination mechanism, show that the effects of energy conservation and carbon reduction is not obvious; even the current resource tax reform is promoted to coal with a higher tax rate. To further confirm how remarkable is the impact of the resource price mechanism on the environmental effects of resource tax reform, we simulate the environmental effects of the reform by an energy CGE model under the assumption that price control is abolished, the results of which are shown in Table 4.

Under the market price mechanism, Xinjiang's resource tax reform will contribute a greater share to the decrease of energy intensity and carbon intensity than that of an administered price mechanism. For example, the comprehensive environmental effects of coal, oil and gas resource tax reform are obvious, and energy and carbon intensities will decrease by as much as 4.90% and 4.39%, respectively, under a tax rate of 20%. A comparison between simulation results under different price mechanisms shows that the resource price determination mechanism plays an important role in the environmental effects of resource tax reform, and the current administered energy price mechanism influences the environmental effects of Xinjiang's resource tax reform. Both consumers and producers behave according to the relative price levels of products for the maximization of utility or profit. When the energy production cost is increased with the reform, the administered price mechanism inhibits price transmission from upstream to downstream, and energy demand will not decline.

In other words, the low resource tax rate, narrow resource tax scope and unreasonable resource price mechanism combine to determine that China's resource tax reform fails to reach the expected environmental goal. A reasonable resource pricing mechanism is the fundamental guarantee for the achievement of the expected effect of oil and gas resource tax reform. Resource price determination mechanism reform should go hand in hand with resource tax reform.

### 4.2. Influence on local and central government fiscal revenues

Transforming resource advantages to economic and financial advantages is perhaps the most urgent task faced by Xinjiang. As an important part of China's energy base, Xinjiang has as much as 20 billion tons of oil and 10 trillion cubic meters of gas, accounting for more than 30% and 34% of China's land-based oil and gas resources, respectively. However, the original resource tax system determines that it is difficult for Xinjiang to turn its resource advantage into economic and financial advantages. To confirm whether Xinjiang's resource tax reform can bolster local government finances as hoped, we adopt an energy CGE model to simulate the degree of influence on fiscal revenues of local and central governments and analyze the resource tax distribution mechanism, which has a direct impact on the fiscal effects of resource tax reform. According to the energy CGE model, the influences of the reform on local and central government fiscal revenues are shown in Table 5.

Xinjiang's current oil and gas resource tax reform clearly increases fiscal revenue collected by local government, and oil resource tax reform makes the biggest contribution because the petroleum industry is Xinjiang's largest industry. Table 5 shows that Xinjiang's oil resource tax reform with a tax rate of 5–10% will result in an increase of local fiscal revenue by 4.07–8.66%; Xinjiang's gas resource tax reform with a tax rate of 5–10% will result in an increase of local fiscal revenue by 0.14–0.30%. Monopolistic resource enterprises, such as PetroChina and Sinopec, benefit from Xinjiang's rich resources, but the previous tax system means that resource enterprises pay little taxes to the local government. For example, some of the resource enterprises' taxes should be paid to the eastern provinces where the corporate headquarters are located, such as Beijing and Shanghai, rather than the places of production according to the tax law. A stream of tax revenue generated by abundant energy resources in Xinjiang is continuously pumped away (Meng et al., 2011). Our calculation shows that Xinjiang's resource tax reform will help to change this situation, and a large portion of resource companies' profits will flow to the local government.

At the same time, Xinjiang's current oil and gas resource tax reform reduces fiscal revenue collected by the central government. Table 5 shows that Xinjiang's oil resource tax reform with a tax rate of 5–10% will result in a decrease of central fiscal revenue by 0.40–0.85%; Xinjiang's gas resource tax reform with a tax rate of 5–10% will result in a decrease of central fiscal revenue by 0.01–0.03%. Most enterprises in the energy industries are large state-owned enterprises, whose profits will be turned over to the central government. As

**Table 4**
Environmental influence degree of Xinjiang's resource tax reform (%).

| Tax rate (%) | Reform on coal | | Reform on oil | | Reform on gas | | Reform on coal oil & gas | |
|---|---|---|---|---|---|---|---|---|
| | EI | CI | EI | CI | EI | CI | EI | CI |
| 5 | −0.43 | −0.49 | −0.46 | −0.33 | −0.22 | −0.16 | −1.12 | −0.99 |
| 6 | −0.53 | −0.61 | −0.57 | −0.40 | −0.27 | −0.20 | −1.38 | −1.23 |
| 7 | −0.63 | −0.73 | −0.68 | −0.48 | −0.32 | −0.23 | −1.65 | −1.46 |
| 8 | −0.74 | −0.85 | −0.79 | −0.56 | −0.37 | −0.27 | −1.91 | −1.70 |
| 9 | −0.84 | −0.97 | −0.90 | −0.63 | −0.42 | −0.30 | −2.18 | −1.93 |
| 10 | −0.94 | −1.08 | −1.00 | −0.70 | −0.47 | −0.34 | −2.43 | −2.17 |
| 15 | −1.42 | −1.64 | −1.52 | −1.06 | −0.70 | −0.51 | −3.69 | −3.30 |
| 20 | −1.89 | −2.17 | −2.01 | −1.41 | −0.91 | −0.66 | −4.90 | −4.39 |

Notes: EI is the abbreviation of energy intensity; CI is the abbreviation of carbon intensity; the simulation is based on Xinjiang's energy CGE model of 2007, under the market price mechanism of oil, gas and electricity.

**Table 5**
Fiscal influence degree of Xinjiang's resource tax reform (%).

| Tax rate (%) | Reform on coal | | Reform on oil | | Reform on gas | | Reform on coal oil & gas | |
|---|---|---|---|---|---|---|---|---|
| | LG | CG | LG | CG | LG | CG | LG | CG |
| 5 | 0.24 | −0.04 | 4.07 | −0.40 | 0.14 | −0.01 | 4.45 | −0.45 |
| 6 | 0.30 | −0.05 | 5.02 | −0.49 | 0.17 | −0.02 | 5.49 | −0.56 |
| 7 | 0.35 | −0.06 | 5.95 | −0.59 | 0.21 | −0.02 | 6.51 | −0.66 |
| 8 | 0.41 | −0.06 | 6.87 | −0.68 | 0.24 | −0.02 | 7.52 | −0.77 |
| 9 | 0.47 | −0.07 | 7.77 | −0.77 | 0.27 | −0.03 | 8.51 | −0.87 |
| 10 | 0.53 | −0.08 | 8.66 | −0.85 | 0.30 | −0.03 | 9.48 | −0.97 |
| 15 | 0.81 | −0.13 | 12.89 | −1.27 | 0.44 | −0.04 | 14.14 | −1.44 |
| 20 | 1.09 | −0.17 | 16.80 | −1.66 | 0.58 | −0.06 | 18.46 | −1.88 |

Notes: LG is the abbreviation of local government; CG is the abbreviation of central government; the simulation is based on Xinjiang's energy CGE model of 2007, under the administered price mechanism of oil, gas and electricity.

mentioned above, resource tax reform results in more companies' profits flowing to the local government. With the decrease of resource companies' profits, central government revenue will decrease indirectly.

Table 5 shows that not only increasing the tax rate but also expanding the tax scope will further promote the transfer of revenues from resource enterprises and the central government to the local government. If the resource tax rate is further increased to 15–20%, the degree of increase of local fiscal revenue will reach as much as 12.89–16.80% for oil resource tax reform and 0.44–0.58% for gas resource tax reform. If resource tax reform is expanded to coal, then it will result in an increase of local fiscal revenue by 0.24–0.53% and a decrease of central fiscal revenue by 0.04–0.08%. Then, coal, oil and gas resource tax reform with a tax rate of 5–20% will result in an overall increase of local fiscal revenue by 4.45–18.46% and an overall decrease of central fiscal revenue by 0.45–1.88%. The simulation results show that Xinjiang's resource tax reform has reached the original fiscal goal to bolster local government finances, and the fiscal effects of the reform will be much clearer if resource tax reform is further expanded.

In China, different provinces share a similar resource tax distribution mechanism, which means that the implementation of the reform in other provinces may have similar results. However, China's resource distribution characteristics determine that nationwide implementation of the reform will bolster local revenue of different regions to different degrees. For example, as China's important energy base, the western region provinces will benefit the most from the reform. Hence, the resource tax reform is an important policy support for the development of the western regions by the central government, which is consistent with China's Western Development Strategy. Therefore, the central government holds a positive attitude toward the reform, even though there is a decrease in the central government revenue.

In other words, resource tax reform will result in a redistribution of revenue among local government, central government, and monopolistic resource enterprises. Revenue will be transferred from resource enterprises and the central government to the local government. Increasing the tax rate and expanding the tax scope will further promote the fiscal effects of resource tax reform.

### 4.3. Influence on sectoral price levels and tax burden

Increasing inflation is considered the main concern of China's resource tax reform. In 2011, China's CPI remained at a high level and reached as much as 6.5% in July. Considering that the resource tax reform may further push up the CPI, the central government waited for more than one year to expand the resource tax reform to the whole nation, when prices were relatively stable. Xinjiang's oil and gas industries are dominated by two state-owned companies (PetroChina and Sinopec), and oil and gas prices are both controlled by the government. The administered price mechanism determines that resource tax reform has no direct impact on price levels, and resource enterprises will bear the increased resource tax burden. However, the coal industry has a higher degree of marketization than the oil and gas industries, so the impact on sectoral price levels and tax burdens will be relatively complex. Therefore, the government is still hesitating to expand the reform to coal. To confirm whether increasing inflation should be a barrier to the promotion of China's resource tax reform, we quantitatively calculate the degree of influence on sectoral price levels from coal resource tax reform and qualitatively analyze the coal price transmission mechanism to explain why certain energy sectors bear the increased tax burden. According to the energy CGE model, the top 10 sectors whose prices are affected the most are shown in Table 6.

With Xinjiang's coal resource tax reform, there is an increasing trend in sectoral price levels, especially the sectors that have a close relation with the coal sector. For example, Table 6 shows that coal resource tax reform with a rate of 5–20% will result in an increase of coke prices as much as 1.67–7.83%. Coal is the main ingredient of coke production, and it is reasonable that the coke price is the most sensitive to the resource tax rate. However, most sectors' percentage increase in prices is less than 1% under the current tax rate of 5–10%, except the coking sector, which means that expanding resource tax reform to coal will not increase inflationary pressure as seriously as expected. One possible reason is that coal is mainly consumed by other sectors in the form of thermal electricity, and electricity prices are controlled in China, which may inhibit the coal price transmission from upstream to downstream. This means that thermal power enterprises will bear the increased burden caused by the reform. To confirm whether the electricity sector plays an important role in the coal price transmission path, we used a SAM price model to analyze the influence mechanism of coal price change.

**Table 6**
Sectoral price influence degree of Xinjiang's coal resource tax reform (%).

| Sector | 5% | 6% | 7% | 8% | 9% | 10% | 15% | 20% |
|---|---|---|---|---|---|---|---|---|
| Coking | 1.67 | 2.09 | 2.50 | 2.92 | 3.33 | 3.74 | 5.80 | 7.83 |
| Steam and hot water production and supply | 0.38 | 0.48 | 0.58 | 0.67 | 0.76 | 0.86 | 1.33 | 1.79 |
| Metals smelting and pressing | 0.10 | 0.12 | 0.14 | 0.17 | 0.19 | 0.21 | 0.33 | 0.44 |
| Nonmetal mineral products | 0.08 | 0.10 | 0.12 | 0.13 | 0.15 | 0.17 | 0.27 | 0.36 |
| Paper and products | 0.07 | 0.09 | 0.10 | 0.12 | 0.14 | 0.16 | 0.24 | 0.33 |
| Chemical fibers | 0.06 | 0.07 | 0.09 | 0.10 | 0.11 | 0.13 | 0.20 | 0.27 |
| Raw chemical materials and chemical products | 0.06 | 0.07 | 0.08 | 0.10 | 0.11 | 0.13 | 0.19 | 0.26 |
| Nonferrous metal smelting and processing | 0.05 | 0.07 | 0.08 | 0.10 | 0.11 | 0.12 | 0.19 | 0.26 |
| Metal products | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.08 | 0.13 | 0.17 |
| Manufacture of machine and equipment | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.07 | 0.11 | 0.15 |

Notes: the simulation is based on Xinjiang's energy CGE model of 2007; we only list the top 10 sectors that are most sensitive to coal price under the administered price mechanism of electricity.

The calculation complexity determines that it is impossible for us to calculate every transmission path of every sector. Therefore, we only analyze the main transmission paths of sectors that are most sensitive to coal prices. It should be noted that the sectors in Table 6 should be not used directly, because the simulation results of the energy CGE model, which adopt an administered electricity price mechanism, fail to capture the influence of the electricity sector. Therefore, a SAM price multiplier analysis is adopted in this paper to find the sectors that are sensitive to coal prices. Structural path analysis (Defourney and Thorbecke, 1984) is used in this paper to capture the linkages between individual SAM accounts and to identify the price transmission mechanism. Table 7 presents the degrees of influence and paths for a unitary cost shock given to coal sector. For brevity, we only report the top 10 sectors that are most sensitive to coal prices and paths that have a minimum share of 5%.

Price multiplier (Global influence) is the percentage change in price of each economic activity when the price of petroleum and natural gas extraction sector increases by 1%. For instance, a 1% increase in the costs of the coal sector leads to an increase of the coke price by 0.483%. Similar to the results of the energy CGE model, the coking sector is the most sensitive to the coal price. Except for the coking sector, there are great differences in the degree of influence of other sectors between Tables 6 and 7 because the SAM price model considers the impact of electricity prices. It indirectly reflects that the electricity price determination mechanism has a clear influence on cost transmission.

Price transmission path explains how a coal price shock travels to the price level of different accounts. For example, the global price influence of the unitary increase in coal prices is to increase the price of the coking sector by 0.483%. The direct price influence is 0.462, and it is extended through the intersectoral relations by a factor of 1.03. The total price influence is 0.475, which is 98.39% of the global price influence. This means that the price influence of the coking sector mainly

**Table 7**
Sectoral price influence mechanism of Xinjiang's coal resource tax reform.

| Origin | Destination | Paths | G | D | U | T | T/G (%) |
|---|---|---|---|---|---|---|---|
| CoalMin | Coke | CoalMin → Coke | 0.483 | 0.462 | 1.03 | 0.475 | 98.39 |
| CoalMin | ElecProd | CoalMin → ElecProd | 0.224 | 0.186 | 1.18 | 0.219 | 97.87 |
| CoalMin | SteamProd | CoalMin → SteamProd | 0.115 | 0.096 | 1.03 | 0.099 | 86.16 |
| | | CoalMin → **ElecProd** → SteamProd | 0.115 | 0.009 | 1.19 | 0.011 | 9.20 |
| CoalMin | Water | CoalMin → **ElecProd** → Water | 0.038 | 0.023 | 1.19 | 0.027 | 72.54 |
| CoalMin | CheFiber | CoalMin → CheFiber | 0.033 | 0.011 | 1.13 | 0.012 | 37.27 |
| | | CoalMin → **ElecProd** → CheFiber | 0.033 | 0.006 | 1.30 | 0.007 | 22.21 |
| | | CoalMin → SteamProd → CheFiber | 0.033 | 0.002 | 1.14 | 0.002 | 5.89 |
| CoalMin | BuildMat | CoalMin → **ElecProd** → BuildMat | 0.033 | 0.010 | 1.26 | 0.013 | 39.15 |
| | | CoalMin → BuildMat | 0.033 | 0.011 | 1.10 | 0.013 | 38.37 |
| CoalMin | NonMet | CoalMin → NonMet | 0.029 | 0.010 | 1.13 | 0.011 | 37.49 |
| | | CoalMin → **ElecProd** → NonMet | 0.029 | 0.006 | 1.30 | 0.008 | 25.72 |
| | | CoalMin → **ElecProd** → Mine → NonMet | 0.029 | 0.002 | 1.51 | 0.003 | 11.68 |
| CoalMin | Textile | CoalMin → **ElecProd** → Textile | 0.027 | 0.009 | 1.22 | 0.011 | 39.99 |
| | | CoalMin → **ElecProd** → Agri → Textile | 0.027 | 0.002 | 1.61 | 0.003 | 9.33 |
| | | CoalMin → Textile | 0.027 | 0.002 | 1.06 | 0.002 | 7.13 |
| | | CoalMin → SteamProd → Textile | 0.027 | 0.001 | 1.07 | 0.001 | 5.02 |
| CoalMin | CheProd | CoalMin → **ElecProd** → CheProd | 0.026 | 0.008 | 1.35 | 0.011 | 41.37 |
| | | CoalMin → CheProd | 0.026 | 0.007 | 1.17 | 0.008 | 31.12 |
| | | CoalMin → Coke → CheProd | 0.026 | 0.001 | 1.17 | 0.002 | 6.01 |
| CoalMin | Paper | CoalMin → Paper | 0.024 | 0.008 | 1.25 | 0.010 | 41.35 |
| | | CoalMin → **ElecProd** → Paper | 0.024 | 0.003 | 1.44 | 0.005 | 19.38 |
| | | CoalMin → SteamProd → Paper | 0.024 | 0.001 | 1.26 | 0.002 | 7.46 |

Note that the full name of each sector is as follows: mining and washing of coal (CoalMin); thermal power production and supply (ElecProd, which is highlighted in bold to emphasize the indirect transmission path with the thermal power production and supply sector); coking (Coke); steam and hot water production and supply (SteamProd); nonmetal mineral products (BuildMat); raw chemical materials and chemical products (CheProd); chemical fibers (CheFiber); nonferrous metal smelting and processing (NonMet); mining of metal ores and nonmetal ores (Mine); water production and supply (Water); manufacture of pulp and paper articles (Paper); agriculture, forestry, animal husbandry & fishery (Agri); textile goods (Textile). The simulation is based on Xinjiang's SAM price model of 2007; we only list the top 10 sectors that are most sensitive to coal price under the market price mechanism of electricity, and paths that have a minimum share of 5%.

comes from the direct transmission path, which also explains the results of the energy CGE model that the price of the coking sector will increase clearly, even when electricity prices are controlled. Table 7 shows that the thermal power production and supply sector plays an important role in the coal price indirect transmission mechanism, except the direct transmission path. Take nonmetal mineral products sector (BuildMat) as an example: 39.15% of the price increase of this sector is transmitted through the indirect path (CoalMin → ElecProd → BuildMat). However, China's current imperfect coal-electricity price linkage mechanism means that the electricity price cannot be adjusted in time. In other words, the administered electricity price mechanism inhibits the electricity sector from shifting the tax burden downstream. It directly confirms that the electricity sector will bear the increased tax burden caused by coal resource tax reform.

In other words, the administered price mechanism determines that it is unnecessary to fear that current oil and gas resource tax reform will increase inflation. Even if resource tax reform is expanded to coal, the increase of sectoral price levels is also limited because electricity prices are controlled by the government. PetroChina, Sinopec and thermal power enterprises will bear the increased burden caused by the reform.

## 5. Conclusions

In June 2010, China began resource tax reform with a pilot program in Xinjiang. This paper discusses the three fundamental issues of China's resource tax reform from a regional perspective: promoting energy conservation and carbon reduction, bolstering local government revenue, and increasing inflationary pressures. First, the Xinjiang energy CGE model is developed in this paper to quantitatively calculate the degree of economic and environmental influence of the reform; second, a SAM price model, as a supplement to the CGE analysis, is adopted to qualitatively analyze the resource price transmission mechanism. The main conclusions are as follows:

1) Contrary to expectations, applying Xinjiang's current resource tax reform merely to oil and gas contributes little to energy conservation and emission reduction and even exacerbates the unreasonable energy structure. Even if the reform is extended to coal with a higher tax rate, the environmental effects are still limited. The low resource tax rate, narrow resource tax scope and unreasonable resource price mechanism combine to determine that the reform fails to reach the expected environmental goals. However, merely increasing the tax rate and extending the tax scope are not enough, and resource price mechanism reform is the key to address this problem. China should adjust the administered resource price mechanism and liberalize resource prices to a larger degree.
2) The original fiscal goal of resource tax reform to bolster local government finances is achieved. The reform will result in a redistribution of revenue among the local government, the central government, and monopolistic resource enterprises. Revenue will be transferred from resource enterprises and the central government to the local government. In addition, resource taxes with a higher tax rate and a larger tax scope will accentuate the revenue redistribution effects of resource taxes, and the fiscal effects of the reform will be much more obvious. China's resource tax reform should be further promoted and deepened to further transform Xinjiang' resource advantages to economic and financial advantages.
3) The previous concern that resource tax reform will increase inflation is unnecessary. The administered price mechanism determines that current oil and gas resource tax reform has no direct impact on sectoral price levels; PetroChina and Sinopec will bear the increased burden caused by the reform. The imperfect coal-electricity price linkage mechanism means that expanding resource tax reform to coal with a higher tax rate still will not impact sectoral price levels as seriously as expected, and the tax burden of thermal power enterprises, which play an important role in the coal price transmission paths, will increase. It is unnecessary to fear that current resource tax reform will increase inflation, which should not, therefore, be a barrier to China's resource tax reform.

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## References

Akkemik, K.A., 2011. Potential impacts of electricity price changes on price formation in the economy: a social accounting matrix price modeling analysis for Turkey. Energy Policy 39, 854–864.

Barker, T., Baylis, S., Madsen, P., 1993. A UK carbon/energy tax: The macroeconomics effects. Energy Policy 21, 296–308.

Beckman, J., Hertel, T., Tyner, W., 2011. Validating energy-oriented CGE models. Energy Econ. 33, 799–806.

Berkhout, P.H.G., Ferrer-i-Carbonell, A., Muskens, J.C., 2004. The ex post impact of an energy tax on household energy demand. Energy Econ. 26, 297–317.

Cao, A.H., Han, B.T., Qi, A.T., 2011. The policy research on the resource tax reform in China. China Popul. Resour. Environ. 21, 158–163.

China statistical yearbook, 2008. National Bureau of Statistics of China. China Statistics Press, Beijing, China.

Debreu, G., 1959. Theory of Value. Cowles Foundation Monograph No. 17. John Wiley & Sons, New York.

Defourney, J., Thorbecke, E., 1984. Structural path analysis and multiplier decomposition within a social accounting matrix framework. Econ. J. 94, 111–136.

Ferran, S., 2010. Double dividend effectiveness of energy tax policies and the elasticity of substitution: A CGE aps Press, praisal. Energy Policy 38, 2927–2933.

Financial yearbook of China, 2008. Ministry of Finance. China financial Press, Beijing, China.

Financial yearbook of Xinjiang, 2008. Xinjiang Financial Yearbook Editing Committee. China financial and economic press, Beijing, China.

Fofana, I., Chitiga, M., Mabugu, R., 2009. Oil prices and the South African economy: a macro–meso–micro analysis. Energy Policy 37, 5509–5518.

Guo, J.E., Qian, D., Lv, Z., Xiong, J., 2011. Analysis on effects of coal resource tax adjustment. China Popul. Resour. Environ. 21, 78–84.

Guo, J.E., Zhang, Z.K., Meng, L., 2012. China's provincial $CO_2$ emissions embodied in international and interprovincial trade. Energy Policy 42, 486–497.

IPCC, 2006. The 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 Guidelines). http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

Johansen, L., 1960. A Multi-sectoral Study of Economic Growth. North-Holland, Amsterdam.

Li, Z.N., 2000. Econometrics. Higher Education Press, Beijing.

Lin, B., He, X., 2008. Chinese oil and gas depletion costs and macroeconomic impacts of resource tax. Econ. Res.J. 05, 94–104.

Lv, Z.D., Guo, J.E., Xi, Y.M., 2009. Econometric estimate and selection on China energy CES production function. China Popul. Resour. Environ. 19, 156–160.

Meng, L., Guo, J.E., Chai, J., Zhang, Z.K., 2011. China's regional CO2 emissions: characteristics, inter-regional transfer and emission reduction policies. Energy Policy 39, 6136–6144.

National Bureau of Statistics of China (NBS), 2008. China Energy Statistical Year Book 2008. China Statistics Press, Beijing.

Parra, J.C., Wodon, Q., 2008. Comparing the impact of food and energy price shocks on consumers: a social accounting matrix analysis for Ghana. World Bank Policy Research Paper No. WPS 4741.

Peretto, P.F., 2009. Energy taxes and endogenous technological change. J. Environ. Econ. Manag. 57, 269–283.

Qian, D., Guo, J.E., Xue, Y., ANIWAER, A., 2012. Research on the factors and treatment strategies of energy intensity in Xinjiang. China Popul. Resour. Environ. 22, 139–146.

Roland-Holst, D., Sancho, F., 1995. Modeling prices in a SAM structure. Rev. Econ. Stat. 77, 361–371.

Semboja, H.H., 1994. The effects of energy taxes on the Kenyan economy: a CGE analysis. Energy Econ. 16, 205–215.

Stern, D.I., 2009. Interfuel substitution: a meta-analysis.

Sun, G., 2007. On the problems and reform ideas of the system of resource tax and fees in China. Tax. Res. 11, 41–44.

Tan, X.D., 2008. Modeling and application of electric power computable general equilibrium model. Thesis to obtain the degree of Doctor of Philosophy in Management Science, North China Electric Power University, Beijing, China, 28–30.

Tarek, G., 2007. Energy taxes as a signaling device: an empirical analysis of consumer preferences. Energy Policy 35, 29–38.

Tax Year Book of China, 2008. State Administration of Taxation. China Tax Press, Beijing, China.

Thompson, P., Taylor, T.G., 1995. The capital-energy substitutability debate: a new look. Rev. Econ. Stat. 77, 565–569.

Vásquez Cordano, A.L., Balistreri, E.J., 2010. The marginal cost of public funds of mineral and energy taxes in Peru. Resour. Policy 35, 257–264.

Wei, W., 2009. An analysis of China's energy and environmental policies based on CGE model. Stat. Res. 7, 3–12.

Wissema, W., Dellink, R., 2007. AGE analysis of the impact of a carbon energy tax on the Irish economy. Ecol. Econ. 61, 671–683.

Xian, F.J., 2010. An analysis on the effects of oil and gas resources tax reform in the Xinjiang Uygur Autonomous Region in Western China. Tax. Res. 26–30.

Xiao, H., 2008. China's fuel tax policy and optimization during the financial crisis period: based on the dynamic CGE model of fuel tax. Thesis to obtain the degree of Doctor of Philosophy in Economics, Wuhan University, Wuhan, China, 21–25.

Xinjiang statistical yearbook, 2008. Xinjiang Statistical Bureau. China Statistics Press, Beijing, China.

Xu, X.L., 2011. Government s decision and economic behaviors in resource tax reform. China Popul. Resour. Environ. 21, 10–15.

Xu, X.L., Wu, F.P., 2011. Study of value compensation mechanism in resource tax reform. China Popul. Resour. Environ. 21, 107–112.

Zhang, C.L., 2006. Research on the relation of resources taxation and regional economic development in Xinjiang. China Popul. Resour. Environ. 16, 44–47.

Zhang, J.G., Zhou, J.G., 2007. Theory and practice of China mineral resource taxs. J. Shijiazhuang Univ. Econ. 4, 57–60.

Zhu, B.C., 2011. National promotion of resource tax reform depends on the price level. Secur. J. (May 1). http://www.ccstock.cn/finance/hongguanjingji/2011-05-09/A450496.html.