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RETRACTED: Carbon pricing and environmental response: A way forward for China's carbon and energy market

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RETRACTED

Addressing the conflict between fossil fuel exploitation, usage, and greenhouse gas emissions is a top priority for China's low-carbon socioeconomic development. Scalable Axisymmetric Matrix "a computerized general equilibrium model" is used to assess the impact of carbon tax policies on energy usage, carbon pollution, and macroeconomic drivers at reduction levels of 10%, 20%, and 30% of emissions. In the meantime, we examine the impact of various carbon tax recycling schemes in line with the tax neutrality concept. Although the carbon tax successfully reduces carbon emissions, we conclude that it will have a detrimental effect on the economy and social well-being. To cope with China's increasing pollution emissions and ecological imbalances, the Chinese government promulgated the environmental protection tax law of the people's Republic of China, which was officially implemented in 2018. Although carbon dioxide is not included in the Taxable Pollutants and Single Quantity Table attached to this law, China has almost reached a consensus on taxing carbon emissions. In 2021, the State Council of China issued the opinions on completely, accurately, and comprehensively implementing the new development concept and doing a good job in carbon peak and carbon neutralization, which made a comprehensive deployment to achieve the "double carbon" goal and improved the carbon tax policy and legal system, which is an essential part of it. Therefore, based on fiscal neutrality, an effective carbon tax recycling scheme can mitigate the adverse effects of its adoption. However, due to the current development in China's energy-generating and transportation sectors, even minor steps can have huge effects on emissions with marginal economic implications.

KEYWORDS

carbon tax, social welfare, energy efficiency, macroeconomic indicators, computable general equilibrium model

Introduction

Several lawmakers have expressed interest in instituting a carbon tax as a means of reducing carbon emissions and raising income for the government. However, carbon taxes must be designed to ensure their usefulness and public acceptance. Because of wealth and resource inequality, poverty, and other societal ills, policymaking in emerging countries may be more complex than in advanced nations. Using a market-based approach to reduce carbon dioxide emissions and combat global warming, carbon taxes are an effective tool (Cosic et al., 2021; Ali et al., 2019). Both rich and emerging nations are debating enacting carbon taxes, with some countries already doing so. Reducing carbon emissions, speeding up industrial transformation, promoting energy efficiency and sustainable development, and mobilizing industrial enthusiasm for green initiatives are all tax aims in different locations. Carbon taxes can have a positive impact on society at the same time as reducing greenhouse gas emissions (Guo and Xiang, 2022; Ali et al., 2022). Reduced carbon emissions, for instance, may reduce the release of other pollutants, while carbon monies may be utilized to assist low-income people in purchasing energy-efficient household items.

As defined by the United Nations Framework Convention on Climate Change, a carbon tax is levied on the amount of carbon dioxide (CO_2) emitted by processes and technologies at the point where coal, liquid fuels, and natural gas are processed or refined (Milyani and Kirschen, 2018). Because using fossil fuels results in a higher social cost than a lower private and market cost, this strategy aims to solve the core threat of climate change. Emissions of greenhouse gases continue to build up in the environment; therefore, an effective carbon price would gradually rise over time to reflect this fact. To be effective, the policy must consider the country's fiscal, social, and economic circumstances when it is being developed (Ali et al., 2020).

Increasingly, governments and corporations agree that carbon pricing is critical in moving away from carbon-based economies. For authorities, carbon pricing is integral to their climate policy toolbox. Even in a constrained budgetary context, it's crucial to have revenue sources like this to help offset the costs. In addition, corporations use internalized carbon pricing to measure the influence of obligatory carbon prices on their operations and anticipate new carbon pollution and income opportunities. Long-term entrepreneurs can also use carbon pricing to estimate the prospective impact of climate change policies on their investment portfolios, reassess investment plans and reallocate resources towards low-carbon or climate resiliency projects.

Habitat loss, poor air quality, and water contamination are some environmental issues that Asian countries have to deal with. Countries in Asia need to do more to solve these ecological concerns. Recent weather extremes have made the threat of global warming more evident and severe (Bi, 2018). Almost all of Asia's countries have committed to reducing their greenhouse gas emissions per the Paris Agreement, ratified in 2016. Asian countries must take dramatic measures to cut greenhouse gas (GHG) emissions if they meet their obligations (Nagatomi et al., 2010). It is proving to be a challenging undertaking. Economic expansion must not be jeopardized as a result of carbon reduction initiatives. It is true, especially in low- and middle-income nations, where many people strive for a better living standard and economic growth. Authorities must raise more money to execute the guidelines and legislation necessary to stimulate growth. If climate change policy mechanisms are effectively developed, they can eventually accelerate environmental conservation and revenue-raising. We can refer to these policy measures as "revenue-raising green policy tools" because they can both preserve nature and raise money. Carbon pricing, such as emissions trading schemes (ETSs) or a carbon tax, is becoming a prominent policy tool for addressing climate change while generating money. Asia is the region in question. Environmental trading systems (ETS) have been widely adopted by countries such as Japan, South Korea, and China, whereas carbon taxes have been imposed in Singapore and Japan (Klemetsen et al., 2020).

Additionally, carbon pricing can play an essential role in generating additional cash to help fight global warming. According to the International Monetary Fund, a carbon tax of $25 per tonne of carbon dioxide (CO_2) may generate an extra 0.8% of GDP across Asia and the Pacific by 2030 (Shawn Lobo and Professor, 2016). Even at $75 per tonne of CO2, according to the same International Monetary Fund report, the carbon tax income in the same region will be 1.9 percent of GDP in 2030. As a result, environmental policy instruments can provide governments with considerable funds.

It's not uncommon for emerging economies to be terrible at public affairs. According to international global warming accords, each government must report on its efforts to reduce greenhouse gas emissions. Around 1.5 billion metric tonnes of carbon dioxide emissions were saved by China's 11th Five-Year Plan initiatives between 2005 and 2010—the world's most significant national emission decline (Mastny, 2010). But China didn't make a big deal of it at the time. Sustainable, low-carbon growth is what China's economy needs to be on its way to achieving. Emerging nations can't pursue the high-emissions path when combating global warming. Instead, they must focus on improving energy efficiency (März et al., 2020). This is a departure from developed nations' "pollution first, clean up later" approach. The Chinese government is considering imposing an industrial automation carbon tax on companies not participating in the emission trading market to combat climate change. For a carbon tax to be effective, it has to consider not only the existing economy's effect but also how the tax's amount should be changed over time in response to developments outside the system.

An effective carbon tax policy for developing nations is discussed in this research. The installation of a carbon tax in underdeveloped countries is streamlined using a pre-defined structure. The structure should be a foundation for developing countries to implement and create a viable and sustainable carbon price strategy.

Literature review

Regarding fossil energy, the amount of CO_2 emitted determines whether a tax is levied. According to Pearce (1991), carbon taxes not only improve the planet but balance the income from carbon pricing against other company taxes, leading to a rise in employment and investment and a more equitable society. The investigation into a carbon tax continues to this day. Studies have investigated the impact of carbon taxes in countries including Spain, South Africa, China, India, and the United Kingdom, among others, and the results are comparable to those found in the aforementioned studies (Runst and Thonipara, 2020; Antosiewicz et al., 2022).

Consumption taxes are a common feature of the carbon tax. Many studies have been done to determine whether a carbon price is compelling. There are many ways in which the introduction of a carbon tax can encourage companies to invest in fuel efficiency and consequently decrease long-term greenhouse gas emissions (Monforti Ferrario et al., 2021). Carbon taxes in the EU's energy sector were effective (Appiah et al., 2020). According to (Tan and Lin, 2020), carbon taxes positively impact greenhouse gas emissions and efficiency. However, many regions have substituted a carbon tax with an emissions trading system (ETS), even though the efficiency of a carbon tax is almost universally accepted.

Furthermore, the carbon tax's capacity to add value is limited by the protracted processes of climate policy debate and legislative change (Stobbe, 2013). Emitters will put off their energy efficiency investments while waiting to see if the carbon price policy will persist because of the unpredictability of the legislation. Moreover, the public's attitude toward carbon taxes is deteriorating, particularly as more people recognize ETS market simulations' potential benefits.

Controversial is how the carbon tax would affect the allocation of the tax. In general, imposing a carbon price may hurt the economy. In many affluent regions, carbon taxes tend to be regressive, but in emerging economies, they can occasionally be progressive (Douenne and Fabre, 2022). Furthermore, a growing number of academics feel that revenue recycling schemes influence income distribution (Alvarez, 2019). Carbon taxes are not necessarily discriminatory; how money is recycled is crucial in determining how the carbon tax expenses are dispersed among the population. Investigation of the distributional impact of carbon taxes is extensive. According to (Shawn Lobo and Professor, 2016), disparities persist even when labor taxes are reduced as part of a carbon tax. (Li et al., 2021) studied the impact of subsidies and a carbon price on families. It is regressive because of the lack of revenue recycling in the carbon pricing (Oliveira et al., 2020).

Researchers have conducted extensive research on China's carbon tax rate equation, and the key findings are as follows. First, some academics recommend a progressive, consistent carbon tax rate (Mayer et al., 2021). They believe the optimal carbon price should rise in tandem with the rate at which GDP grows. A low initial tax rate can be used to mitigate the negative effects of a carbon tax on the economy (Sabine et al., 2020). Third, certain researchers make another argument in favor of a dynamically differentiated carbon tax rate. According to (Burke et al., 2019), the best carbon tax model for China would be one with a modest beginning tax rate that progressively rises over time. For steel, a differentiated carbon tax is preferable to a uniform carbon tax rate since the cost of emission reductions is more negligible. Several academic researchers have examined the fixed carbon tax concept in different circumstances. There are significant differences in hypotheses and techniques, which results in a different ideal carbon tax rate. A consensus is that smaller carbon taxes would not lead to cleaner energy use. In contrast, higher carbon taxes on industries with high energy will lead to more significant environmental gains.

Traditional econometrics and engineering analyses like Data Envelopment Analysis have little power to perform the alternative assessment. Simulating counterintuitive circumstances is made more accessible by using equilibrium assessment models built on game theory. One model, the Computable General Equilibrium (CGE) model, can simulate various social subjects and their interrelationships (for example, the specific topic, employers, purchasers, the authority, and foreigners). CGE model uses input-output tables to get much of its data, which means it may use real-world data to depict a variety of business behaviors. When comparing CT with ETS, it's essential to consider how each has affected the respective industries. As a result, the CGE model is the one we will use to investigate the matter.

Model description and data sources

Since its inception, this CGE model has been frequently applied (Kumar and Hussain, 2014; Guo et al., 2020) to simulate and examine energy and climate policy effects under a general equilibrium perspective (Permatasari, 2019). In this model, which is based on Walras' general equilibrium theory (Misaki, 2021) and has a core economic unit of employers, buyers, governments, and overseas domains, one or more parameter disruptions can be studied about the interactions of other factors and countries. The comprehensive model is depicted in Figure 1.

This module's basic structure is a 5-layer layered. Coal, oil, and gas are defined by Constant Elasticity of Substitution (CES)

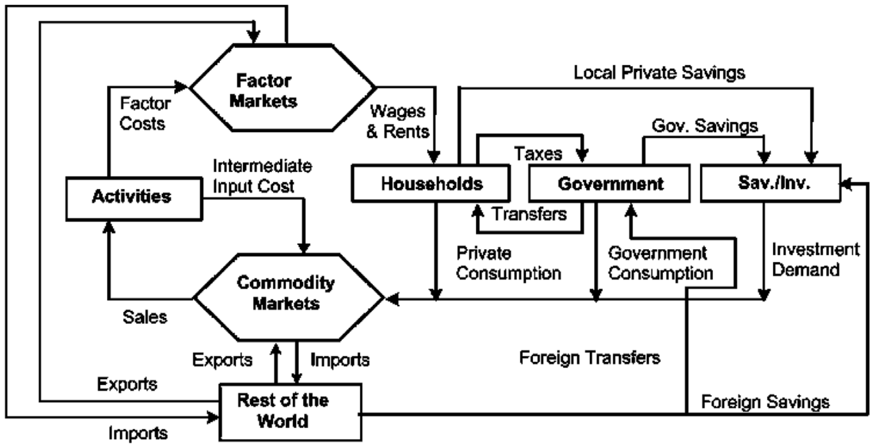

FIGURE 1
Skeleton of proposed CGE model.

functions as a fuel production factor because of the role they play in carbon emissions and their ability to be substituted. The CES feature combines the energy synthesis factor with capital to create the energy capital component, as has been shown in numerous prior studies (Quaas et al., 2020). Then, the energy-capital-labor element, or value-added composite materials, are formed using the CES equation. It enables the use of numerous input factors in place of one. Finally, energy, capital, and labor are employed to generate sectoral outputs using a Leontief component (Tsionas and Andrikopoulos, 2020). Although petroleum products are separated in most studies on the CGE model, the methods used are crude and don't take the differences in intermediate inputs into account. Stone-Geary utility functions are commonly used in the home consumption function, although estimating their coefficients is challenging. At the same time, this is a static examination. As a result, a simple linear function is used to represent home consumption. With the closed rule, we assume that capital and labor costs are endogenous according to the neoclassical closure rule. To put it another way, there is full employment in both the labor and capital markets. Equivalent variability is used to evaluate social welfare. Commodity prices are used to determine the baseline, and the adjustment in household utility levels is used to determine whether or not a policy is effective after it is put into place. During the environmental module, you'll learn about carbon dioxide emissions caused by burning fossil fuels, as well as the concept of carbon taxes. Fuel-related carbon dioxide emissions are subject to the carbon tax.

This CGE model derives its fundamental data from the 2018 social accounting matrix (SAM) table, which is dependent on China's 2018 input-output table and pertinent statistics on customs, government revenue, money transfers, and capital movements (Chang, 2022). The sources for the capital, government, and foreign inputs are the 2018 China Statistical Yearbook 2019, the 2018 China Financial Yearbook, the 2018 China Tax Yearbook, the 2018 Energy Statistical Yearbook of China, and the 2018 China Environmental Statistical Yearbook, and the National Bureau of Statistics (Press, 2019). In addition, the 2017 Flow of Funds Statement includes household savings. The statistics regarding the carbon dioxide emissions of China's three fossil energy sources come from International Energy Statistics.

Principally, the replacement elasticity coefficient, the friction factor, and the carbon dioxide emission coefficient are the model's features that require calibration. In this work, alternate elastic parameters are chosen primarily based on prior research.

Carbon dioxide emissions can be paid attention to details in this model's climate action simulation. As a result, the carbon tax is based on the amount of CO_2 emissions. The ultimate investment and consumption requirements meet only a tiny percentage of the entire demand for fossil energy. The design approach of the carbon tax is:

$$CO2TX_i = tc \cdot \sum_j E_{i,j}.\theta_i \tag{1}$$

$$CO2TX_j = tc \cdot \sum_j E_{i,j}.\theta_i \tag{2}$$

$$TCO2TX = \sum_j CO2TX_i \tag{3}$$

where $CO2TX_i$, $CO2TX_j$, and $TCO2TX$ symbolize the carbon tax imposed on the transforming inputs of fossil energy i, the carbon tax imposed by sector j, and the total carbon tax, respectively; The equation is used to calculate the answer Eq. (4).

$$tc_i = \frac{\mathrm{CO2TX_i}}{\mathrm{pq_i} \cdot \mathrm{qq_i}} \tag{4}$$

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where pq and qq reflect the demand for and price of fossil fuels, respectively. Consequently, the cost of fossil energy consumption will rise to $(1 + tc_i) \cdot \mathrm{pq}_i$. Due to the carbon tax, fossil fuels will be more expensive to use in manufacturing, resulting in higher taxes for the authorities.

The model is built on the assumption of market factor flow and clearance. CGE models can be improved by making these improvements: 1) Energy elements are broken down into subcategories. The CGE model does not decompose energy into its parts. Fuel oil and natural gas components were treated separately from the energy components for analysis. The Cobb–Douglas mechanism is responsible for supplying energy (Henningsen and Henningsen, 2011). Monitoring changes in energy use and modeling the consequences of carbon tax plans are required to divide the energy market. CO_2 and air pollution emissions were added to the output module to evaluate the environmental impact of various tax schemes. Closes in the neoclassical style are employed in this piece. The cleanup of commodity markets has been completed. There is no limit to the number of items that can be exported at a special price and currency rate. The general equilibrium criterion is met when all domestic items are readily available.

$$Q_s = \sum\nolimits_a QINT_{ca} + \sum\nolimits_h QINV_c + Q_{ch} + QG_c, \tag{5}$$

Merchandise supply in China is represented by Q_s, investment demand is represented by INV_c, and consumer demand is represented by Q_{cd}.

$$GDP = \sum\nolimits_a \sum\nolimits_h QH_{c,h} + QINV_c + \sum\nolimits_c QG_c + \sum\nolimits_c (QE_c - QM_c). \tag{6}$$

This research has devised two elements to be tested out to categorize the circumstances. The CO_2 tax policy is the first, and the CO_2 tax cycle is the second. We based our CO_2 tax strategy on a "business as usual" (BaU) assumption. The intermediate energy inputs into manufacturing are subject to a CO_2 tax, while the final consumption segment is exempt from this tax. There are three possible outcomes of the CO_2 tax cycle. First, maintain government revenue neutrality by lowering the resident income tax rate, if possible. Second, assuming normal business circumstances continue, lower the corporate income tax rate to keep government revenues stable—reduce company indirect tax rates to maintain government revenue neutrality in the standard business scenario.

Several scholars have called for carbon pricing. In light of the prevalent assumption that high taxes hamper economic growth, the carbon tax was steadily increased. Scenario 1, scenario 2, and scenario 3 were performed to see how the carbon tax would affect the economy's capacity to absorb CO_2 emissions and how the economy would respond to the tax. Reducing CO_2 and other air pollution emissions is one of the goals of a carbon price. However, carbon taxes also raise the tax burden on enterprises, which hurts business and individual income gains and overall economic growth. It is bad news for enterprises, household income, and the economy as a whole. The completed simulation scenarios are shown in Table 1.

Result and discussion

Carbon dioxide emission reductions lead to a rise in the carbon tax threshold, as seen in Table 2. Carbon taxes on fossil fuels (coal, oil, and natural gas) are steadily rising as the ad valorem carbon tax rate on these fossil fuels steadily rises. Coal's ad valorem tax rate will increase to 41.95 percent when emissions are reduced by 30 percent. Oil and natural gas prices are comparatively low. Varied emission reduction scenarios have different impacts on CO_2 emissions from fossil fuels. We can see that coal is the primary source of the reduction effort. When CO_2 emissions are reduced, the energy consumption reduction ratio increases. The coal reduction ratio is the biggest of the three. However, the drop in electricity is only 1.54 percent, which isn't much.Whereas En_{CO_2} energy usage is the total amount of CO_2 emissions resulting from that intake, E_i denotes the amount of energy used, S_i is coal conversion coefficient for a range of energy sources, and Ef_i indicates the emission rate of CO_2. Different energy sources and their coefficients for carbon emission has presented in Table 3 for more understanding in this regard.

$$En_{CO_2} = \sum_i E_i \times S_i \times Ef_i, \tag{7}$$

China's carbon emissions are decreased by 1.1 percent in the first year of implementation and by 9.8 percent throughout the program's lifetime. Table 4 demonstrates that the reduction in carbon emissions due to coal consumption accounts for most of the decline (8.2 percent). Coal is the most common and carbon-intensive in China, so this is not surprising. As a result, coal-fired power stations are being phased out in favor of low- or no-carbon alternatives like natural gas.

The levy of carbon taxes caused a decrease in both nominal and real GDP, and as mitigation has continued to rise, the decline has continued to grow. Table 5 highlights the macroeconomic effects of carbon pricing. Households see a rise in overall income due to a carbon tax, which increases as emissions are reduced. Savings increase as a result of a decrease in demand from households. As the carbon tax has risen, social benefits have dwindled. Businesses lose money when they impose a carbon price. Their savings have also reduced with the growth in emission reductions, and the decline is much more significant than before. Taxes are the primary source of funding for the federal government. Government revenue and savings have risen dramatically as a result of the increased revenue from the CO_2 tax. Government revenue will rise by 1.71, 3.51, and 5.51 percent if CO_2 is lowered by 10, 20, and 30 percent, respectively. The decrease in CO_2 intensity continues to increase as emission reductions continue to rise.

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TABLE 1 Carbon tax policy under three simulation settings.

Tax rate	CO_2 tax policy		
	Scenario-1	Scenario-2	Scenario-3
5Yuan per ton of carbon emission			
10Yuan per ton of carbon emission			
40Yuan per ton of carbon emission			

TABLE 2 Carbon tax strategy under different energy scenarios.

Energy	Scenario				
	Fossil energy tax rate	Fossil energy reduction contribution	Energy consumption change	Carbon tax yuan per ton	
Coal		96.67%	−10.51%	29.25	10%
(Oil and gas)	0.029	2.22%	−0.98%	—	
Electricity	—	—	−0.47%	—	
Coal	0.20	96.02%	−25.05%	70.53	20%
(Oil and gas)	0.08	3.63%	−3.01%	—	
Electricity	—	—	−0.99%	—	
Coal	0.39	96.00%	−35.34%	130.02	30%
(Oil and gas)	0.10	3.08%	−5.77%	—	
Electricity	—	—	−1.54%	—	

TABLE 3 Different energy sources and their coefficients for carbon emission.

Coefficient	Energy sources							
	Coal	Coke	Crude oil	Gasoline	Kerosene	Diesel oil	Fuel oil	Natural gas
Coal	0.69	1.01	1.29	1.25	1.62	1.49	1.55	1.28
CO2	1.98	2.96	3.02	3.35	3.03	3.33	3.04	2.51

To reap environmental gains, GDP declines, and economic changes lower household incomes. In 2015 and 2020, real GDP growth will be down by 0.1% and 0.6%, respectively. Table 6 indicates how much each GDP component adds to GDP's overall growth. Real GDP has declined over time due to the drop in government spending. There will be a 0.2% decrease in government spending and a 0.8 percent decrease in total investment. 0.4 percent growth in exports and 0.4 percent decline in imports. A nominal factor returns decline can be seen at the bottom of Table 6; real household income and little household income both fall. Household consumption suffers due to the confluence of declining incomes and increased unemployment. The GDP price deflator has declined despite energy prices rising due to the carbon tax (Table 6). The growing cost of energy forced businesses to reduce production. As a result, decreased output equates to decreased profitability, and reduced profitability equates to a diminished return on investment.

It is seen in Table 6 that rising prices and declining output costs have a significant impact on the export price index. It is because about 80 percent of total export revenues come from semiconductors, which are in high demand.

TABLE 4 Effects of the carbon tax on energy efficiency.

Carbon emission	Energy sources									
	Coal	Coke	Crude oil	Gasoline	Kerosene	Diesel oil	Fuel oil	Natural gas	CO_2 (aggregate)	
5Yuan per ton	5.50	−0.07	−0.10	−0.20	−0.19	−0.15	−0.19	−0.15	4.45	Energy efficiency
10Yuan per ton	8.02	−0.18	−0.22	−0.30	−0.39	−0.33	−0.29	−0.036	6.28	
40Yuan per ton	9.23	−0.31	−0.41	−0.40	−0.49	−0.61	−0.40	−0.49	6.12	
5Yuan per ton	−0.91	−0.69	−0.71	−0.30	−0.60	−0.29	−0.99	−0.41	−4.90	Energy mix and efficiency
10Yuan per ton	−2.95	−2.10	−2.19	−0.79	−1.55	−0.99	−2.56	−1.61	−14.74	
40Yuan per ton	−6.01	−4.10	−4.23	−1.59	−3.01	−2.12	−5.46	−2.51	−29.03	

TABLE 5 Macroeconomic variables statistics.

Scenarios (%)	Social welfare	GDP (real)	GDP (nominal)	Domestic			Business		Fiscal		Intensity
				Income	Demand	Saving	Income	Saving	Income	Saving	CO_2
10	−789	−0.10%	−0.08%	0.05%	−0.29%	0.05%	−0.19%	−0.19%	1.71%	171%	−10.01%
20	−1749	−0.31%	−0.23%	0.08%	−0.61%	0.07%	−0.49%	−0.39%	3.51%	3.51%	−20.15%
30	−3,005	−0.49%	−0.29%	0.10%	−0.89%	0.09%	−0.68%	−0.69%	5.51%	5.51%	31.17%

TABLE 6 Macroeconomic effects of the different carbon tax.

Carbon emission	Factor under observation						
	GDP	Export	Import	Labor	Stocks	Govt. Spending	
5Yuan per ton	−0.31	−0.63	−0.38	−0.04	0.30	−0.41	Energy efficiency
10Yuan per ton	−0.49	−1.41	−0.51	−0.05	0.32	−0.68	
40Yuan per ton	−0.50	−0.60	−0.59	−0.08	−0.34	−0.89	
Base worth (billion-RMB)	85,426	168,540	15,540	45,201	2,662	46,589	
5Yuan per ton	−0.15	−0.39	−0.15	−0.08	−0.05	−0.28	Energy mix and efficiency
10Yuan per ton	−0.39	−1.10	−0.39	−0.21	−0.09	−0.69	
40Yuan per ton	−1.11	−2.22	−1.13	−0.56	−0.29	−1.89	

Table 7 depicts the shifts in major economic entities under various simulation scenarios. Households' labor income is constant in each of the four scenarios, whereas the income of capital drops. Under the baseline scenario and the three simulated scenarios, household capital income decreased by 0.39, 0.48, 0.39, and 0.31 percent. Thus, as shown in Table 4, residents' total income drops under all four scenarios, and the decline in the simulated scenario is more prominent than in the baseline scenario. Consumer demand increased by 1.01 percent in Scenario 1, but it decreased in the other situations. In scenario 1, households' savings declined by 0.07 percent. The reduction was 0.05 percent in scenario 2 and 0.04 percent in scenario 3. The carbon tax reduced residents' social well-being to 1805.0 in the baseline scenario. Compared to the baseline scenario, households'

TABLE 7 Macroeconomic variables of different bodies.

Scenarios	Domestic						Business		Fiscal	
	Social welfare	Labor output (%)	Capital output	Income (total)	Demand	Saving	Income (total)	Saving	Income (total)	Demand
Scenario-1	3,310.13	0.00	−0.48%	−0.10%	1.01%	−0.07%	−0.41%	2.51%	0.00%	−0.19%
Scenario-2	−2,189.5	0.00	−0.39%	−0.09%	−0.72%	−0.05%	−0.48%	2.51%	0.00%	−0.31%
Scenario-3	−340.01	0.00	−0.31%	−0.08%	−0.10%	−0.04%	−0.24%	-0.26%	0.00%	0.39%
BaU	−1805.0	0.00	−0.39%	0.09%	−0.60%	0.09%	−0.39%	−0.45%	3.53%	3.15%

TABLE 8 Carbon emission and economic statistics.

Scenario	Heads				
	Δ GDP (real)	Δ GDP (nominal)	Δ Investment (total)	Δ CO_2 (Intensity)	CO_2 tax (Yuan per ton)
Scenario-1	−0.29%	−0.24%	−0.44%	−20.21%	70.25
Scenario-2	−0.27%	−0.20%	1.11%	−20.02%	72.12
Scenario-3	−0.25%	−0.88%	−0.26%	−21.23%	75.57
BaU	−0.30%	−0.25%	−0.22%	−20.05	70.03

social welfare increased to 3,310.13 and 340.01 in scenarios 1 and 3 when a carbon tax was implemented, and resident income tax was reduced.

As seen in Table 7 for the enterprise, income declined in all four possible outcomes. A 0.39 percent decrease occurs in the baseline scenario, whereas 0.41 percent decreases occur in situations 2 and 3. A 0.48 percent decrease occurs in scenario 3. Under scenario 2, companies' profits have decreased when a carbon price is implemented but corporate income tax is reduced, and savings have increased because of the lower corporate income tax rate. Specifically, corporate savings have grown by 2.51 percent. Corporate savings have decreased in other instances. Under these three simulations, the government's total revenue remains the same. There is a 19 percent decrease in demand from the federal government under scenario 1, whereas a 31% decrease is shown under scenario 2. Government demand, on the other hand, grows by 0.39 percent in scenario 3. A lower corporate tax rate in Scenario 2 leads to more corporate savings but lower spending and income for residents due to this decrease. Local welfare benefits have decreased considerably more compared to the baseline scenario. Option 3 lowers indirect tax rates for businesses while simultaneously increasing government spending on services and goods. As a result, residents' social well-being has improved compared to the baseline scenario, which just imposes a carbon price.

Data on GDP changes can be found in Table 8. Each of the four scenarios decreased both the nominal and real GDP. Scenario 3's nominal GDP declines by 0.88 percent compared to the baseline scenario, whereas the declines in scenarios 1 and 2 are each 0.24 percent. Compared to the BaU, Scenario 1 sees a bigger drop in real GDP of 0.30 percent. 1.11 percent more money is invested in scenario 2 compared to scenario 1. There is a 0.44 percent and a 0.26 percent reduction in scenarios 1 and 3.

The Carbon Emissions Influence as indicated in Table 8, the baseline scenario's carbon dioxide emission intensity has decreased by 19.84 percent when cutting emissions by 20 percent. It's possible to accomplish carbon emission reductions in scenarios 1, 2, and 3 nearly identical to the BaU's 19.8 to 19.86 percent reductions in carbon emissions. There has been little change in the carbon tax compared to the BaU. Carbon tax prices in the four scenarios range from 71.35 yuan/ton to 76.97 yuan/ton.

Discussion

The investigation explores the influence that carbon tax strategies have on energy utilization, CO_2, and sectoral economic and macroeconomic variables under different scenarios for reducing CO_2. With an ad valorem tariff, the tax rate on fossil fuels gradually increases as emissions decrease. Regarding these three, coal has a higher tax rate than oil or natural gas (Welfens and Kauffmann, 2005; Ali et al., 2020). Because of the high carbon emission coefficient of coal and the fact that coal dominates China's energy consumption structure, coal is responsible for most of the reduction in emissions. It's no secret that CO_2 emissions have been steadily decreasing over time, leading to an overall fall in energy use, with coal taking the biggest hit, followed by electricity. Coal is the primary source of carbon dioxide emissions in China's fossil fuel use, and the empirical results of this work also support this conclusion (Schiermeier, 2015). It would significantly impact coal more than any other energy source if carbon taxes were imposed. Because of this, the coal demand will decrease due to lower manufacturing costs. Electricity is a significant user of fossil fuels as a secondary energy source. However, because it is funded by the collection of carbon taxes rather than by the emission of CO_2, it has a minimal impact on electricity usage. Carbon taxes have had a considerable effect on the demand for coal, as seen by the decline in demand that has occurred as emissions reductions have progressed. Non-power sector use of oil and gas has fallen during the past few years. Oil and natural gas consumption has risen due to a combination of causes, including the substitution of input factors between sectors and the growth in the prices of other input factors for the power sector. A carbon tax charge has decreased emissions from many sectors, while total CO_2 emission reductions have continued to rise. Coal-intensive industries, such as power plants, have the most significant impact on reducing CO_2 emissions.

Taxes on carbon emissions raise the demand of citizens, which in turn increases their social well-being. The "double dividend" that comes from carbon taxes has been realized by reducing greenhouse gas emissions. First, the corporate income tax rate is reduced as carbon fees are imposed. As a result of the carbon tax, businesses' capital prices and total income continue to decline. On the other hand, corporate savings have grown dramatically due to lower corporate tax rates. As citizens' capital income declines, they experience a fall in their wealth and social well-being, which prevents them from reaping the benefits of the carbon tax's "double dividend." The indirect tax rate for corporations is reduced as carbon fees are imposed. Tax burdens influence consumer demand and price changes for domestically produced goods since indirect taxes only apply to the distribution of domestically produced goods. Because of this, corporate revenue and savings will diminish, as well as citizens' capital earnings decline. Because of this, the demand for goods and services by inhabitants has increased. At the same time, citizens' socioeconomic welfare has improved due to the carbon tax.

It is therefore critical to conduct an in-depth analysis of the green economy's growth drivers. For this study, changes in public spending are an essential indicator. We can predict what will happen to the entire economy by running a simulation. Results showed that efficiency gains of 4% had been made in non-energy sectors and electricity generating. Carbon emissions per tonne of CO_2 will be reduced by 5 Yuan due to improved efficiency. It is possible to reduce greenhouse gas emissions by as much as 95% in the case of fossil fuels, including coal and natural gas. While natural gas emissions grow in the latter case of a carbon tax, they reduce in the former. It is projected that real GDP will continue to rise in the future. The decline in exports and the rise in imports have resulted in slower growth in real GDP. Investment goods output and consumption will increase due to this enhanced profitability. ' Lower real GDP growth can be attributed to lower exports and a rise in imports.

The electricity industry is predicted to grow the greatest, with oil-fired power generating increasing output and renewable power generation increasing output. Therefore, it is possible to improve the lives of families via efficiency techniques. They benefit from higher primary factor returns, in other words. The last policy simulation looks at a different combination of power generation policies after efficiency gains in the prior scenario. During the following 3 years, coal will be phased out and replaced by renewable energy.

Conclusion

To achieve green and sustainable growth, we want to learn how a carbon tax policy that promotes the development of a low-carbon economy may be efficiently executed. Studies have shown that carbon taxes positively impact corporate carbon dioxide emissions, encourage the development of more energy-saving emission reduction technology, and promote the development of more renewable resources. On the other hand, a carbon tax will negatively impact economic growth, citizens' income, and social welfare, according to the study's findings. It is possible to lessen the adverse effects of the carbon tax on the industries that are closely associated by including a proper carbon tax recycling mechanism in the policy formulation process. However, on the other side, installing a carbon tax recycling system based on tax neutrality is beneficial to accomplishing carbon emission reduction goals. On the other hand, it has the potential to raise the standard of living for local citizens, so realizing the carbon tax's second benefit. According to the study results, three taxation scenarios show that energy efficiency will be enhanced and carbon dioxide emissions lowered in the country.

Through the research and analysis of the current situation of China's existing legal system, the establishment of China's Environmental Protection Tax Law has laid the foundation for the construction of a carbon tax. To levy carbon dioxide emissions, China should be good at introducing the good experience of other countries to develop China's environmental tax law, define the positioning of a carbon tax, and establish an implementation scheme that reasonably integrates carbon tax as one of the tax items into the Environmental Protection Tax Law. At the same time, it is necessary to coordinate and balance the adverse effects caused by carbon tax collection and select the construction mode of an integrated carbon tax legal system in combination with the reality of China's development to integrate into the Environmental Protection Tax Law fully.

Compared to tax payments made in installments, taxing without compensation has a marginally more significant impact on carbon dioxide emissions. Taxing energy carriers according to their carbon content can better align energy prices with government efforts to reduce greenhouse gas emissions. For example, carbon taxes with revenue redistribution can help increase social well-being even if the benefits of better environmental quality are not considered.

In the future, we plan to overcome some of the limitations of this study. For example, adding more production inputs (such as labor and capital), markets, and production sectors to the chosen model in future works is possible.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Author Contributions

This research paper contributed by the abovementioned authors in following way: "YW, XZ, and AO contributed to conception and design of the study. AA organized the database. ZR performed the statistical analysis. YW wrote the first draft of the manuscript. ZR, AO, XZ, and AA wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version."

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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