RESEARCH-ARTICLE

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Research on the Impact of China's Low Carbon City Pilot on High-Quality Economic Development Based on the Difference-in-Differences Model

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Abstract

This paper takes China's low-carbon city pilot as a quasi-natural experiment and constructs a multi-period difference-in-differences model to comprehensively evaluate the impact of the low-carbon city pilot on the high-quality development of urban economy. The study finds that the low-carbon city pilot has significantly promoted the high-quality development of urban economy. Further research finds that adjusting and optimizing industrial structure and encouraging green technological innovation are important mechanisms by which the low-carbon city pilot promotes the high-quality development of urban economy.

CCS Concepts

• **Applied computing**; • **Law, social and behavioral sciences**; • **Economics**;

Keywords

Low-carbon City Pilot, High-Quality Economic Development, Industrial Structure Adjustment and Optimization, Green Technological Innovation, Difference-in-Differences Model

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1 Introduction

Since the reform and opening up, China has achieved rapid economic development and significant improvement in people's living standards in a short period of time. However, a series of problems have also emerged, such as the deterioration of the ecological environment, the imbalance of industrial structure, and the risk of local government debt. Especially, global climate change has become one of the most severe challenges facing the world today. Climate change not only threatens the balance of natural ecosystems but also poses a huge challenge to the sustainable development of human society. In recent years, concepts such as low-carbon and emission reduction have received increasing attention from scholars and government officials, and high-quality development has gradually become the core of economic development. As an inevitable choice to address global climate change, the construction of low-carbon cities provides a feasible path to alleviate climate change and promote high-quality economic development through measures such as reducing greenhouse gas emissions, improving energy efficiency, and promoting the use of renewable energy.

In recent years, the low-carbon city pilot has become a hot issue in academic research. Literature closely related to this paper includes the following categories, which focus on the environmental effects, economic effects, and social effects brought about by the Low Carbon City Pilot (LCCP).

In terms of environmental effects, Zhou et al. (2022) estimated the impact of the LCCP on energy conservation of different enterprises and found that the policy significantly reduced the coal consumption and coal intensity of enterprises.[1] Niu et al. (2023) found that the low-carbon city pilot policy improved the energy efficiency of pilot cities.[2] Wang et al. (2024) used a dual-machine learning model to find that the low-carbon city pilot policy promoted carbon neutrality in Chinese cities.[3] Wang et al. (2024) found that the low-carbon city pilot policy achieved a synergistic effect of pollution reduction and carbon reduction.[4] The LCCP can reduce urban carbon emissions by influencing residents to form green living awareness and cultivate green living habits. [5, 6]

In terms of economic effects, Zhao et al. (2021) found that the low-carbon city pilot policy had a significant promoting effect on FDI.[7] Qiu et al. (2021) found that the low-carbon city pilot policy could enhance the green total factor productivity of cities.[8] Zheng et al. (2021) found that the construction of low-carbon cities was conducive to industrial structure upgrading.[9] Chen et al. (2021) found that the LCCP could improve the total factor productivity of enterprises by improving technological innovation and optimizing resource allocation.[10] Huang et al. (2021) tested the impact of the LCCP on corporate R&D and found that the policy increased the proportion of R&D investment in total assets by 0.145%. [11]

In terms of social effects, some scholars have found that the low-carbon city pilot policy can improve air quality and enhance residents' health levels. [12, 13] Liu et al. (2022) found through empirical tests based on the difference-in-differences method that

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the low-carbon city pilot policy had a negative impact on urban land use efficiency. Liu and Li (2023) found that the low-carbon city pilot policy had a significant impact on the labor income share of enterprises. [14]

Existing research on low-carbon city pilots has yielded fruitful results, laying a solid foundation for further expanding the research direction of this paper. Compared with existing literature, the possible innovations of this paper are reflected in: Firstly, there is still relatively little literature on the relationship between low-carbon city pilots and high-quality economic development. This paper systematically examines its impact on the high-quality economic development of cities, thereby enriching the research achievements of low-carbon city pilots and high-quality economic development from the perspective of research. Secondly, most studies only considered the first two batches of pilot cities, but precisely ignored the third batch of pilot cities, which have the largest number and the greatest intensity. The research of this paper covers three batches of pilot cities to make up for the deficiencies of existing studies. Thirdly, this paper not only explains the mechanism by which low-carbon city pilots promote the high-quality economic development of cities, but also uses the multi-period difference-in-differences method for empirical testing, which can identify more accurate policy effects.

2 Theoretical Analysis

As a new type of urban development model, the pilot project of low-carbon cities has attracted much attention against the background of increasingly serious global climate change and environmental problems. The pilot project of low-carbon cities not only helps to achieve sustainable urban development but also has a positive impact on the high-quality development of urban economy. [15]

Firstly, the pilot project of low-carbon cities promotes the popularization of low-carbon technologies and clean energy, improves energy utilization efficiency, reduces energy consumption and carbon emissions, thereby reducing urban production costs, enhancing the competitiveness and sustainable development capacity of urban economy.[16] In addition, the pilot project of low-carbon cities has also promoted the development of related industries, such as renewable energy, energy conservation and environmental protection, providing new impetus for economic growth.

Secondly, the construction and development of low-carbon city pilots require a large amount of talent support, thus creating new employment opportunities. [17] At the same time, the construction of low-carbon city pilots also promotes the development of related industries and the optimization and upgrading of urban industrial structure, providing more job opportunities for employment.

Thirdly, the pilot project of low-carbon cities promotes the popularization of low-carbon technologies and clean energy, reduces energy consumption and carbon emissions, reduces the risk of urban environmental pollution and ecological damage, thereby improving the urban environmental quality.[18] In addition, the pilot project of low-carbon cities also promotes urban greening and ecological restoration, promotes the health and stability of urban ecosystems, and guarantees the urban environmental quality.

Based on the above analysis, this paper proposes Hypothesis 1: The pilot project of low-carbon cities can promote the high-quality development of urban economy.

Industrial structure upgrading is the core driving force for the high-quality development of urban economy. Through promoting industrial restructuring and optimization, the pilot project of low-carbon cities will phase out traditional high-energy-consuming and high-emission industries and replace them with low-energy-consuming and low-emission green industries.[19] This industrial upgrading not only reduces urban energy consumption and carbon emissions, but also improves the added value and core competitiveness of urban economy, thereby promoting the high-quality development of urban economy. Accordingly, this paper proposes Hypothesis 2: The pilot project of low-carbon cities promotes the high-quality development of urban economy by adjusting and optimizing industrial structure.

Technological innovation is the core element of cultivating and developing new quality productivity, the primary driving force leading the high-quality development of economy, and a key indicator reflecting the comprehensive competitiveness of a country. Pilot cities of low-carbon cities can reduce the cost of green technological innovation for enterprises through fiscal and financial instruments, attract innovative talents to gather, encourage enterprises to carry out green technological innovation activities, and then improve the green total factor productivity, and ultimately promote the overall high-quality development of economy.[20] Accordingly, this paper proposes Hypothesis 3: The pilot project of low-carbon cities promotes the high-quality development of urban economy by encouraging green technological innovation.

3 Empirical Research Design

3.1 Empirical Model

The existing literature on policy effect evaluation of quasi-natural experiments generally uses the difference-in-differences(DID) method for regression analysis. The Time-varying DID describes the situation where the timing of treatment periods is not completely consistent among individuals, that is, the timing of treatment periods varies from individual to individual. The model is as follows:

$$Y_{it} = \alpha + \theta treat_i \times post_{it} + \beta X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

In model (1), Y_{it} represents the explained variable,$treat_i \times post_{it}$ represents the core explanatory variable, where $treat_i$ is a dummy variable indicating whether an individual receives treatment. If an individual receives treatment, it is assigned a value of 1; if not, it is assigned a value of 0. $post_{it}$ represents the dummy variable before and after treatment. If the current period is during the treatment period, it is assigned a value of 1; otherwise, if the current period has not yet entered the treatment period, it takes a value of 0. In model (1), the coefficient θ of the interaction term $treat_i \times post_{it}$is what we are concerned about, which is the overall average treatment

effect. The coefficient θ is expressed as:

$$\theta = \{E[Y_{it} \mid treat_i = 1, post_{it} = 1] - E[Y_{it} \mid treat_i = 1, post_{it} = 0]\}$$
$$\{E[Y_{it} \mid treat_i = 0, post_{it} = 1] - E[Y_{it} \mid treat_i = 0, post_{it} = 0]\}$$
$$(Y_1 - Y_0) - (C_1 - C_0) = (\theta + \lambda_t) - \lambda_t$$
$$(Y_1 - C_1) - (Y_0 - C_0) = (\theta + \mu_i) - \mu_i$$
$$\theta$$

The meaning of the above formula is that the difference between the changes before and after treatment in the treatment group and the control group is the average treatment effect. The interaction term $treat_i \times post_{it}$ in the above model is equivalent to the dummy variable D_{it} indicating whether individual i receives treatment in period t. Therefore, the multi-period DID model can also be set as follows:

$$Y_{it} = \alpha + \theta D_{it} + \beta X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

This paper takes China's low-carbon city pilot as a quasi-natural experiment and constructs a difference-in-differences model to evaluate the actual effect of the low-carbon city pilot on the high-quality development of urban economy. The baseline regression model is as follows:

$$HED_{it} = \alpha + \theta LCCP_{it} + \beta X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

In model (3), HED_{it} is the explained variable of this paper, representing the level of high-quality economic development of city, $LCCP_{it}$ is the core explanatory variable of this paper, representing the dummy variable of the low-carbon city pilot.

According to the theory of spatial economics, there may be spatial correlation in the high-quality regional economic development. For this reason, this paper constructs a spatial panel regression model. On the basis of controlling the spatial correlation of high-quality economic development, it further examines the robustness of the actual effect of low-carbon city pilots on the high-quality development of the economy.The spatial panel regression model is as follows:

$$HED_{it} = \alpha + \rho \sum_{j=1, j\neq i}^{n} HED_{jt} + \theta LCCP_{it} + \beta X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (4)$$

In model (4), the coefficient$\rho$is used to test the spatial correlation of high-quality regional economic development.

3.2 Variable Selection and Data Sources

Explained Variable: High-quality Economic Development of Cities (HED). Based on the research of Zhang et al. (2023), Guo and Sun (2023), this paper construct a comprehensive index system for the level of high-quality economic development of cities, and then measures the level of high-quality economic development of cities using the entropy value method. [21, 22]

Core Explanatory Variable: Low-carbon City Pilot (LCCP). Treatment group cities are assigned a value of 1 after being selected as pilot cities, otherwise 0, control group cities are assigned a value of 0 throughout the sample period.

Control Variables: Financial Development, represented by the ratio of the sum of the end-of-year financial institution deposits and loans of the city to GDP; Government Intervention, represented by the ratio of the city's fiscal expenditure to GDP; Population Density, represented by the ratio of the total population of the city to the administrative area of the city; Human capital, represented by the number of college students per 10,000 people. Among them, value-type variables are deflated using the corresponding price index.

Due to the lack of data on some indicators before 2006 and considering the serious lack of data for some cities, this paper finally selects panel data of 280 prefecture-level and above cities in mainland China from 2006 to 2022 as the research sample.

4 Empirical Results Analysis

4.1 Benchmark Regression Results

The benchmark regression results are shown in Table 1. Columns (1) and (2) are regressions based on ordinary panel data, and the difference between them is whether the control variables are included in the regression using the benchmark model. Column (3) further considers the spatial correlation of high-quality economic development of cities and then uses the spatial panel regression model to examine the robustness of the regression results. The regression results of columns (1) to (3) all show that the low-carbon city pilot has significantly promoted the high-quality development of urban economy, and Hypothesis 1 is verified.

4.2 Robustness Test

4.2.1 Parallel Trend Test. The basic premise of using the difference-in-differences method is to satisfy the parallel trend assumption. Consistent with the general practice of existing multi-period DID literature, this paper constructs Model (5) for the parallel trend test.

$$HED_{it} = \alpha + \sum_{i=1}^{6} \theta_{-i} pre_{it} + \theta_0 current_{it} + \sum_{i=1}^{5} \theta_i post_{it} + \beta X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (5)$$

Among them, pre_{it} are dummy variables for the 6th to 1st years before each city is established as a pilot city,$current_{it}$ is the interaction term of the dummy variable for the year when each city is established as a pilot city,$post_{it}$ are dummy variables for the 1st to 5th years after each city is established as a pilot city. The test results are shown in Figure 1, which shows that there is no significant difference in the economic development quality between the treatment group and the control group cities before the establishment of low-carbon pilot cities, passing the parallel trend test.

4.2.2 Placebo Test. Using the difference-in-differences method to evaluate policy effects also requires passing the placebo test. For the multi-period DID model constructed in this paper, conducting a placebo test requires randomly drawing cities that are the same number as any pilot year's pilot cities as a pseudo-treatment group, as well as any year as a pseudo-policy pilot year, and then generating fictional policy dummy variables to re-enter the baseline model (3) for regression. It can be found from Figure 2 that most of the 500 fictional regression coefficients are concentrated near 0, while the actual estimated coefficient (corresponding to the dashed line on the right) is significantly different from the above coefficients, thus passing the placebo test.

4.2.3 Exclude the Interference of Other Policies. To prevent the interference of other related policies on the benchmark regression results, the policy dummy variables of the two pilot policies most

Table 1: Benchmark Regression Results

Variable	(1) HED	(2) HED	(3) HED
LCCP	0.0069***	0.0062***	0.0057***
	(0.0018)	(0.0018)	(0.0097)
Control Variables	Not Controlled	Controlled	Controlled
ρ			0.8492***
			(0.0340)
City Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	4760	4760	4760
R^2	0.9308	0.9333	0.2859

Note: ***, **, * represent significance at the 1%, 5%, and 10% levels, respectively. The values in parentheses are cluster-robust standard errors at the city level, and the same below.

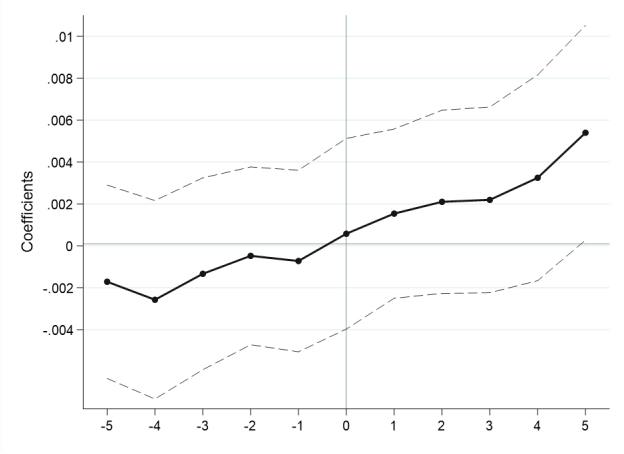

Figure 1: Parallel Trend Test

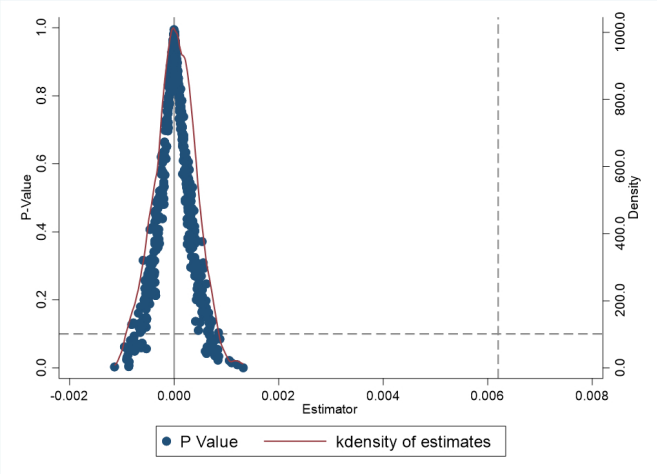

Figure 2: Placebo test

relevant to the theme of this paper during the sample period—"Carbon Emission Trading Pilot" and "Green Finance Reform and Innovation Pilot Zone Pilot"—(CET and GF, respectively) are introduced into the baseline model (3) in turn for regression again, as shown in Table 2. In Table 2, the coefficients of the core explanatory variable LCCP are significantly positive, which once again illustrates the robustness of the benchmark regression results.

4.3 Impact Mechanism Test

To verify Hypotheses 2 and 3, that is, whether the low-carbon city pilot promotes the high-quality development of urban economy by adjusting and optimizing industrial structure and encouraging green technological innovation, this paper constructs a mediation effect model to empirically test these two impact mechanisms. In view of the estimation bias of the traditional three-stage mediation effect model and the recognition of the promoting effect of industrial structure adjustment and optimization and green technological innovation selected in this paper on economic development quality by academia and government, this paper focuses on the impact of the core explanatory variable of the low-carbon city pilot on the mediating variables. The mediation effect model constructed in this paper is as follows:

$$M_{\text{it}} = \alpha + \gamma LCCP_{it} + \beta X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \tag{6}$$

In Model (6), M is the mediating variable, referring to industrial structure adjustment and optimization and green technological innovation. Industrial structure adjustment and optimization is measured by the calculation result of the added value of the primary industry accounting for 1 times the GDP plus the added value of the secondary industry accounting for 2 times the GDP plus the added value of the tertiary industry accounting for 3 times the GDP. Green technological innovation is measured by the number of green invention patent applications per 10,000 people in the city.

Table 3 shows the regression results of the impact mechanism test. The low-carbon city pilot has significantly promoted industrial structure adjustment and optimization, indicating that the low-carbon city pilot indeed promotes the high-quality development of urban economy by adjusting and optimizing industrial structure, and Hypothesis 2 is verified; The low-carbon city pilot

Table 2: Exclude the Interference of Other Policies During the Same Period

Variable	HED	HED
LCCP	0.0033*	0.0062***
	(0.0017)	(0.0018)
CET	0.0113**	
	(0.0051)	
GF		0.0132*
		(0.0080)
Control Variables	Yes	Yes
R^2	0.9348	0.9339

Table 3: Impact Mechanism Test

Variable	Industrial Structure Adjustment and Optimization	Green Technological Innovation
LCCP	0.0495***	0.5311***
	(0.0074)	(0.1353)
Control Variables	Yes	Yes
R^2	0.8169	0.6637

has a significant positive incentive effect on green technological innovation, indicating that the low-carbon city pilot indeed promotes the high-quality development of urban economy by encouraging green technological innovation, and Hypothesis 3 is verified.

5 Conclusions and Policy Implications

5.1 Conclusions

This paper first systematically analyzes the impact mechanism of low-carbon city pilots on the high-quality economic development of cities from a theoretical perspective and proposes relevant hypotheses. Then, by using the quasi-natural experiment of low-carbon city pilots, it constructs a multi-period difference-in-differences model to comprehensively evaluate the actual effect of low-carbon city pilots on the high-quality economic development of cities. The following main conclusions are drawn: (1) Low-carbon city pilots have significantly promoted the high-quality economic development of cities. (2) The inspection of the impact mechanism finds that low-carbon city pilots promote the high-quality economic development of cities by adjusting and optimizing the industrial structure and encouraging green technological innovation.

5.2 Policy Implications

Firstly, Expand the pilot scope in a timely manner and give full play to the important role of the low-carbon city pilot in promoting high-quality economic development. Against the background of further implementing the new development concept and accelerating the era of high-quality economic development, governments at all levels should clearly recognize that low-carbon development is an important measure to achieve harmony between man and nature and promote high-quality economic development. Therefore, relevant decision-making departments should timely summarize pilot experience, form a comprehensive policy system that can be used for reference and replication, expand the pilot scope when the time is right, and finally promote it comprehensively.

Secondly, Smooth the role channels of the low-carbon city pilot in promoting high-quality economic development. Governments at all levels should further strengthen the integration of relevant policies such as finance and taxation, play a good combination of policies, fully connect the construction of low-carbon cities with important measures to promote high-quality economic development such as industrial structure optimization and adjustment and green technological innovation.

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References

[1] Zhou Q, Cui X, Ni H, *et al.* The Impact of Environmental Regulation Policy on Firms' Energy-Saving Behavior: A Quasi-Natural Experiment Based on China's Low-Carbon Pilot City Policy[J]. Resources Policy, 2022, 76(6): 102538.
[2] Niu H, Vatsa P, Li M J. Environmental regulation and energy efficiency: empirical evidence from the low-carbon city pilot program in China[J]. Energy efficiency, 2023, 16(6): 6111-6123.
[3] Wang Z Z, Zhou F T, Zhong J H. Can China's low-carbon city pilot policy facilitate carbon neutrality? Evidence from a machine learning approach[J]. Economic Analysis and Policy, 2024, 84(12): 756-773.
[4] Wang H, Gu K, Dong F, *et al.* Does the low-carbon city pilot policy achieve the synergistic effect of pollution and carbon reduction?[J]. Energy & Environment, 2024, 35(2): 569-596.
[5] Zhang J, Zhang L, Qin Y, *et al.* Influence of the Built Environment on Urban Residential Low-Carbon Cognition in Zhengzhou, China[J]. Journal of Cleaner Production, 2020,271(10): 122429.
[6] Liu X, Xu H. Does Low-Carbon Pilot City Policy Induce Low-Carbon Choices in Residents' Living: Holistic and Single Dual Perspective[J]. Journal of Environmental Management, 2022, 324(12): 116353.
[7] Zhao C, Wang B. Does China's Low-Carbon Pilot Policy Promote Foreign Direct Investment? An Empirical Study Based on City-Level Panel Data of China[J]. Sustainability, 2021,13(19): 10848.

[8] Qiu S, Wang Z, Liu S. The Policy Outcomes of Low-Carbon City Construction on Urban Green Development: Evidence from a Quasi-Natural Experiment Conducted in China[J]. Sustainable Cities and Society, 2021, 66(3): 102699.
[9] Zheng J, Shao X, Liu W, *et al.* The Impact of the Pilot Program on Industrial Structure Upgrading in Low-Carbon Cities [J]. Journal of Cleaner Production, 2021, 290(5): 125868.
[10] Chen H, Guo W, Feng X, *et al.* The Impact of Low-Carbon City Pilot Policy on the Total Factor Productivity of Listed Enterprises in China[J]. Resources, Conservation and Recycling, 2021, 169(6): 105457.
[11] Huang J, Zhao J, Cao J. Environmental Regulation and Corporate R&D Investment-Evidence from a Quasi-Natural Experiment[J]. International Review of Economics & Finance, 2021, 72(3): 154-174.
[12] Margaryan S. Low Emission Zones and Population Health[J]. Journal of Health Economics, 2021, 76(3): 102402.
[13] Ye J, Qin Z, Chen X. Adapt by Adopting Cleaner Vehicles?—Evidence from a Low-Emission Zone Policy in Nanchang, China[J]. China Economic Review, 2021, 66(4): 101598.
[14] Liu J B, Feng H Y, Wang K. The Low-Carbon City Pilot Policy and Urban Land Use Efficiency: A Policy Assessment from China[J]. Land, 2022, 11(5): 1-18.
[15] Liu Q Z, Li R K. Cities' low-carbon transformation and labor income share of companies: evidence from the low-carbon city pilot program in China[J]. Environmental Science and Pollution Research, 2023, 30(47): 104672-104686.
[16] Zhang B B, Zhou J T, Yan Z J. Low-carbon City Pilot Policies and Total Factor Energy Efficiency Improvement: A Quasi-Natural Experiment from the Implementation of Three Batches of Pilot Policies[J].Economic Review, 2021(05):32-49.
[17] Wang F, Ge X. Does the low-carbon transition impact employment: empirical evidence from low-carbon city pilots[J].China's Industrial Economy, 2022(05):81-99.
[18] Ge L M, Zheng H Y, Sun P B,Zhu J L.Low-carbon empowerment and efficiency: the impact of low-carbon city pilot policies on environmental welfare performance[J]. Statistical Research, 2024,41(02):100-113.
[19] Deng X, Ren Y M, Yu G H. Low-carbon City Construction and Industrial Structure Optimization and Upgrading:Empirical Evidence from Low-carbon City Pilot Work[J]. Soft Science, 2023,37(02):10-19.
[20] Song S Y, Wei X J. Low-carbon city construction, green technology innovation and inclusive low-carbon growth[J].Economic latitude,2023,40(05):14-25.
[21] Zhang Q, Li J, Huang L H. Coupling analysis and driving factors between carbon emission intensity and high-quality economic development: Evidence from the Yellow River Basin, China [J]. Journal of Cleaner Production, 2023, 423(10): 138831.
[22] Guo J, Sun Z X. How does manufacturing agglomeration affect high-quality economic development in China? [J]. Economic Analysis and Policy, 2023, 78(6): 673-691.