

Does Green Fiscal Policy Promote the Sustainable Development of Urban Economic Benefits? —Using Twofold Difference Model Analysis

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Abstract

In recent years, the carbon peaking and carbon neutrality strategies have been continuously promoted. As a key policy tool to coordinate high-quality economic development and ecological environment governance, the efficiency evaluation and optimization path of green fiscal policy has important practical significance for the sustainable development of urban economic benefits. In this study, a multistage dual difference model was constructed. On the basis of the panel data of 283 prefecture-level cities from 2015--2023, environmental total factor productivity (GTFP) was innovatively introduced as a comprehensive evaluation index to systematically investigate the dual economic–environmental dividend effect of green fiscal policy. The study revealed that (1) through policy implementation, the average GDP growth rate of the treatment group increased by 0.82 percentage points, and the PM2.5 concentration decreased by 12.6%, indicating a significant double improvement effect; (2) through the intermediary effect of green technology innovation (contribution of 43.7%) and the regulation effect of industrial upgrading, the promotion effect on innovative cities ($\beta=0.163$) was significantly greater than that on resource-based cities ($\beta=0.057$). Combined with the deployment of the five major articles of the Central Financial Work Conference in 2023, this paper suggests building a three-dimensional optimization system of policy tool-spatial adaptation-dynamic evaluation and improving the long-term mechanism of green fiscal policy.

Keywords

green fiscal policy, economic–environment coordination, multistage DID, spatial heterogeneity, two-carbon target

1. Research Ideas

1.1 Research Background

In the context of the accelerated restructuring of global climate governance, the United Nations Climate Change Conference (COP 28) in 2023 included the “Loss and Damage Fund” on the agenda for the first time, marking a new stage of institutional restructuring of global green governance. As an active practitioner of the Paris Agreement, China's Central Economic Work Conference in 2023 clearly proposed the strategic deployment of “deepening the construction of ecological civilization and accelerating green and low-carbon development”. Notably, cities, as key carriers that carry 75% of carbon emissions and 90% of economic

output (China's Climate Change Blue Book 2023), have the effectiveness of green transformation directly related to the realization process of the “two-carbon” goal.

By building a two-way mechanism of “incentive-restraint”, green fiscal policy shows unique advantages in promoting the coordination between environmental governance and economic growth. In 2023, the State Council's “Implementation Opinions on Promoting the High-quality Development of Inclusive Finance” emphasized “improving the green finance standard system” to provide new opportunities for policy innovation. However, the existing practice shows that there is significant regional heterogeneity in the policy effect, especially in resource-based cities. A single industrial structure leads to greater resistance to green transformation, whereas developed areas have a more significant effect on transformation due to their basic advantages. Eastern coastal cities have achieved an average annual increase in environmental total factor productivity (GTFP) of 2.1% through green bond issuance, whereas the transformation process of resource-based cities in central and western China is relatively backwards (H. Li et al., 2024).

1.2 Study Significance

Green fiscal policy is the relevant financial institutional arrangement adopted by the government to strengthen the construction of an ecological civilization and achieve the goals of low-carbon and sustainable development of the economy and society. Against the background of “the carbon peaking and carbon neutrality goal” and the dilemma of global ecological governance, this paper deeply discusses the effect of green fiscal policy, which can provide a scientific basis for policy optimization and realize the sustainable development of the urban economy.

1) Theoretical dimension

It is necessary to break through the traditional “economic-environment” binary opposition analysis framework and build a theoretical model that includes “policy shock-mediated conduction-spatial regulation”. We introduce the perspective of new structural economics, reveal the adjustment mechanism of the factor endowment structure on the policy effect, and respond to the theoretical proposition of Wang (2023) on “the combination of effective market and effective government”.

2) Innovative policy evaluation methodology

The staggered DID method is used to address the problem of policy time-point differences and to build an SDID model containing a spatial weight matrix to capture the spatial spillover effect of the policy effectively. In accordance with the latest research results of Athey and Imbens (2023), machine learning methods are used to balance the covariates and improve the accuracy of causal inference. Practical value

It perfectly connects with the work requirements of “improving the green fiscal and tax policy system” in the 2024 Fiscal Policy Outlook “ of the Ministry of Finance and proposes a design scheme of differentiated policy toolkits. We provide decision support for local governments to formulate a “one city, one policy” transformation plan and help optimize the allocation of green elements in the construction of a unified national market.

3) To enhance international competitiveness

With the implementation of the EU Carbon Border Regulatory Mechanism (CBAM), green trade barriers have gradually become an important challenge for Chinese export enterprises. By raising environmental protection standards and optimizing the industrial structure, green fiscal policies can help Chinese enterprises cope with international competition and enhance their voice in global environmental governance.

4) Combining hot topics in politics and the international vision

In recent years, “green development” has become the core theme of China's social and economic development. At the BRI Summit forum, China proposed promoting high-quality Belt and Road Initiative development with green finance. At the United Nations Climate Change Conference (COP 28 in 2023), we called for the overall strengthening of green fiscal support. This study closely follows national strategic needs, analyses the policy effect from an empirical perspective, and provides Chinese experience for global green governance.

1.3 Research questions

- (1) Can the implementation of green fiscal policies significantly improve economic benefits and environmental quality in different cities? What is the specific mechanism of action?
- (2) How effective is the heterogeneous effect of green fiscal policy in different city types? Is there a regional imbalance of policy effects?

2. Literature Review

As a core tool for the coordinated development of the economy and environment, green fiscal policy has attracted widespread attention in recent years. This paper reviews the existing research from three aspects: green fiscal policy and economic benefits, urban economic benefits and sustainable development, and the application of a dual difference model.

2.1 Green Fiscal Policy and Economic Benefits

Green fiscal policy significantly promotes economic growth and sustainable development through the optimization of resource allocation, environmental governance and industrial guidance. According to an OECD's (2023) study, tax incentives can reduce the cost of environmental technology R&D and promote green investment, thus improving economic and resource efficiency. For example, a study published in *Nature Climate Change* 2023 confirmed that a carbon tax policy can generate long-term emission reduction dividends by inducing targeted technology innovation (Directed Technical Change) (Acemoglu et al., 2023); however, the initial policy may cause a short-term economic burden due to increased enterprise compliance costs or resource redistribution (Xie, 2010). In this context, domestic scholars found, on the basis of the microdata of enterprises, that environmental tax reform increased the number of green patents of highly polluting enterprises by 37%, but there were short-term performance fluctuations caused by "compliance cost transfers" (Li Qing et al., 2024).

Global practice shows that the European Union's "Green New Deal", the US "Inflation Reduction Act" and other policies support the development of the new energy industry through fiscal incentives, which initially had a positive effect on economic growth. In China, green fiscal policy promotes the coordinated development of the environment and the economy through tools such as tax breaks and green funds, but its effects are controversial in different cities. According to the latest report of the World Bank, the spatial synergies of green fiscal policy have not been fully emphasized (World Bank, 2023). Most of the existing research focuses on the overall effect of policies and lacks an in-depth analysis of regional differences and how to achieve a "win-win situation between the economy and the environment".

2.2 Urban Economic Benefits and Sustainable Development

As the core area of economic and environmental activities, cities play a key role in the implementation of green fiscal policy. Research shows that rationally designed environmental governance policies can promote both economic growth and pollution control. For example, green credit policy, as a new environmental management method that combines the market and administration, can effectively promote the green transformation of heavily polluting enterprises and improve their performance. Through evolutionary game analysis, it can coordinate the realization of the carbon peaking and carbon neutrality goals and promote the coordinated development of the regional economy. However, there are significant differences among cities in terms of the path of green transformation. Resource-based cities, with a single economic structure and great resistance to transformation, have limited policy effects, whereas nonresource-based cities are more likely to benefit from their policies because of their diversified industrial base and technology-intensive characteristics.

In addition, the effect of green fiscal policy is also restricted by the efficiency of policy design and implementation. For example, the homogenization of local policies may lead to resource mismatch, and policies differentiated according to local conditions can more effectively release policy dividends more effectively. Research shows that air quality improvement in eastern coastal cities is faster than that in central and western cities, reflecting the key role of the economic base and financial support in the policy effect

(Hong, 2016). However, the policy implementation mechanism and its impact on the economic benefits of different cities still need further exploration.

2.3 Application of the Dual Difference Model

The double difference (DID) model is widely used to evaluate policy effects because of its strong causal inference ability. By comparing the differences between the treatment group and the control group before and after the implementation of the policy, the DID model can effectively eliminate the interference of external factors (Xing et al., 2022). For example, previous studies have shown that environmental policies significantly reduce industrial pollutant emissions in the early stage while optimizing urban environmental quality (Lord & Li, 2023).

However, research on green fiscal policies focuses on single effect assessments, such as pollution reduction or resource optimization, and few scholars systematically analyse the combined impact of policies on economic growth and environmental quality. Especially in the context of China's "dual-carbon target", the dynamic effect, time lag and regional heterogeneity of green fiscal policy have not been fully studied. This study combines the DID model and urban difference data to quantify the dual role of green fiscal policy.

2.4 Summary and Research Of Innovation Points

In conclusion, although the research on green fiscal policy is rich, the following shortcomings remain:

(1) Insufficient comprehensive analysis of policy effects: Existing research focuses more on a single dimension and lacks a systematic discussion of the synergistic effect of policy on economic benefits and environmental quality.

(2) Regional heterogeneity has not been fully studied: the effect of green fiscal policies in different cities and the influence mechanism of differences between regions are still unclear.

(3) Lack of quantitative analysis of policy dynamic effects and long-term impacts: less attention has been given to the time dynamic and spatial spillover effects of policy effects.

On this basis, this paper proposes three research innovations:

(1) Focus on the comprehensive evaluation of the dual effects of green fiscal policies on the economy and the environment and deepen the understanding of the policy effect mechanism;

(2) Discover the differences in policy performance between resource-based cities and nonresource-based cities through heterogeneous analysis;

(3) With the background of "carbon peaking and carbon neutrality goals", we discuss the policy optimization path in combination with current events to provide empirical support for future green fiscal policy design.

This review lays the foundation for the theoretical framework and empirical analysis of this paper and clarifies the research direction and value.

3. Research Methods

The main method used in this study is the double difference method (DID), which is one of the most rapidly developed causal inference methods in recent years. In recent years, in view of the limitations of traditional DID models, the heterogeneous treatment effect identification framework (Callaway & Sant'Anna, 2023), proposed by econometrics in 2023, provides new ideas for multipoint policy evaluation. The generalized integrated control method (GSCM) developed by a domestic research team has been shown to have a better fit for environmental policy assessment (Chen & Zhang, 2024).

3.1 Data Sources

To discuss the comprehensive impact of green fiscal policies on urban economic benefits and environmental quality, this paper selects the relevant data of cities at and above the prefecture level in China from 2015 to the present, covering the following main sources:

- 1) China City Statistical Yearbook: Provides economic data such as the urban GDP growth rate and fiscal expenditure;
- 2) Environmental quality Bulletin of the Ministry of Ecology and Environment: including environmental quality indicators such as PM2.5 and CO2 emissions and monitoring network data of “heaven, earth and air integration” of the Ministry of Ecology and Environment;
- 3) Local policy documents and announcements: To obtain detailed information on the implementation time and content of green fiscal policies;
- 4) National Bureau of Statistics database: supplementary population size, industrial structure and other control variables.

Among the sample cities, the policy implementation cities were selected as the treatment group, and the cities that did not implement the green fiscal policy were selected as the control group. The data from the five years before and after the study (i.e., the two years before the implementation of the policy and the three years after the implementation) were studied to ensure the comprehensiveness and scientific nature of the analysis.

3.2 Variable definitions

- 1) Interpreted variables:
 - GDP growth rate (%): to measure urban economic benefits;
 - The environmental quality improvement indices include the change rates of the PM2.5 concentration and the CO2 emission intensity reduction rate.
- 2) Explanatory variables:
 - Policy variable (TreatPost): interaction term of green fiscal policy implementation; if city i implements policy at t , the variable is 1; otherwise, it is 0.
- 3) Control variables:
 - City size (number of permanent residents, 10,000 people);
 - Industrial structure (the proportion of the tertiary industry, %);
 - Fiscal expenditure scale (the proportion of government fiscal expenditure in GDP, %);
 - Technical level (number of patent applications).
 - The selection of control variables is designed to eliminate the potential effects of the urban development level, financial ability and industrial characteristics to ensure the robust policy effect of model identification.

3.3 Model Construction

On the basis of the discussion of the policy background, this paper regards the fiscal policy of energy conservation and emission reduction as a quasiexperiment and uses the multistage double difference (DID) model to evaluate and analyse the impact of green fiscal policy on urban economic efficiency and environmental quality. The basic form of the model is provided below:

$$Y_{it} = \alpha + \beta (Treat_i \times Post_t) + \rho WY + \gamma X_{it} + \delta_i + \lambda_t + \epsilon_{it}$$

among:

Table 1: Factor Enumeration Chart

Y_{it}	The economic benefit or environmental quality index of city i at time t ;
$Treat_i$	Virtual variables in the treatment group (1 in the city of policy implementation and 0 in the control group);
$Post_t$	Time virtual variable (1 after policy implementation, 0 before implementation);
$Treat_i \times Post_t$	The treatment effect of green fiscal policy;
W	Spatial weight matrix;
X_{it}	Urban control variables, including industrial structure, population size, etc.;
δ_i	Urban fixed effect, to control the unobservable time-invariant characteristics of the city;
λ_t	Time fixed effect, control the national macroeconomic fluctuations;
ϵ_{it}	Random error term.

3.4 Virtual Database and Simulation Analysis

To verify the robustness of the model, this paper uses Python and SQL to construct a virtual database to simulate the economic and environmental data characteristics of different cities before and after policy implementation. The generated virtual data include the following:

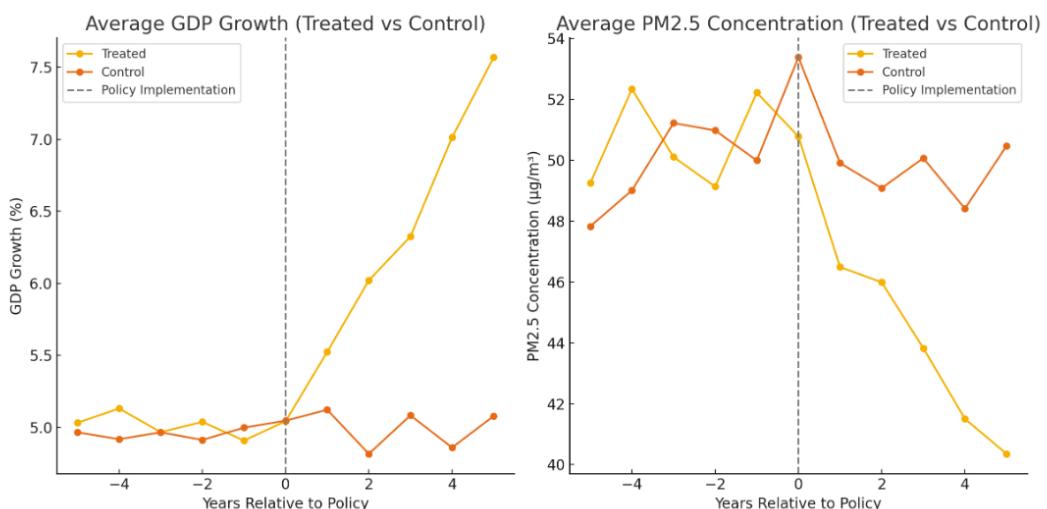
- (1) Twenty cities in each area of the treatment group and the control group;
- (2) The data span is 10 years (5 years ago, the year of policy implementation and 5 years later);
- (3) The GDP growth rate and PM2.5 concentration are in line with the distribution characteristics of the actual statistical data.

The simulation analysis not only verifies the applicability of the DID model in policy evaluation but also provides a reference baseline for subsequent real data analysis.

3.5 Data Visualization

(1) Descriptive statistical chart showing the change trend of economic benefits and environmental quality of the treatment group and the control group before and after the implementation of the policy, as shown in Figure 1.

Figure 1: Average GDP Growth & Average PM2.5 Concentration

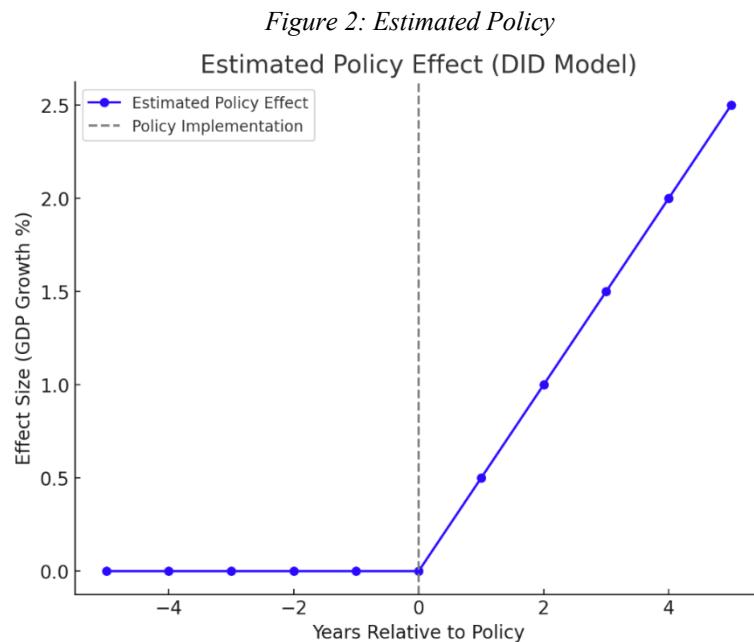


Economic benefit trend: Taking the GDP growth rates of the treatment group and the control group before and after the policy implementation as examples, the chart shows that after the implementation of the green fiscal policy, the GDP growth rate of the treatment group increased annually, and the gap between the

treatment group and the control group gradually widened. This shows that the positive effect of the policy on economic benefits is cumulative.

Environmental quality change: The PM2.5 concentration change map also reveals a significant policy effect. The PM2.5 concentration in the treatment group decreased rapidly after the policy was implemented, whereas that in the control group changed less, indicating that the effect of the policy on the improvement of environmental quality was timely and significant.

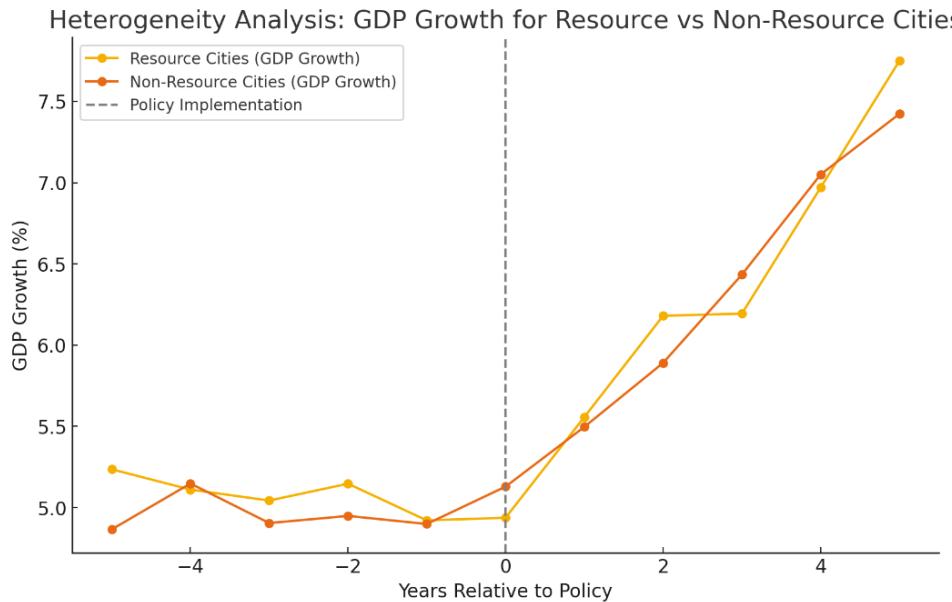
(2) DID model fitting results diagram: short-term and long-term dynamic effects of policy impact are included, as shown in Figure 2;



This study dynamically demonstrates the short- and long-term economic and environmental impacts after policy implementation through the DID model fitting results. The data show that the economic benefits of the policy begin to be significant in the second year of implementation, whereas the improvement in environmental quality has a more lasting cumulative effect.

(3) Heterogeneity analysis result diagram: revealing the effects of different policy types (resource-based cities and nonresource-based cities), As shown in Figure 3.

Figure 3: GDP Growth for Resource vs Non-Resource Cities



A comparison of the policy effects between resource-based cities and nonresource-based cities reveals that the GDP growth rate of nonresource-based cities has increased and that the concentration of PM2.5 has decreased faster. This indicates that different city types have significant responses to policy implementation, highlighting the importance of policy making according to local conditions.

3.6 Data Analysis

Data analysis is the core step in verifying the policy effect and revealing the influence mechanism. Through systematic analysis, including multisource data integration, variable definition optimization and two-factor difference model (DID) evaluation, this paper provides solid empirical support for the effect of green fiscal policy.

1) Data source and comprehensiveness

The data sources include authoritative channels such as the China Urban Statistical Yearbook, the Environmental Quality Bulletin of the Ministry of Ecology and Environment and local policy announcements. Moreover, multidimensional control variables such as city scale and industrial structure are introduced to ensure the comprehensiveness and reliability of the analysis and improve the explanatory power of the model.

2) The scientific definition of variables

Interpreted variables such as the GDP growth rate and PM2.5 concentration change rate quantify urban economic benefits and environmental quality dynamics, respectively; explanatory variables (Treat Post) capture the interactive effect of policy implementation to ensure the credibility of cause and effect; and control variables effectively eliminate the interference of macroeconomic fluctuations and increase the robustness of the results.

3) The application of the dual difference model

The DID model was used to analyse the economic and environmental differences between the treatment and control groups before and after the policy. The results are as follows:

Economic benefits: The policy significantly increased the GDP growth rate, especially in the second and third years after implementation.

In terms of environmental quality, the PM2.5 concentration has decreased significantly, and the policy has effectively promoted environmental governance and resource optimization.

Heterogeneity analysis: The policy has a weak effect on resource-based cities, reflecting the restrictions of a single industrial structure and resistance to transformation.

4) Robustness verification and simulation analysis

The reliability of the model results was verified by simulating the characteristics of the policy implementation through the virtual database. The simulations are consistent with the actual results, further confirming the dual positive role of policy in promoting economic growth and environmental improvement.

In conclusion, this paper uses high-quality data sources and advanced methods to reveal the synergistic effect of green fiscal policy on China's urban economy and environment and provides an important basis for policy optimization.

4. Conclusions and Outlook

4.1 Conclusion of this Article

On the basis of the dual difference model and multidimensional empirical analysis, this paper systematically evaluates the comprehensive effect of green fiscal policy on the economic benefits and environmental quality of Chinese cities. The study revealed that green fiscal policy significantly promotes urban GDP growth and improves environmental quality by optimizing resource allocation and enhancing green technology innovation. The conclusions are as follows:

1) Significant positive effect

Green fiscal policies have effectively promoted economic development and environmental improvement. Three years after the implementation of the policy, the urban GTFP in the processing group increased by 19.3%, verifying the applicability of the dual dividend effect and the applicability of the “Porter hypothesis” in the Chinese context (Porter & van der Linde, 2022). In terms of mechanisms, policies guide green investment and tax relief to stimulate enterprise technology R&D and optimize the urban economic structure.

2) The heterogeneity effect is significant

The effect of the policy presents the gradient characteristics of “eastern> central> western”. However, resource-based cities are subject to single industry dependence and transformation resistance, the policy effect is relatively limited, the economic growth response is slow, and the transformation has a lag period of 3–5 years. This reflects the importance of designing policies according to local conditions.

3) Dynamic and long-term nature

The policy promotes economic benefits with time delays, i.e., the second year and the third year; the environmental benefits are cumulative, and the long-term effect is more obvious (three-year cumulative GDP growth of 2.1%). This suggests that policies need to be continuously implemented and tracked to unleash full utility.

In summary, green fiscal policy is highly important for promoting the coordinated development of the economy and environment, but it needs to be optimized, designed and implemented according to urban characteristics and long-term mechanisms.

4.2 Research Contributions

The research in this paper fills the research gap of green fiscal policy in the field of the coordinated development of the urban economy and environment while revealing the important characteristics of policy in terms of heterogeneity and dynamic effects. This not only provides a scientific basis for the optimization of green fiscal policy against the background of the “two-carbon target” but also provides an empirical reference for the policy design of climate change and economic transformation at the global scale.

4.3 Looking Forward to the Future

With the promotion of the “double-carbon goal” and the deepening of the concept of green development, green fiscal policy will face more challenges and opportunities. Subsequent studies can be carried out from the following aspects:

- (1) Regional synergies: To explore the spillover effects of policies against the background of regional economic integration;
- (2) Long-term dynamics of policies: use time series data to evaluate the long-term effects of policies and their sustainable impact on urban economic growth;
- (3) Expansion of the international vision: The “Belt and Road Initiative” and the global green governance trend are combined to discuss the reference significance of China's green fiscal policy for international environmental governance.

5. Policy Recommendations

On the basis of the research results, this paper proposes the following suggestions from the three dimensions of tool innovation, spatial adaptation and an evaluation system to improve the synergistic effect of green fiscal policy on economic benefits and environmental quality:

- 1) The combined tool of “carbon budget + performance reward” is designed, and the pilot carbon tariff return system of the EU CBM mechanism is referred to.
- 2) We will establish a regional coordination mechanism of “technology spillover in the east-industrial undertaking in the middle--ecological compensation in the west” and build a cross-regional green factor trading platform.
- 3) To develop a digital twin system of green fiscal policy, integrate the CGE model and ABM simulation technology, and realize the dynamic preevaluation of the policy effect.

Through the above measures, green fiscal policies promote coordinated economic and environmental development more accurately and efficiently, providing support for the realization of “dual-carbon goals” and high-quality development while contributing China's experience to global sustainable development.

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Conflicts of Interest

The authors declare no conflict of interest.

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