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Forest Carbon Sequestration Subsidy and Carbon Tax as Part of China's Forestry Policies

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Academic Editors: Thomas J. Straka and Timothy A. Martin
Received: 23 November 2016; Accepted: 21 February 2017; Published: 27 February 2017

Abstract: Forestry is an effective strategy for climate change mitigation. However, forestry activities not only sequester carbon but also release CO_2. It is therefore important to formulate carbon subsidy and carbon taxation policies on the basis of the price of carbon. In this study, a forestry-based Computable General Equilibrium (CGE) model was built by using input-output data of China in 2014 to construct a Social Accounting Matrix (SAM). The model simulates different carbon price scenarios and was used to explore the effects of carbon subsidy and carbon taxation policies on the forestry economy. The main results can be summarized as follows: When the carbon price is low, the implementation of the policy increases forestry output and causes forest product prices to rise. When the carbon price is high, the carbon tax will produce an inhibitory effect, and output and prices will decline. With the constant rise of the carbon price, value addition will decrease, with flow to other industries. For the carbon sequestration policy, there is a reasonable carbon price range bound. In light of these results, relevant policies are proposed.

Keywords: forest carbon sequestration subsidy; carbon tax; CGE; China; forestry policies

1. Introduction

Climate change is one of today's most important global environmental issues, which directly affects all natural ecosystems and socio-economic systems. The negative effects of global climate change have become a major global threat and a considerable challenge facing mankind.

Forests play an effective role in climate change mitigation because approximately 17.4% of the annual global carbon dioxide emissions are caused by deforestation and forest degradation [1]. Forest ecosystems are regarded as the most efficient carbon sequestration systems in the terrestrial ecosystem. Many public services provided by forest ecosystems have made a great contribution to CO_2 reduction. Forests can be seen as the largest terrestrial organic carbon pool; tree growth is the CO_2 absorption process that can effectively reduce atmospheric CO_2 concentration.

There are two methods through which forests can address climate change: First, reduce greenhouse gas emissions; second, increase the absorption of greenhouse gasses (carbon sink). A carbon sink is a natural or artificial reservoir that accumulates and stores some carbon-containing chemical compound for an indefinite period. Forestry is an effective way and important means to mitigate climate change, forming a broad consensus among the participating countries and organizations of the United Nations Climate Conference. Therefore, two mechanisms were proposed at the Cancun climate conference, i.e., REDD+ (reducing emissions from deforestation and forest degradation) and LULUCF (land use, land-use change, and forestry) [2,3]. The special status of forestry in addressing climate change has been fully affirmed by the international community.

Although carbon sequestration is an important strategy, leakage can be a problem when seeking to reduce carbon emissions. The magnitude of leakage caused by implementing China's forestry policies is between 79.7% and 88.8%, with carbon leakage mainly displaced to Russia, Southeast Asia, and the European Union [4]. At present, some researchers have studied carbon subsidies and carbon taxes, which can be divided into two categories: Firstly, the effect of a carbon subsidy and carbon taxes on macroeconomics [5]. This author found that a carbon tax has very limited impact on GDP [6]. Wang reported similar results, but he pointed out that a carbon tax scheme has a significant stimulatory effect on the slowing of CO_2 emissions despite its limited impact on China's economy [7]. Zhu analyzed the policy effectiveness of a carbon production tax and carbon consumption tax with high, medium and low tax rates and found that a carbon tax could effectively reduce CO_2 emissions [8]. Secondly, a carbon subsidy and carbon taxes impact forest management decisions [9–12]. A modified Hartman model was used to determine the impact of a carbon subsidy and tax policy on slash pine; the results showed that the carbon subsidy and tax policy increased the optimal rotation age, land expectation value and the carbon sink [13]. Shen and Zhu used the improved Faustmann model to study the effect of carbon sink subsidies and carbon taxes on rotations of different species and the potential carbon sink [14].

The studies mentioned above have paid much attention to emissions without taking into account the special role of the forest carbon sink. Afforestation and reforestation projects in the United States absorb about 5×10^8 t of carbon every year, accounting for one-third of CO_2 emissions of the whole country [15]. There would be a huge estimation deviation of the carbon sink subsidies and carbon tax without considering the forest carbon sink. In addition, the research mainly focuses on the micro-level analysis, without taking into account the mutual influence among the forestry industry cycles, products and elements. For example, under the condition of carbon sink subsidies or carbon trading, the economic value of the carbon sink would increase forestry output, and then have an impact on the price and other factors of forest products, which have not yet been resolved in existing research. The existing forest carbon sink studies mostly focus on the inside of forestry sectors, without taking into account the various sectors of the whole economy. Thus, on the whole, how the carbon sink subsidy and carbon tax affect the forestry economy at the macro level has become an urgent scientific and practical problem.

According to China's seventh forest resources inventory, the total carbon storage has reached 7.811 billion t [16]. As the largest carbon emitter in the world, China has to face the serious carbon emission problem existing in the forest resource property rights system and allocation methods as well as the operation mechanism, especially with increasing industrial and economic growth in recent years. How to quantify the ecological value and then reflect the profit function of forests producers or owners is now a hot topic among the governments and academic areas. Through an input–output approach, it was found that 10.03%–26.54% of China's annual CO_2 emissions are produced during the manufacture of export goods destined for foreign consumers, while the CO_2 emissions embodied in China's imports accounted for only 4.40% (1997) and 9.05% (2007) of these amounts [17]. Through a computable general equilibrium model, the environmental and economic effects of the carbon market in China were analyzed to offer a scientific basis and reference for policy makers when developing the regulation framework for the Chinese national carbon market [18]. A Computable General Equilibrium (CGE) model was constructed to project the local emission trajectory of CO_2 and air pollutants under business-as-usual (BaU) and policy scenarios in Guangdong province and the rest of China from 2007 to 2020 [19].

There are still no mandatory emissions standards in China, and a long time is needed to establish the carbon market transactions of forest sequestration. Policy instruments have become the primary means to solve the "market failure" by promoting the economic development of the forest carbon sink before the establishment of the carbon market. Studies have shown that carbon sink subsidies based on the price and tax policy have greater maneuverability and better implementation of the results [20]. Therefore, studies on the effect of different carbon price subsidies for carbon sinks and the carbon tax policy have an important significance in the response to climate change, promoting forestry development and the forestry economy.

This study attempts to build a Computable General Equilibrium (CGE) model to quantify and consider the double impact of a carbon sink subsidy and carbon tax for the forestry economy and analyze the final consumption changes of forestry outputs and forest products, providing a scientific basis for the development of a carbon sink subsidy and carbon tax policy.

2. Current Situation and Economic Properties of Forest Carbon Sequestration

2.1. The Forest Carbon Sequestration Market Is Developing Rapidly

The first greenhouse gas emission reduction platform in the world, Chicago Climate Exchange (CCX), started operation in 2003 through a membership system involving dozens of different industries such as aviation, automobile, electric power, environment, transportation and so on. Since the beginning of the transaction, its members have reduced carbon emissions by 450 million tons. Its influence is still felt in the North American carbon markets, where voluntary actors transacted almost 8 $MtCO_2$ e of CCX credits in 2012—pushing the voluntary market as the whole over the one-million-tonne mark. The quota trading system of the European Union Emission Trading Scheme (EU ETS), also known as the European Union Emissions Trading Scheme, was the first large greenhouse gas emissions trading scheme in the world and remains the largest. It was launched in 2005 to fight global warming and is a major pillar of the EU climate policy [21]. A global carbon trading system has gained shape since several major Asia-Pacific economies declared their participation. As the largest national source of greenhouse gasses, China is probably the most prominent newcomer. Pilot emission trading schemes are being introduced in this country with prospects for developing a national scheme [22].

The Kyoto Protocol allows developed countries to undertake REDD credits through developing afforestation and reforestation carbon sequestration projects in developing countries. On the other hand, developing countries can use the developed countries' funds and advanced technologies to promote the development of their economies; many developed countries and developing countries take this opportunity to carry out relevant forestry carbon sequestration projects at a rapid speed. After the signing of the Kyoto Protocol in 1997, the CDM forestry carbon sequestration pilot project was fully developed [23,24]. In 1992, the Dutch Electricity Council (SEP) created the forest absorbing CO_2 emissions (FEA) policy with a total budget of 180 million US dollars for forestry carbon sequestration projects around the world [25]. The first investment was a restoration project for a tropical rainforest in Sabah, followed by four forestry carbon sequestration projects in Malaysia, Ecuador, the Czech Republic, the Netherlands and Uganda to offset carbon emissions from their plants. The implementation of the forestry carbon sequestration projects has created employment opportunities for the local community and gained enormous social, economic and environmental benefits, leading to the development of tourism and reduced environmental pollution.

As shown in Table 1, the condition of forest carbon sequestration projects around the world is developing rapidly.

Table 1. The condition of developing forest carbon sequestration projects around the world.

Country	Forest Carbon Project	Area/hm^2	Expected Life Time/a	Expected Carbon/t	Investor
Indonesia	Reduced impact logging for carbon sequestration	600	40	-	America
Russia	Reforestation in Vologda	2000	60	228,000	America
Malaysia	Enrichment planting, restoration project	16,000	25	4,300,000	Holland
Argentina	Reforestation in Rio Bermejo	70,000	30	4,345,500	America
Brazil	Rainforest plantation	1214	40	727,525	America
Chile	SIF carbon sequestration	7000	51	385,280	America
Mexico	Scole Te agroforestry project		30	16,000–354,000	UK and France
Uganda	Forest rehabilitation in national park	27,000		172,000	Holland

2.2. Current Situation of Forest Carbon Sink Service Market in China

A "Joint Declaration on Climate Change" was issued by China and USA in 2015; China promised to start a carbon emissions trading system in 2017. Since signing the "Kyoto Protocol" in 1997, especially after the 2009 climate summit in Copenhagen, Denmark, China has faced a serious ecological deficit due to considerable greenhouse gas emissions in recent years. As the world's largest developing country, high carbon emissions is an indisputable fact for China. The Chinese government established the National Climate Change Coordination Group in 1990 and the National Coordination Committee on Climate Change in 1998. The new National Climate Change Coordination Committee was formally established in October 2003, and the State Forestry Administration established the Carbon Sequestration Management Office by the end of 2003. Sponsored by the State Forestry Carbon Sequestration Management Office, the Environmental Policy and Management Center of Tsinghua University and the USA Nature Conservancy launched "Chinese net carbon sequestration" in December 2005. At the same time, the Forestry Administration State, World Wildlife Fund, Chinese Agricultural Policy Center, Chinese Forestry Academy, and other units have held numerous seminars and training courses since 2003 for the emergence of developing forest carbon sequestration projects in China to promote the development of China's forest carbon sequestration trading market [26].

In view of the important role and cost advantage of forest carbon sequestration in climate change, China regards forest carbon sequestration as an important choice to mitigate climate change, and put forward the corresponding action plan and development target. At the United Nations Climate Change Summit on 22 September 2009, China promised that forest carbon sinks and forest areas would be increased by 40 million hectares and forest reserves by 1.3 billion cubic meters by 2020 from the 2005 levels. The implementation of these goals and programs will further improve China's forest carbon sink capacity.

The results of the Eighth National Forest Inventory (NFI) showed that China's forest areas covered only 21.63 percent of the country's land as of the end of 2013, far below the global average of 31 percent, and the average amount of forest stock volume was less than 1/7 of the world's; in addition, less carbon absorption is also an indisputable fact [27]. At present, a number of carbon emission rights trading exchanges have been set up in China but these are still in an early stage; the biggest problem is confusion surrounding carbon trading standards and authorities. The realization of forest carbon income through market transactions also requires a long process of development; therefore, policy tools are particularly important.

At present, China has not introduced mandatory emission reduction regulations or standards or market transactions means to increase forest carbon sinks. If the market has not been established, the policy tools become the main means to deal with the "market failure" and promote forest carbon economy development.

2.3. The Economic Properties of Forest Carbon Sequestration

2.3.1. Dual Attributes of Forest Carbon Sequestration Properties

The forest carbon sequestration property has dual attributes: competitive and exclusive. The reliance of forest carbon sequestration on forest resources is limited both spatially and temporally. The competitive and exclusive nature of the forest carbon sink property reflects the exclusion that one party obtain the limited resources after another party possesses them. Both parties pay the corresponding costs in order to obtain the forest carbon property, and the higher the demand for forest carbon property rights, the stronger the competition and the higher the costs of the exclusive property.

However, different from private goods that only pursue the private utility maximization, the consumer utility of the forest carbon sink property also has public properties that can improve the quality of the social environment and the social satisfaction [28,29]. As the object of the forest carbon property, forest carbon resources are public goods, and forest carbon sequestration produced from forest resources are state and collectively owned by the country government in China; thus, it is difficult to distinguish the property value based on the property value difference between the public and private from the view of worth value. The dual attributes of the forest carbon sequestration property make it complicated to define the property value due to the unclear definition of property.

2.3.2. Diversity of Forest Carbon Sink Property Value

From the view of ecological capital value, the ecological environmental system, as one of the wealth creation elements, not only provides humanity with a variety of products directly but also offers a variety of beneficial features such as provisioning, regulating, and cultural functions, which reflect the intrinsic value of ecosystems.

Forest ecosystems have been identified as the largest land carbon sink and account for more than half of the carbon stored in the terrestrial ecosystem. The forest carbon sink converts the value of forest carbon capital to economic activities of value elements, which can transfer the value to forest carbon capital goods, realizing the currency of the forest carbon exchange value through market transactions. Any form of value can reflect the value of the forest carbon property, and the market value of forest carbon capital is the fairest value in the modern theory of the market category.

2.3.3. High Risk of Forest Carbon Sink Property Rights

Forest carbon property rights are the exclusive property system for forest carbon sink effect setting within certain spatial and temporal limits. Firstly, due to vulnerability to natural disasters or man-made destruction, forest ecosystems often lose the forest carbon sink effect, which may even be converted into a carbon source, so the forest carbon sink property would lose its value. Secondly, the forest carbon sink effect exhibits an initial increase and then falls with the growth cycle of the trees, so the value of the forest carbon property rights would be volatile according to the prices of the forest carbon property market. Finally, the forest carbon sink effect is complicated with a high degree of uncertainty; when opaque information exists among relevant stakeholders of forest carbon property rights, then the moral hazard of property transactions would be relatively high, even for the modern production methods related to inherent carbon locking techniques—it is difficult to invest in the forest carbon sink production system when facing the risk of the forest carbon property, which is different from ordinary property rights. Currently, there is no suitable legal system or provisions to protect the legitimacy of forest carbon property rights in China, as well as law related to the regulation of the forest carbon sequestration property.

3. Material and Methods

3.1. Model Construction

As a powerful tool for policy analysis, the Computable General Equilibrium (CGE) model has been widely used for more than 30 years and has gradually become a standard empirical economic analysis tool [30]. With the rapid development of computer science, a general equilibrium model that describes the economic system can be built, combined with the production function, utility function and other specific characteristics of a real economic system, such as the system structure, production technology, and consumer behavior. The model has the following two main characteristics: First, the quantity and relative price are endogenously generated by the model. At the same time, the quantity and price change result can be obtained when the model is run. Second, the model focuses more on the optimal allocation of resources. It is the impact of external shocks or policy interventions on the impact of the economy rather than the exact results. Many scholars have begun to use the model to simulate the carbon taxation scenario and analyze the impact of macroeconomic indicators such as carbon tax, investment, import and export and national income.

The CGE model describes the relationship among supply, demand, and market through a system of equations with the following three advantages over other economic models: (1) Derived from Walras' general equilibrium theory, the CGE model has a stronger economic theoretical foundation than the econometric model and more emphasis on the importance of price; (2) the CGE model overcomes the neglect of relative price in an input-output model and the strong assumption in a linear programming model, then the production process of various economic entities can be used with a non-linear function; (3) the CGE model describes the equilibrium process of multiple markets by maximizing the profit of the producer and has the characteristics of taking all the participants and markets into consideration.

The economic agents of the model include residents, enterprises, governments and foreign sectors. The model in this study includes four modules of production and trade module, the body module, price module and closing module. In the model, the endogenous variables are denoted by uppercase letters, and the parameters are denoted by lower case letters.

$$PA_a \times QA_a = (1 + tu_a) \times (PVA_a \times QVA_a + PNTA_a \times QNTA_a), a \in A \quad (1)$$

PA_a and QA_a represent the price and the production of commodity a respectively; PVA_a and QVA_a represent the added value price and the added value amount of commodity a; $PNTA_a$ and $QNTA_a$ represent the price and the amount of the intermediate inputs of commodity a; tu_a represent the carbon tax rate in this model. Equation (1) shows the mechanism by which output prices are produced in production, the value of output price for the commodity a is equal to the sum of the added value and the value of the intermediate input, that is, the income of the commodity a is used to pay for the added value reward and the intermediate input.

$$PVA_a \times QVA_a = WL \times (1 + tvl) \times QL_a + WK \times (1 + tvk + butie) \times QK_a \quad (2)$$

WL and WK represent the price of labor and capital respectively; tvl and tvk represent the added tax rate of labor value and capital appreciation tax rate; QL_a and QK_a represent the labor demand and capital demand of producing the commodity a; $butie$ represent the carbon sink subsidies in this model. The value added a represents the sum of the added value of labor and the value of capital, that is, all the added value used to pay for labor and capital.

A set of equations is usually used in the CGE model to describe the relationship between the demand and supply of the product market and factor market, including variables like products and production, as well as their prices. Under certain restrictions, a comparison is conducted on the changes in economic variables before and after the impact of various simulations according to profit maximization of producers and utility maximization of consumer principles. The System of National Accounts 1993 describes SAM in its broadest form, namely, as a means of presenting national accounting data in the form of a matrix. In this study, the goods market can be divided into forestry, animal husbandry, fishery and other industries; factor markets include two production factors of labor and capital. The model includes four modules of production and the trade module, the body module, price module and closing module.

3.1.1. Production and Trade Module

Under the constraints of technical conditions, use the principle of minimizing costs and maximize profits to produce products. Production input decisions are based on the principle of cost minimization, which determines the Constant Elasticity of Substitution (CES) function of the composite products, then the intermediate inputs of the Leontief function between import and domestic production can be obtained. The Constant Elasticity of Transformation (CET) function is usually used in output decisions based on the principle of profit maximization to determine the ratio between the exports and domestic consumption in output.

The production activities that are produced by the production department include decision-making and output decisions. The model assumes that all firms are characterized by constant returns to scale, using a nested Leontief function and a CES function to describe the production function.

For international trade, the model assumes that China is the recipient of international trade price, and exports have unlimited flexibility when a commodity is not exported, all for domestic consumption. At the same time, the import prices are exogenous to the model, and the equilibrium is determined by domestic demand and international trade.

3.1.2. Body Module

Model basic economic units include residents, enterprises and government. The residents pursue effectiveness maximization with the income constraint, i.e., the rational allocation.

For residents, the model assumes that they are the recipients of the price and maximize the utility of the behavior in their own income constraints. The utility of the residents is described by the Stone-Geary utility function, which allows incomplete substitution among commodities, and derives the resident demand function represented by the LES expenditure function. In the first layer, the composite commodity is described by domestic production and importation of the CES function. In the second layer, the composite consumption is represented by the domestic production and imports of the CES function.

For the enterprises, the model assumes that they provide capital elements and obtain the capital reward, adding the government's transfer payments together constitutes the enterprise pre-tax income. The income of the enterprise minus the income tax is equal to the enterprise's savings.

For the government, the model assumes that it satisfies the cost minimization constraint and takes the government purchase as an exogenous variable. The government has four economic behaviors: tax, savings, consumption and transfer payments. Government revenues are derived from value-added tax (VAT) and customs duties, which are used for commodity consumption, government savings, and transfers to other economic entities. In the CGE model for the forest carbon sink, government savings are the difference between income and expenditure.

3.1.3. Price Module

As a bridge connecting the other modules, the price module assumes constant returns to scale and monetary neutrality, which means demand and supply behavior depends on relative prices. The endogenous price variables connect the exogenous price and the non-price variable. For the export price:

$$PE_a = pwe_a \times (1 + twe_a) \times EXR, a \in A \tag{3}$$

PE_a represents the export price of the commodity a through the local currency calculation; pwe_a represents FOB price of goods in foreign currency; twe_a and EXR represent the export tax rate and exchange rate respectively. The formula shows that export prices are influenced by international market prices and exchange rates. Because no export tax on forest products is set in this model, so we can know $twe_a = 0$, $PE_a = pwe_a \times EXR, a \in A$. Export prices and the domestic consumer market prices can be derived when pwe_a and EXR are determined. For the import price:

$$PM_a = pwm_a \times (1 + twm_a) \times EXR, a \in A \tag{4}$$

PM_a represents the import price calculated in the local currency of the commodity a; pwm_a represents the CIF value of goods in foreign currency; twm_a and EXR represent import tariff and exchange rate respectively. Equation (4) shows the mechanism of price action on imported goods, and there is a corresponding Equation (4) for each imported commodity. Equation (4) shows that import prices are influenced by international markets and related exchange rates. Equations (4) and (3) are similar, and both the export tax rate and the import tax rate increase the price of the commodity. For the commodity sales price:

$$PA_a \times QA_a = PG_a \times QG_a + PE_a \times QE_a, a \in A \tag{5}$$

PG_a and QG_a represent the price and the number of domestic consumer commodity a respectively; QE_a represents the number of the export commodity a. Equation (5) shows the sales price relationship, indicating that the sales price value is equal to the sum of the domestic sales value and the export value of the commodity a. Equation (5) shows that the production price is the weighted average price of the domestic sales price and the export price. For the commodity consumption price:

$$PC_a \times QC_a = PD_a \times QD_a + PM_a \times QM_a, a \in A \quad (6)$$

PC_a and QC_a represent the consumption price and consumption number of the commodity a; PD_a and QD_a represent the domestic production price and the domestic production of commodity a; QM_a represent the quantity of imported commodity a. For the intermediate input prices:

$$PNTA_a = \sum\nolimits_{b \in B} \text{int}_{ba} \times PC_c,\ a \in A,\ c \in C \quad (7)$$

In the equation (7), int_{ba} represents the intermediate input coefficient which denotes the quantity of commodity c required to be used in the intermediate input for producing a unit commodity a. Equation (7) indicates that the price of the intermediate input is weighted by the compound price and the intermediate input coefficient.

3.1.4. Closure Module

The model satisfies the equilibrium of the commodity market, factor market, capital market, government budget balance, international revenue and expenditure balance. The capital price was chosen as the price benchmark combined with the Keynes theory. The total investment was determined endogenously by all components of savings, the foreign account was balanced by exchange rates, labor, and capital elements supply, which can flow freely among the various sectors.

For commodity market equilibrium, the total supply in the domestic market is equal to the total domestic demand for different sectors of different products, including the intermediate input demand, resident consumption demand, investment and the government consumption. Investment and government consumption are determined by exogenous variables.

For the factor market, the supply of labor factor is changed according to the change of factor demand. Labor factor demand and labor factor supply are endogenous in the model and are in equilibrium under the labor factor price. The labor factor can flow freely among different departments.

For the capital market, assume that the supply of factors changes with the change of factor demand. Capital factor demand and capital factor supply are decided by the model endogenously, and the equilibrium of capital factor price can be realized. The capital element can flow freely among different departments.

For the government budget balance, the government budgetary equilibrium requires total government revenue equal to total expenditure. The model assumes that government taxes are given by exogenous parameters. The government balances government budgets with fiscal surpluses or fiscal deficits. Total savings equals total investment.

For the international revenue and expenditure balance, the current foreign exchange income of the project is equal to the expenditure of the current account plus the capital account and foreign exchange reserves, that is, the foreign exchange deficit is balanced by the net savings of the foreign sector.

3.2. SAM Table Preparation, Data Source and Parameter Correction

The Social Accounting Matrix was developed in this study, as is shown in Table 2. The data were mainly derived from the 2014 China Input-Output Extension Table, the 2014 China Finance Yearbook 2014 China Tax Yearbook, and the forestry sector data from the 2014 China Forestry Statistical Yearbook. Due to the different data sources, the original social accounting matrix was not balanced, so cross-entropy (CE) was used for the self-compiled social accounting matrix for leveling [31].

Table 2. Macro social accounting matrix of China (10^8 dollar).

	Forestry	Agricultural	Other	Forest Products	Agri-Products	Other	Labor	Capital	Resident	Enterprise	Government	Saving-Investment	Foreign
Forestry				269									0.4
Agricultural					7076								95.8
other						96,691							13,736
Forest Products	17.5	3.6	343						6		18.2	−0.14	
Agricultural Products	12.0	962.8	4223						1608.4		474.5	295.5	
other	55.3	1880.4	71,573						12,533.5		4585	15,897	
Labor	175.3	3758.3	11,992										
Capital	9.1	197.6	16,795										
Resident							15,926	1292			785.7		
Enterprise								15,467					
Government	33	762.6	5593		31	148.8			460.8	3744.3			
Saving-Investment								8106.6	9893	4004.8		−3288.9	18,715.6
Foreign				95	237.5	10,260							

In the CGE model, the subsidy is mostly realized through tax reduction. Taxation and subsidy belong to the fiscal policy of the government department, in which the tax is the government revenue and the subsidy is the government expenditure. The government's revenue will be regarded as a subsidy for the department; therefore, the subsidy of this study is also achieved through tax rate changes to carry out the simulation.

The following were taken into account: Data mainly from the "2014 China input-output extension table" and the actual situation in 2014 as the baseline scenario; Simulations of different carbon price levels of carbon subsidies and the carbon tax and the two aspects that impact the forestry economy, including the impact on forestry output, forest product prices and other aspects.

According to the preliminary estimation, the annual carbon emission from forestry in China is 221,382,100 t, the forest carbon sequestration is 334,117,700 t, and the annual carbon sequestration is 112,735,600 t [30]. Guo estimated that the annual average carbon sequestration in 2004–2008 was 114.9 TgC/a (1 Tg = 1012 g = 102 t) [31]. The specific formula is as follows:

$$\text{Annual carbon emissions} = \frac{\text{Total carbon stock}}{\text{Total volume of forest stock}} \times \text{Total annual harvest} \tag{8}$$

$$\begin{aligned}\text{Annual carbon sequestration} = \tfrac{\text{Total carbon stock}}{\text{Total volume of forest stock}} \times \\ (\text{Annual net increase in volume} + \text{Total annual growth})\end{aligned} \tag{9}$$

As is shown in the Table 3, the change in forestry output in different carbon prices is based on the following factors: international carbon market price in 2014 and changes of the price level that may occur in the optimal rotation of the forest.

Table 3. The change of forestry output under different carbon prices (%).

Output Index	Carbon Price		
	5.8 Dollar/t	**43.4 Dollar/t**	**57.9 Dollar/t**
Forest product price changes	+6.2	−31.3	−43.3
Forest product price output changes	+0.00627	−0.00552	−10.8527
Value addition of forestry	+0.5347	−1.842	−25.0729
Import change	−1.06	−0.46	+12.347
Export change	−54.57	−15.91	−18.91

4. Results and Discussion

4.1. Impact on Forestry Output

When the carbon price is 5.8 dollar/t, the implementation of carbon sequestration subsidies and carbon tax policy increased the current forestry output by 0.00627%; the forest products price increased by 6.2%, and the added value of the forestry sector investment increased by 0.5347%. The main reason is that the output of the forestry sector subsidies for carbon sequestration increased output, and carbon taxes reduced output. However, the subsidies still played a major role, resulting in a smaller increase in production that was not offset by the carbon tax on forest product prices, leading to forest product price increases. The increase in the price of forest products increases the price of forest products in intermediate inputs, and the substitution effect between intermediate input and added value increases the input value of the added value.

When the carbon price is 43.4 dollar/t, the implementation of carbon subsidy and carbon tax reduced the current forestry output by 0.00552%; the forest product price and the forestry sector input value decreased by 31.3% and 1.842%, respectively, mainly due to the cost of subsidies that reduced the final product prices and carbon prices so that subsidies offset the role of carbon tax, resulting in lower prices of final products and the output also declined slightly. In terms of import and export of final forestry products, the decrease in forest product prices resulted in a decrease of 0.46% in imports, while a decrease in output suppressed forest exports, resulting in a 15.91% decrease in exports.

The impact of carbon tax on the forestry sector mainly showed inhibition when the carbon price reached 57.9 dollar/t. The carbon tax resulted in a significant decline in market demand for the products, and the output effect of the carbon sequestration subsidies did not offset the decline in market prices. As a result, forestry sector output dropped by 10.8527%, and forest products prices also decreased by 43.3%. The decrease in the forest product price caused the price decrease of the middle input forest products. The substitution effect caused the decrease of input added value, which resulted in a decrease in the input value of 25.0729%.

When carbon prices are low, the implementation of carbon sequestration subsidies and carbon tax policies will result in higher prices for forest products and higher output; at higher carbon prices, the implementation of carbon sequestration subsidies and carbon tax policies will result in the decline of the forest product prices and output reduction. It can be seen that carbon sequestration and carbon tax policies have an opposite effect on forestry. In addition, the effect varies with carbon price changes, so that carbon subsidies and carbon tax policies at a reasonable price will benefit China's forestry development, otherwise they will have a strong inhibitory effect on forestry.

In terms of forestry value added, it can be seen that at lower prices, the implementation of carbon sequestration subsidies and carbon tax policies did contribute to the forest development. The forestry sector added value would increase by 0.5347% when the carbon price is 5.8 dollar/t. The carbon tax, which increases the forest products prices, levied part of the flow of factors to other industries, resulting in a forestry output increase of 0.00627%, indicating that China's forest product market demand is still inelastic; the increase in forest product prices is greater than the reduction in forest product consumption. At this point, the demand elasticity of the product market is less than the supply elasticity, and more carbon tax has been passed on to consumers. The carbon taxes greatly increase the forest tax costs and reduce the investment rate return of forestry, but the carbon sequestration subsidies offset the impact of the carbon tax and optimize the internal structure of the forestry industry, and there is a more rational allocation of the production factors of forestry, which improve the investment income of forestry.

4.2. Impact on Consumption of Forest Products

Table 4 shows the effects of carbon sequestration subsidies and carbon taxes on forestry output at different carbon price levels.

Table 4. Forestry consumption with different carbon prices (10^8 dollar).

Consumption Index	Carbon Price			
	Base Period Scenario	**5.8 Dollar/t**	**43.4 Dollar/t**	**57.9 Dollar/t**
Forestry Intermediate Investment	24.4	24.2	24.4	24.5
Agricultural Intermediate Investment	5.1	5.1	5.3	5.2
Other Intermediate Investment	478.1	478.3	44.1	43.8
Household Consumption	8.4	8.4	8.1	8.2
Other Intermediate Investment/Total Forestry Consumption	92%	92%	92%	92%

When the forest products are used in the forestry investment, carbon subsidy and carbon tax would reduce the forestry intermediate input under the low carbon price scenario, but with an increase in the carbon price, forestry intermediate inputs would increase, eventually exceeding the base period scenario. This is determined by the relative prices of the intermediate inputs of production inputs and factor endowments. For the forestry products, the ratio of the relative price to the rate of marginal productivity is higher than that of factor endowments and other intermediate inputs at the low carbon price. The "crowding-out effect" reduces the intermediate input of forest products to forestry. When the carbon price rises, the ratio of the relative price to the marginal rate of output declines and forms an alternative to other inputs.

When the forest products are used as inputs for agriculture and other industries, carbon subsidies and carbon taxes increase the input of forest products. However, with an increase in the carbon price, the intermediate input of forest products decreases, which is lower than the base period. When the price of carbon is low, the other two kinds of intermediate inputs lead to the substitution of the middle input of forestry with lower relative prices. When the price of carbon increases, the price advantage will decrease and the other two kinds of intermediate inputs decrease.

Due to carbon sequestration subsidies and the opposite effect of carbon taxes, when the forest products were used for household consumption, the consumption of the residents would decrease first and then increase. At the same time, the price of forest products would rise under a low carbon price because the consumption demand of inhabitants was restrained and the consumption decreased. However, with an increase in the carbon price, the price of forest products would begin to decline.

The implementation of a carbon subsidy and carbon tax has changed the quantity of forest products in consumption, but the structure has not changed much. Intermediate inputs for industry and services (i.e., other industry intermediate inputs) account for 92 percent of total forestry consumption. Therefore, it is necessary to increase the alternative materials usage to optimize the consumption structure of forestry and to inhibit the consumption of forest products in industries and services, encourage consumption and forestry reproduction, including differential pricing.

5. Conclusions and Recommendations

5.1. Conclusions

This study explored how the carbon sequestration and carbon tax subsidies affect the forestry economy by constructing a CGE model. From the simulation results, the following can be seen: (1) The role of subsidies and tax effects outputs is clear at a low carbon price; subsequently, the price of forest products and forestry output will increase. The role of tax completely covers the role of subsidies at a high carbon price; the effect of implementing policies on the forestry economy is negative, and with the increase in the carbon price, the negative effect becomes more obvious. (2) There is a reasonable carbon price range between carbon sequestration and carbon tax subsidies; the implementation of carbon sequestration and carbon tax subsidies will facilitate forestry development in the interim, and in addition to the range, the implementation of carbon sequestration and carbon tax subsidies would hamper forestry development. This differs from the traditional understanding that a higher carbon price is not conducive to forestry.

5.2. Recommendation

The amount of total forest carbon sequestration is large and has grown rapidly in recent years. It is vital to encourage the property investment of forest carbon sequestration and thus reduce the social costs, especially with the establishment of carbon emissions mechanisms. Therefore, determining a reasonable compensation for the value of forest carbon sequestration has become a key issue to incentivize the investment of forest carbon property. The following policy recommendations are proposed based on the above findings and conclusions: (1) Under the background of a current decline in international carbon prices and domestic carbon market, the government should introduce carbon sequestration subsidy policies to encourage carbon afforestation and sequestration enhancement projects and promote the development of forestry; (2) An associated carbon tax policy should be established while implementing carbon sequestration subsidies to provide subsidized funds for enhancement of forest carbon sequestration, and to prevent and reduce deforestation to some extent; (3) Make relative policies to guide companies to ensure forest carbon sequestration to offset carbon emissions and reduce expenditure pressures; (4) A forest carbon tax should be used for tax subsidies for forest carbon sequestration, establishing an appropriate mechanism for supervision and inspection to promote special carbon tax use.

Acknowledgments: The first author acknowledges the support provided by the China Scholarship Council. This study was supported by the National Natural Science Foundation (Grant No. 41271537) and Research Innovation Program for College Graduates of Jiangsu Province (Grant No. KYZZ15_0159). We would like to thank the anonymous reviewers for their constructive comments and suggestions.

Author Contributions: J.L. and F.W. conceived and designed the research; J.L. ran the model; J.L. and F.W. analyzed the data; J.L. wrote the paper.

Conflicts of Interest: The authors declare no conflict of interest.

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