

Retraction

Retracted: New Environmental Protection Taxes in China from the Perspective of Environmental Economics

Discrete Dynamics in Nature and Society

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] Q. Tu and Y. Wang, "New Environmental Protection Taxes in China from the Perspective of Environmental Economics," *Discrete Dynamics in Nature and Society*, vol. 2021, Article ID 8622081, 10 pages, 2021.

Research Article

New Environmental Protection Taxes in China from the Perspective of Environmental Economics

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In recent decades, most countries have implemented environmental protection by formulating relevant environmental regulations to reduce environmental pollution and improve environmental quality. China enacted new Environmental Protection Tax Law in 2018 and abolished the old system of pollution discharge fees. This paper analyzes and predicts the effectiveness of these new environmental tax policies within the framework of a macroeconomic dynamic stochastic general equilibrium (DSGE) model. Bayesian estimation is applied to estimate dynamic parameters based on China's macroeconomic data from 1978 to 2018. We find that the implementation of China's new environmental tax will lead to a significant increase in environmental quality through a reduction in the amount of pollution. However, the study reveals that new environmental taxes may have certain negative influences on economic growth. Consumption, output, wages, and capital could fall by 1.26%, 0.34%, 1.16%, and 1.12%, respectively, which may slow the pace of China's development.

1. Introduction

Over the last few decades, climate change and global warming have become top concerns for environmentalists, and the international community more generally. Human activity is estimated to have caused an approximate shift of 1.0°C in the Earth's temperatures since those recorded in the preindustrial era. If the temperature continues to increase at the current rate, it is likely to rise an additional 1.5°C between 2030 and 2052 [1]. In order to prevent climate anomalies and a rise in sea levels, many countries have proposed carbon reduction schemes. In 2015, the Chinese government proposed a clear and stringent emission reduction target for 2030, to strive for a decrease in carbon dioxide emissions per unit of gross domestic product (GDP) of 60%–65% less than those in 2005. To achieve this target, the government has formulated a series of regulations on environmental protection, including the Environmental Protection Tax Law promulgated in January 2018. This is the

first environmental protection tax in China's history, and its implementation discontinues China's pollution charging system, which has been in place for over 40 years. Most studies conclude that this previous pollution discharge fees system did not effectively reduce pollution emissions due to low charging standards [2–4]. The major differences between the environmental tax law and the pollution discharge system are the supervision intensity and the administrative law-enforcement agency. Environmental taxes are levied by tax authorities in accordance with the environmental law, compared with the system of pollution discharge fees, which are charged by administrative departments. The stronger and more rigid enforcement of the tax authorities has enhanced the regulatory stringency of environmental tax system.

Previous empirical studies on environmental policy can be divided into two main areas: (1) optimal environmental policy development and recommendations and (2) the impact of environmental policies on environmental quality and macroeconomic development.

1.1. Optimal Environmental Policy Development and Recommendations. Angelopoulos et al. [5] first used the DSGE approach to study environmental issues and compared three environmental policies: taxes, pollution permits, and numerical rules for emissions. They found that the most effective way is to levy taxes to subsidy public expenditure. Heutel [6] studied optimal environmental policy under a decentralized real business-cycle (RBC) model containing carbon dioxide emission. Additionally, Fischer and Springborn [7] identified that an intensity target has a greater effect on economic growth than a cap or tax on emissions. Based on the Ramsey growth model, Van der Ploeg and Withagen [8] determined the conditions for the rise and fall of the optimal carbon tax. With environmental factors being introduced into the New Keynesian DSGE model, Annicchiarico and Di Dio [9] concluded that the optimal environmental policy response to shocks is strongly influenced by price adjustments and monetary policy reactions. Chen and Nie [10] established a social optimal welfare model based on oligarchic competition and evaluated the impact of carbon tax on social welfare in the production and consumption links. Xiao et al. [11] established a dynamic stochastic general equilibrium (DSGE) model using a New Keynesian framework, identifying that various environmental policies are countercyclical, and emissions intensity policies are most effective in controlling fluctuation. Comparing various alternatives to reducing greenhouse gas pollution, Metcalf [12] argues that a carbon tax is the most cost-effective way to achieve a specific reduction in greenhouse gas emissions.

1.2. The Impact of Environmental Policies on Environmental Quality and Macroeconomic Development. Studies that fall into the second area draw two main conclusions. First, there is a trade-off between environmental regulations and economic growth; environmental policies undermine economic growth while improving the quality of the environment. Therefore, the recommendation is that policy-makers need to strike a balance between environmental quality and economic output. In one study, Li and Xiong [13] found that the levy of environmental protection tax on pollution reduction is greater than the inhibition of economic development. Wu [14] studied the dynamic effects of environmental protection policies, government pollution control expenditure, and environmental consumption preferences on macroeconomics, using a three-sector DSGE model. He concluded that the imposition of a carbon tax and an increase in environmental consumption preferences can significantly improve environmental quality but has a negative effect on economic growth. Lin and Jia [15] proposed that the Carbon Tax System (CTS) would maximize emission reduction with only a modest effect on GDP and suggested a higher tax rate on energy-related enterprises.

The second perspective in this area of the literature is based on the idea of a “double dividend.” Porter and Van der Linde [16] proposed that environmental regulations would stimulate technological innovation (commonly called the “Porter Hypothesis”). Several empirical findings are

consistent with the idea that incrementally introducing environmental regulations can bring about economic growth while improving the quality of the environment. For instance, Feng [17] constructed a Ramsey-Cass-Koopmans model based on China’s panel data (2007–2012), verifying the Porter Hypothesis; the results demonstrated that there is a multiple equilibrium relationship between economic growth and environmental regulation. Lu et al. [18] found similar evidence that the collection of environmental taxes will lead to an increase in key economic variables, as well as a reduction in carbon emissions.

In comparison to an emissions intensity target or an emissions cap, which directly limits pollutant emissions, environmental taxes reduce pollution through indirect charging. Whether indirect charging will play a role in adequately reducing pollution in China has become a central concern for policy-makers. By studying a pilot project, the Pay for Permit (PFP) policy in China, He and Zhang [19] concluded that the implementation of environmental taxes had a positive effect on pollution control but did not encourage environmental technology innovation in the short term. Comparatively, He et al. [20] established an Autoregressive Distributed Lag error-correction model (ARDL-ECM) and predicted that environmental taxes would not reduce carbon dioxide emissions in China. In another study, Li and Masui [21] established five different environmental tax scenarios to simulate the impact of China’s environmental taxes. The simulation results show that environmental taxes can reduce the emission of most pollutants but may impede economic development. Departing from previous research, this study evaluates the impact of China’s new Environmental Protection Tax Law on environmental quality and economic development under the framework of a DSGE model.

Previously, substantial fruitful studies focused on how to determine the optimal environmental policies and the impacts of environmental regulation on economic growth. However, will the introduction of the new environmental policies reduce pollution emissions? Furthermore, if they do result in an improvement of the environment, will they also present a “double dividend” resulting in economic growth? In the context of the new Environmental Protection Tax Law in China, questions such as these are worthy of research and discussion. DSGE stands out from other equilibrium models because responses of future uncertainties can be simulated through stochastic shocks [11]. As Linde [22] notes, DSGE models are used by many governments for macropolicy research and are considered to be a primary tool for policy decisions in the long term. In the studies of environmental policy, Angelopoulos et al. [5] first introduced pollution into DSGE model. Thereafter, environmental economists began to pay attention to the dynamics of environmental policy. In order to explore how the new Environmental Protection Tax Law will affect China’s future environmental quality and economic development, this paper uses DSGE model to predict the impact of environmental tax on environmental quality index and major economic indicators under the equilibrium conditions of government revenue maximization, consumer utility maximization, and enterprise profit maximization.

The structure of this paper is as follows. Introduction section reviews the empirical literature on environmental policy. In Materials and Methods section, we introduce the structure of the DSGE model and solving process. Results and Discussion section describes the results of model prediction and simulation. Finally, Conclusions section contains the conclusion and discussion.

2. Materials and Methods

2.1. The DSGE Model. To explore the effectiveness of the new Environmental Protection Tax Law and its macroeconomic fluctuations, we used a macroeconometric DSGE model with an environmental department in the context of uncertainty shocks. The structure of the DSGE model that we have used builds on the work of Fischer et al. [6, 7, 18]. Differently from Lu et al. [18], however, we use environmental tax variables to replace the pollution discharge fee variable and assume that there is a stochastic shock on the environmental tax rate. This adjustment makes the model more applicable to the new environmental tax scenario.

The entire DSGE model comprises three agents, that is, households, enterprises, and government, and two systems, that is, the economic system and environmental system. In addition to referring to the macroeconomic literature, we add China's macroeconomic data to assist in calibrating the parameters.

2.2. Households. Suppose there are typical householders with an unlimited life span in a closed economic environment [18]. The householders own the enterprises and

provide the labor, and the householders also draw profits from the enterprises. Representative households maximize their lifetime utility by choosing consumption and labor:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t, G_t). \quad (1)$$

The utility function $U(C, N, G)$ of the representative householder is denoted as

$$U(C_t, N_t, G_t) = \ln C_t - \theta_N \frac{N_t^{1+\vartheta}}{1+\vartheta} + \theta_G \frac{G_t^{1-\zeta}}{1-\zeta}, \quad (2)$$

with budget constrain and capital accumulation function:

$$\begin{aligned} C_t + I_t + B_{t+1} &\leq W_t N_t + R_t K_t + P_t - T_t + (1 + R_t) B_t, \\ K_{t+1} &= I_t + (1 - \delta) K_t, \quad \text{for } t = 0, 1, 2, \dots, \end{aligned} \quad (3)$$

where $U(C_t, N_t, G_t)$ denotes the agent's utility function at time t , C represents the consumption goods, N is the labor, $\beta \in (0, 1)$ is the discount factor, θ_N is the proportion coefficient of the labor supply, and ϑ is the elasticity of the labor supply.

G denotes government expenses, θ_G is the proportion coefficient, and ζ is the elasticity of government expenses. I and K are the investment and the stock of capital, respectively. B is government liability, W is the wage rate, R is the capital interest rate, P is the profit of the enterprise, and T represents the amount of environmental tax.

The Lagrangian formula was constructed to solve the utility maximization problem:

$$\begin{aligned} \mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^t &\left(\ln C_t - \theta_N \frac{N_t^{1+\vartheta}}{1+\vartheta} + \theta_G \frac{G_t^{1-\zeta}}{1-\zeta} \right) \\ &+ \lambda_t (W_t N_t + R_t K_t + P_t - T_t + (1 + R_t) B_t - C_t - (K_{t+1} - (1 - \delta) K_t) + B_{t+1}). \end{aligned} \quad (4)$$

The first-order condition can be determined by taking the derivatives of the Lagrangian function with respect to consumptions, labor supply, capital stocks, and government liability. Then, we let the first-order equations equal 0:

$$\frac{1}{C_t} = E_0 \beta \frac{1}{C_{t+1}} (R_t + (1 - \delta)), \quad (5)$$

$$\frac{W_t}{C_t} = \theta_N N_t^\vartheta, \quad (6)$$

$$\frac{1}{C_t} = E_0 \beta \frac{1}{C_{t+1}} (1 + R_{t+1}). \quad (7)$$

The production technology was modelled by the Cobb-Douglas production function:

$$Y_t = A_t K_t^\alpha N_t^{1-\alpha}. \quad (8)$$

The budget constraint for a typical enterprise is denoted as

$$W_t N_t + R_t K_t = L_{t+1} - (1 - R_{t-1}) L_t, \quad (9)$$

where α is the proportion coefficient of the outputs. L represents the corporate bonds. A denotes the total factor productivity following an exogenous process:

$$\ln A_t = \rho_A \ln A_{t-1} + \varepsilon_{A,t}, \quad \varepsilon_{A,t} \sim i.i.d.N(0, \sigma_A^2). \quad (10)$$

2.3. *Enterprises.* For a typical enterprise, the optimal solution becomes maximizing profit:

$$P_0 = E_0 \sum_{t=0}^{\infty} Y_t + L_{t+1} - (1 - R_{t-1})L_t - W_t N_t - R_t K_t, \quad (11)$$

$$R_t = \alpha \frac{Y_t}{K_t}, \quad (12)$$

$$W_t = (1 - \alpha) \frac{Y_t}{N_t}. \quad (13)$$

Enterprises pollute the environment during the production process. Utility is indirectly affected by government expenditures and environmental taxes on pollutants. We assumed that the emissions are proportional to the production using coefficient $g(\mu_t)$. Pollutant emissions Z are a by-product of the production of the enterprise, subject to the following form [6]:

$$Z_t = g(\mu_t)Y_t, \quad (14)$$

$$g(\mu_t) = 1 - \mu, \quad (15)$$

where $g(\mu_t) = 1 - \mu$, μ is the fraction of emissions abated in time t .

Following the viewpoint of Lu et al. [18], the evolution of environmental quality depends on current-period emissions Z_t , the environmental treatment effects γ , and the natural remediation capabilities φ . H is government pollution abatement, which is used to control the environmental pollution of the enterprise in the production process. Q is the amount of pollutants used to indicate environmental quality. Environmental quality Q is defined as

$$Q_{t+1} = Z_t + \varphi Q_t + \gamma H_t. \quad (16)$$

2.4. *Government.* In this paper, the government regulates and controls environmental quality and macroeconomics by formulating environmental tax policies. The government levies a carbon tax on the emissions of enterprises at tax rate. All tax revenue is used for government pollution abatement. The scope of taxation of the new Environmental Protection Tax Law includes air pollutants, water pollutants, solid waste, and noise pollution. We assumed that the government expenditure and environmental tax all follow an AR (1) stochastic process and that $\varepsilon_{G,t}$ and $\varepsilon_{\tau,t}$ would follow a normal distribution with different volatilities:

$$\ln G_t = \rho_G \ln G_{t-1} + (1 - \rho_G) \ln \nu Y + \varepsilon_{G,t}, \varepsilon_{G,t} \sim i.i.d.N(0, \sigma_G^2), \quad (17)$$

$$\ln T_t = \rho_\tau \ln T_{t-1} + (1 - \rho_\tau) T_0 + \varepsilon_{\tau,t}, \varepsilon_{\tau,t} \sim i.i.d.N(0, \sigma_\tau^2). \quad (18)$$

2.5. *Resource Constraint.* By simplifying the budget constraints of each department, the resource constraint of the economy is denoted as

$$Y_t = C_t + I_t + G_t + H_t. \quad (19)$$

The steady-state values are obtained by solving the equilibrium conditions composed of simultaneous questions (4), (5)–(10), (12)–(14), and (16)–(19).

2.6. *Parameter Calibration and Estimation.* Subsequently, we used both the Bayesian estimation method and a calibration method to determine the parameters of the previously presented model. For static parameters related to the householders, enterprises, and the government department, we referred to relevant previous papers and used China's macroeconomic data for verification. The Bayesian estimation method was applied to dynamic parameters $\rho_A, \rho_G, \rho_\tau, \varepsilon_A, \varepsilon_G, \varepsilon_\tau$ in the AR (1) process. Bayesian analysis is based on the likelihood function and fits the DSGE model to time series rather than equilibrium relationships (e.g., GMM estimation). Additional information can be obtained from the prior distribution and used to estimate parameters. These characteristics make Bayesian method widely used in DSGE model [23].

2.7. *Calibration of Static Parameters.* In addition to referring to the previous literature, we also added China's macroeconomic data to assist in calibrating the parameters. The values of the main state parameters are listed in Table 1.

Based on China's macroeconomic data, we calibrated two state parameters: discount factor and environmental tax rate.

Most of the previous literatures indicate a value between 0.9 and 0.99 for the discount factor β : Fischer and Springborn [7] 0.95, Lintunen and Vilmi [24] 0.995, and Xiao et al. [11] 0.99. Using data from China's consumer price index (collected from the National Bureau of Statistics of China) from 1978 to 2018, we estimated that the average price level during this period has increased by about 4.95%. Thus, we used the discount rate 0.95.

The environmental tax rate was estimated using GDP and the Environmental Pollution Treatment amount from 2000 to 2017 (collected from the National Bureau of Statistics of China). It was determined as 0.013, which is close to that of Lu et al. [18]: 0.01.

2.8. *Bayesian Estimation.* We assumed that three exogenous variables A, T, G follow the AR (1) stochastic process. The prior distributions of coefficients ρ_A, ρ_G and ρ_τ were specified by beta distributions with prior means of $-0.85, 0.95,$ and $0.45,$ respectively, and a standard deviation of 0.05 [14, 27]. The beta distribution was chosen to satisfy the stationary conditions. $\varepsilon_A, \varepsilon_G$ and ε_τ all follow an inverse gamma prior distribution with a prior mean of 0.01 [18]. The gamma distribution ensures the nonnegativity of the residual. The unilateral HP filtering method is used to detrend

TABLE 1: Summary of basic parameter values.

No	Parameter	Description	Value
1	Δ	Depression rate	0.025
2	θ	Utility coefficient of labor supply	0.5
3	ϑ	Elasticity of labor supply	2.0
4	α	C-D parameter of capital	0.33
5	μ	Pollutants discharge coefficient	0.601
6	ϕ	Pollutant decay	0.992
7	γ	Coefficient of emission reduction	0.345
8	ν	Coefficient of government consumption expenditure	0.14
9	β	Discount factor	0.95
10	τ	Environmental tax rate	0.013

1: For the capital depreciation rate, we used 0.025 with reference to previous literature: Heutel [6] 0.025, Annicchiarico and Di Dio [9] 0.025, and Xiao et al. [11], 0.025. 2: The utility coefficient of labor supply refers to Lu et al. [18] 0.5. 3: The elasticity of labor supply refers to Lintunen and Vilmi [24] 2.0, and Pop [25] 2.0. 4: The C-D parameter of capital refers to Fischer and Springborn [7] 0.33, and Yongsung and Sun-Bin [26] 0.36. 5: The pollutants discharge coefficient refers to Lu et al. [18] 0.601, Xu et al. [3] 0.601, and Xiao et al. [11] 0.6. 6: Pollutant decay refers to Heutel [6] 0.9979, Annicchiarico and Di Dio [9] 0.9979, and Lu et al. [18] 0.992. 7: The coefficient of emission reduction refers to Lu et al. [18] 0.345. 8: The coefficient of government consumption expenditure refers to Lu et al. [18] 0.14.

TABLE 2: Bayesian estimation results.

	Prior mean	Post. Mean	90%	HPD interval	dist	pstdev
<i>Parameters</i>						
rhoa	0.85	0.8926	0.8427	0.9401	Beta	0.05
rhog	0.95	0.9739	0.954	0.9927	Beta	0.05
rhot	0.45	0.4291	0.357	0.4985	Beta	0.05
<i>std of shocks</i>						
e_a	0.01	0.006	0.0049	0.0071	invg	Inf
e_t	0.01	0.0328	0.0264	0.0385	invg	Inf
e_g	0.01	0.0648	0.0503	0.0798	invg	Inf

the data, and the seasonal observable variables are adjusted by the X-13-ARIMA method.

Table 2 shows the prior mean, posterior mean, and the 90% confidence interval of the parameters. The Metropolis–Hastings algorithm was used to estimate the posterior distributions of the parameters. Consistent with An and Schorfheide [23], the posterior distributions were evaluated by maximizing their log posterior functions based on prior distribution and the likelihood of China’s real macroeconomic data. Under the Bayesian estimation method, the model performed 20,000 sampling times to obtain a posterior distribution.

Full sample period data from 1978 to 2018 were used in the model estimation. There are three key macroeconomic annual China time series observable variables: the log difference of real output ($\ln Y_t$), the log difference of real capital ($\ln K_t$), and the log difference of consumption ($\ln C_t$). Data was collected from the National Bureau of Statistics of China. The results of the estimation are summarized in Figure 1, where the black lines represent posteriors distributions, and the grey lines represent priors’ distributions. Overall, the results demonstrate that macroeconomic data is informative on the stochastic process. The coefficients of productivity and government expenses are -0.89 and 0.97 , respectively, and appear highly persistent with the posterior mean. This suggests that most forecast errors will be caused by these two variables. The means of the standard error of the exogenous shocks are, relatively, far lower. This implies that the volatility of the forecast error will not be significant.

3. Results and Discussion

3.1. Steady-State Values and Scenario Comparison. This section aims to analyze the changes in steady-state values of major economic variables under the mechanism of the new environmental tax policy. In order to facilitate this analysis, we set up two contrasting scenarios: implementing a new environmental tax and no environmental tax implementation. Table 3 shows the steady-state values of major economic variables in the context of both scenarios.

Contrary to the Porter Hypothesis that reasonable environmental regulation could simultaneously increase environmental quality and commercial output [1, 18, 28, 29], we found that an increased level of environmental regulation would significantly increase environmental quality but would negatively impact total output and other major economic variables. This conclusion is consistent with the results of Ederington and Minier [6, 30].

Comparing the two scenarios, the implementation of new environmental policies will result in most economic variables decreasing to new steady-state values. According to our results, when the government levels an environmental tax, the total economic output will fall by 0.34%. Due to the pressure of taxation, enterprises’ costs will increase and, subsequently, be passed on to consumers. Government taxation will lead to a decline in wages (-1.16%) and, thereby, a reduction in consumption (-1.26%). Capital and investment will also drop by 1.12%. In order to maintain a steady income, families will increase their workload, causing labor to increase by 0.05%. In summary, from the perspective of economic growth, the implementation of environmental taxes will lead to an increase in corporate costs, a decrease in household income, and a decrease in output and consumption levels. These results indicate that, to a certain extent, environmental taxes will reduce economic growth.

From the aspect of environmental governance, the implementation of environmental taxes has a significantly positive effect on environmental quality. Since the pollution caused by enterprises will require tax payment, their production costs will likely increase. In this scenario, companies

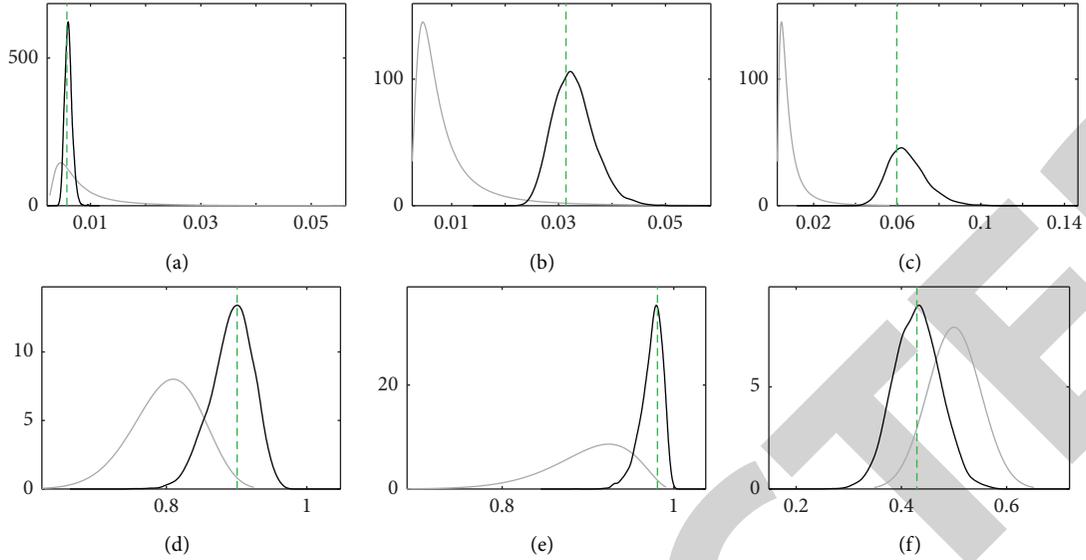


FIGURE 1: Priors and posteriors distributions. (a) SE_e_a. (b) SE_e_t. (c) SE_e_g. (d) rho_a. (e) rho_g. (f) rho_t.

TABLE 3: Steady-state values of major economic variables in different scenarios.

Economic variables	Description	No policy	New environmental tax	Change in percentage
C	Consumption	1.8623	1.8389	-1.26%
R	Interest rate	0.0776	0.0776	0.00%
W	Wage	1.3665	1.3506	-1.16%
N	Labor	1.2114	1.2120	0.05%
A	Total factor productivity	1.0000	1.0000	0.00%
K	Capital	10.5032	10.3860	-1.12%
Y	Output	2.4708	2.4625	-0.34%
Z	Pollutant emissions	1.4850	1.4800	-0.34%
H	Government pollution abatement	—	0.0192	NA
Q	Environmental quality	185.6220	184.1660	-0.78%
G	Government expenses	0.3459	0.3448	-0.34%
T	Environmental tax	—	0.0130	NA
I	Investment	0.2626	0.2596	-1.12%

are reducing emissions while also reducing production. According to our analysis, current pollutant emissions will be reduced by 0.34%. The stock of pollutants will also be reduced by 0.78%, which indicates an improvement in environmental quality. In summary, the new environmental tax law will have a positive impact on improving the environment but will reduce the rate of economic growth.

3.2. Dynamics in the Context of the New Environmental Policy Regime. In this section, we present our analysis of the dynamic properties under the condition of the new environmental tax policy. The steady-state analysis above was based on a deterministic model without consideration of the uncertainty of exogenous variables with exogenous shocks. To analyze this effect, we set three exogenous shocks in the model: a technology shock, an environmental tax rate shock, and a government expense shock. In this model, 1000 periods of the stochastic simulation were carried out, and 50 periods of impulse responses were calculated using the first-order Taylor approximation.

3.2.1. Technology Uncertainty. Under the condition of the new environmental tax policy, we assumed a steady-state level economy at Time 0. We set a positive one-unit technology shock and analyzed the impact of this shock on the main economic variables over the next 50 periods. As shown in the results presented in Figure 2, a technology shock will have a significantly positive effect on all economic variables. That is, scientific and technological progress can promote economic development, which is also consistent with the actual economic situation.

Wage, labor, output, and investment rise abruptly and then generally remain in decline until they reach a new steady state. However, consumption, capital stock, and government expense rise rapidly in the first few periods and then fall consistently, showing a nonstandard, inverted *U*-shape. The impact of the shock peaks around the tenth period. This reflects a delay in the response of these three variables to a technology shock.

It is worth noting that, in this model, a technology shock also increases the production of pollutants. This is because advances in technology will have enabled companies to

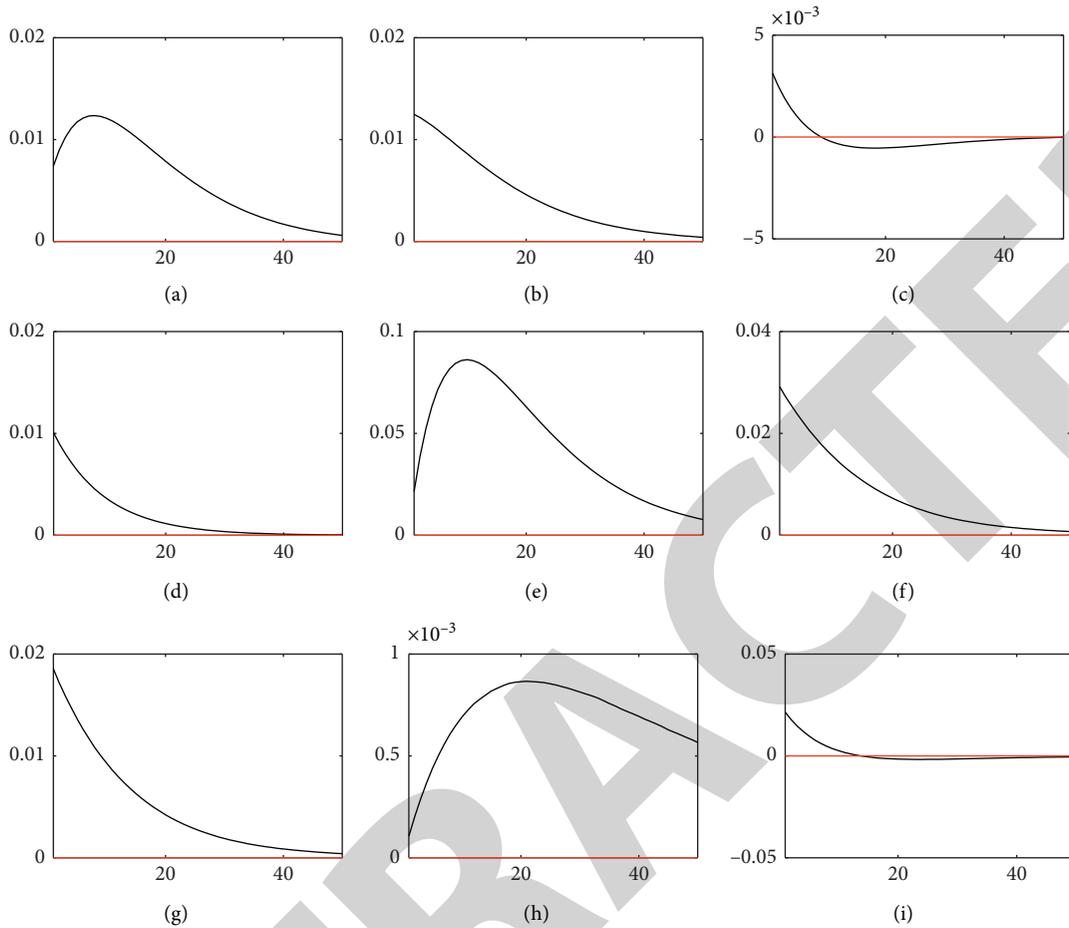


FIGURE 2: Impulse response to a technology shock. (a) C . (b) W . (c) N . (d) A . (e) K . (f) Y . (g) Z . (h) G . (i) I .

increase production, while simultaneously increasing emissions in the production process. Thus, policy-makers will need to trade-off between economic development and environmental protection.

3.2.2. Environmental Policy Uncertainty. The new Environmental Protection Tax Law was officially implemented in China in January 2018. In order to facilitate implementation, a “replacement period” has been initiated, where the total annual amount of environmental taxes is basically equivalent to the total annual pollution discharge fee of the past few years. The optimal tax rate and the uncertainty of taxation are issues worth studying. In this section, we set a one-unit positive environmental policy shock to simulate how this change will affect the economy.

The results in Figure 3 show that, overall, environmental tax shocks will have a negative impact on various economic indicators. Given a one-unit positive shock, the output immediately deviates negatively from the steady-state value. There is also a direct decline in labor and wages to varying degrees. These indicators then slowly recover and gradually approach the steady-state value. Consumption, capital stocks, and government expenditure fall at first and then rise back to the steady-state value gently in a U-shape.

An increase in the environmental tax rate will lead to an increase in the production costs of enterprises. This is an important cause of the reduction in pollution emissions. In our analysis, given an environmental shock, the pollution discharge deviated negatively in the first period and returned to the steady-state value around the 30th period.

As can be seen from the analysis, the uncertainty of environmental taxes has a major impact on economic development. As such, the determination and adjustment of the environmental tax rate will become one important means for the government to control and adjust economic development.

3.2.3. Government Expense Uncertainty. In most countries, government expenditure has consistently been an important means of fiscal regulation. Therefore, it is necessary to study the impact of government expenditure shocks on the economy. For this assessment, we assume that there is a one-unit positive shock on government expenditure in the following 50 periods.

An increase in government spending will have a direct and significant effect on improving total output. A 1% government expenditure shock will result in a 1% increase in the total output. However, in comparison to a technology shock, the effect of a government expenditure shock is significantly weaker.

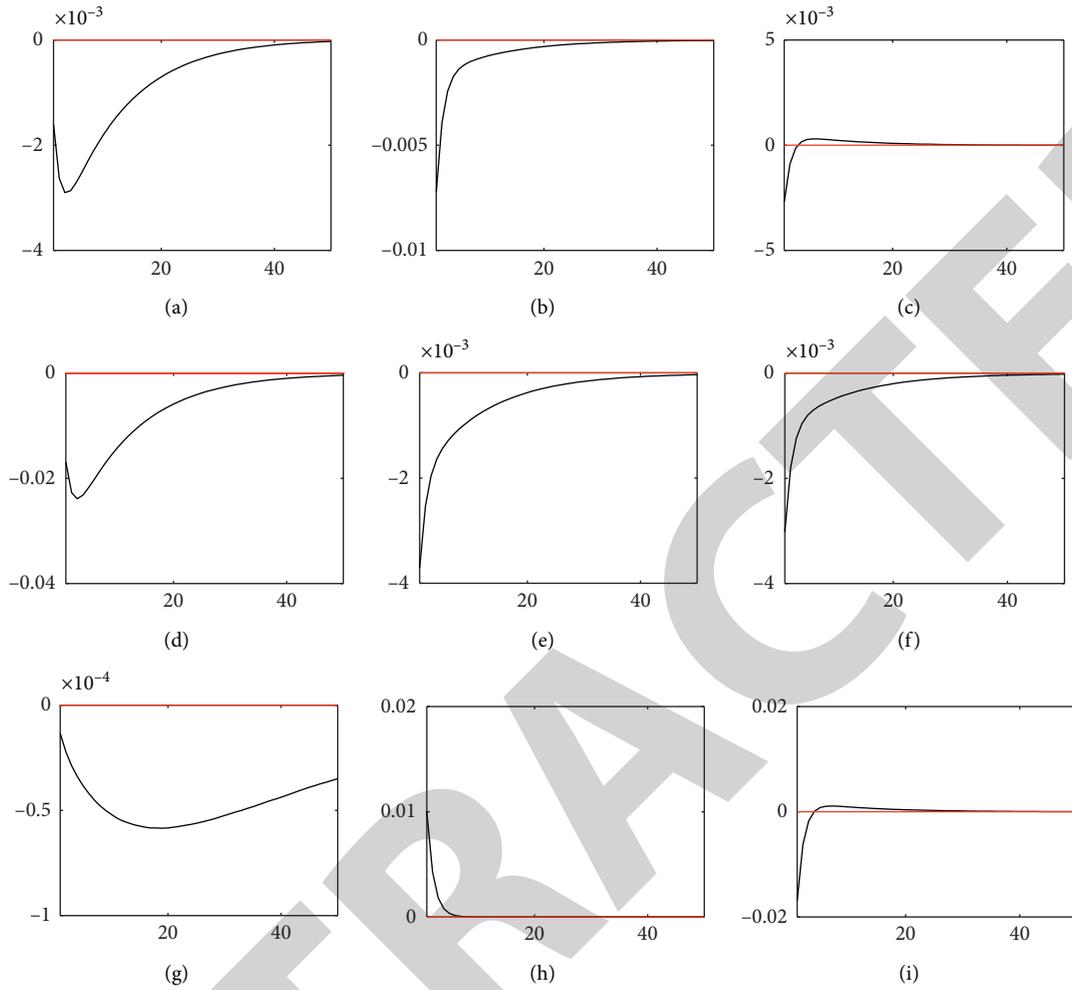


FIGURE 3: Impulse response to an environmental tax rate shock. (a) C . (b) W . (c) N . (d) K . (e) Y . (f) Z . (g) G . (h) T . (i) I .

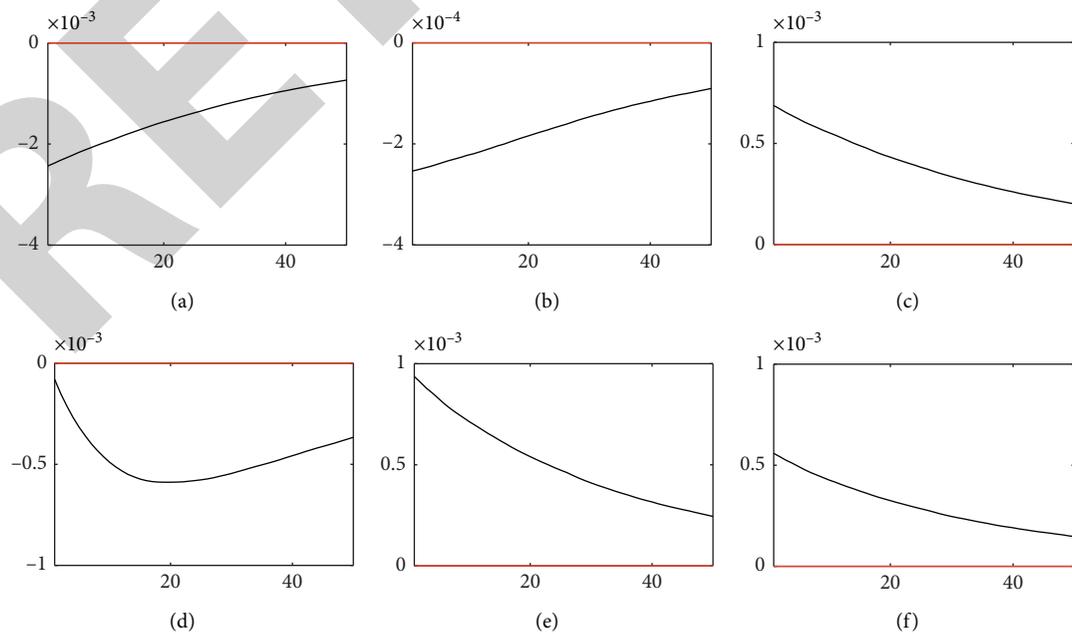


FIGURE 4: Continued.

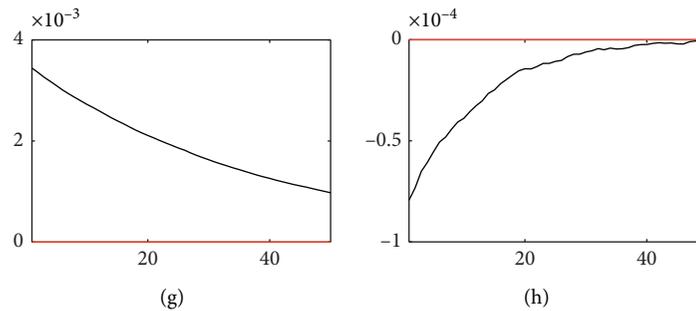


FIGURE 4: Impulse response to a government expense shock. (a) *C*. (b) *W*. (c) *N*. (d) *K*. (e) *Y*. (f) *Z*. (g) *G*. (h) *I*.

From the results shown in Figure 4, consumption, investment, wage, and capital stock would also decline to varying degrees due to government involvement. The government's largest increase in fiscal expenditure would be in public construction, while, lowering the afore-mentioned economic variables, the demand for labor will increase. That is why labor will increase by 0.7% at Time 0.

From an environmental point of view, an increase in public construction projects caused by the impact of government expenditure will also increase pollutant emissions to some extent. This effect continues to decline over the 50 periods but does not return to a steady-state value at the end of the 50th period. Therefore, it is evident that the impact of the government expenditure shock will be longer in duration than that of the other two shocks.

4. Conclusions

Given the recent implementation of new Environmental Protection Tax Law in China, there is a clear rationale for studying the kind of effects the law will have on the country's economy and environment. In this study, we used a three-sector DSGE model to estimate the effects and dynamics of the new environmental policy regime. The main findings of this paper are as follows.

The changes in the steady-state values before and after the implementation of the Environmental Protection Tax Law in the simulation conducted in this study are evidence that the new policy may improve environmental quality in the medium and long term. However, the new tax law may have an adverse impact on total output, consumption, and investment, thereby reducing the rate of economic growth. To maintain stable economic growth, we propose that other fiscal policies should be introduced to mitigate short-term economic fluctuations.

Through the simulation of three different stochastic shocks, the primary economic variables show different trends. In the case of a one-unit positive technology shock, the productivity of enterprises will be improved; there will be an increase in total output but a simultaneous increase in pollution. Due to the increase in production costs caused by taxes, positive changes in environmental tax rates could undermine economic development but improve environmental quality. Direct investment in government-funded public construction could bring direct economic growth but

would result in increasing pollution. Nonetheless, compared with technological shocks, a shock in government spending will have a longer but weaker impact.

One major goal of the environmental protection tax is to force energy-related companies to undergo technological innovation and adopt clean production models to improve the quality of the environment ultimately. However, as a result of the negative impact of environmental taxes on the economy, the sudden implementation of a high environmental tax will bring a sharp increase in production costs. In order to alleviate the taxation pressure on enterprises in the short-term, the government implemented a "tax-to-transfer" program. Under the principle of a "tax shift," the total annual amount of taxation of enterprises is approximately the same as the previous pollution discharge fees. This policy could alleviate the economic decline to some extent.

In order to fully reflect the effect of the Environmental Protection Tax Law and accelerate environmental improvements, we recommend to (1) adjust the tax rate to optimize the efficiency of the new environmental tax. (2) Subdivide the category of enterprises, and incentive green businesses by preferential policies such as government subsidy, tax reductions, or refunds. In theory, all environmental tax revenue could be used to subsidize enterprises that use cleaner production models. (3) Use environmental protection tax as an economic means to guide more capital investment on green industry.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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