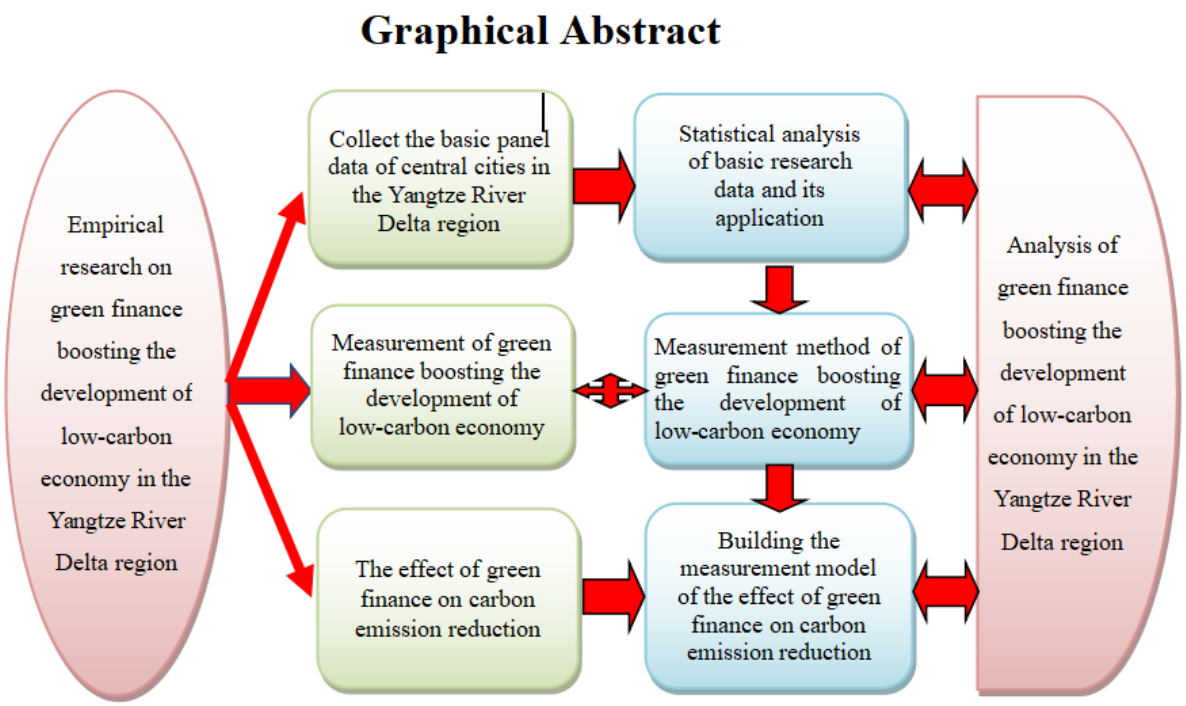
# Empirical research on green finance boosting the development of low-carbon economy in the Yangtze River Delta region

Chuanhui Wang[1], Yu Chao[1,2], Weifeng Gong[1,*]

[1]School of Economics, Qufu Normal University, Rizhao 276826, China

[2]School of Business,Nanjing University of Information Science and Technology, Nanjing 210044, China

## GRAPHICAL ABSTRACT




## ABSTRACT

In order to address the increasingly prominent issues of sustainable development in resources, environment, and ecology, the support of green finance and the transformation of a low-carbon economy are two complementary and pivotal strategies and paths on the journey towards achieving the grand goal of "carbon neutrality". To facilitate the smooth implementation of China's carbon emission reduction efforts, a thorough analysis of the coordinated development between green finance and the low-carbon economy is crucial. This paper utilizes panel data from central cities in the Yangtze River Delta region to conduct an analysis, exploring the impact of green finance levels on carbon emissions through the application of bidirectional fixed-effects and mediation effect models.The research results indicate that the level of green finance can suppress carbon emissions to

a certain extent and promote low-carbon development in the region. These findings are confirmed through robustness tests. In analyzing the mediation mechanism, it is discovered that government investment in environmental protection plays a mediating role in the process of green finance influencing carbon emissions. Additionally, a regional heterogeneity analysis reveals that regions with higher levels of green finance development exert a more significant impact on carbon emissions.
**Key words:** green finance, low-carbon economy, two-way fixed effects, mediating effects, regional heterogeneity

## 1. Introduction

The report of the 20th National Congress of the Communist Party of China profoundly expounded the core essence of "Chinese-style modernization", emphasizing the modernization process that harmoniously integrates humans and nature. With this strategic guidance, China's ecological civilization construction in the new era has identified green development as the overarching theme, striving to contribute a harmonious coexistence between humans and nature. Currently, all parties worldwide are facing the common challenge of global climate change, and there is a global consensus on promoting a low-carbon and green economic transformation in world economic development models. At the 75th United Nations General Assembly, General Secretary Xi Jinping clearly outlined the strategic vision of achieving "dual carbon" targets, which is a necessary path for economic restructuring to achieve higher-level transformation and upgrading, the core driving force for accelerating the construction of a new energy system, and an inherent requirement for achieving high-quality development.Green finance serves as a vivid practice of high-quality, low-carbon, and new development models in the financial sector. It acts as a financial lever to control carbon emission intensity and volumes, playing a pivotal role in promoting the smooth operation of the social economy, the sustainable development of the ecological environment, and the transition from a high-carbon, energy-intensive economic model to a low-carbon, energy-saving economic model. In 2016, China established a relatively comprehensive green finance policy system. In 2017, a green finance reform and innovation pilot zone was established, opening a new chapter in practice. In 2021, the significant value of green economy and the transformation of development models was further emphasized, and the crucial role of green finance was highlighted in the "Opinions on Carbon Peak and Carbon Neutrality Work". In 2022, the "14th Five-Year Plan" energy conservation and emission reduction program was issued, emphasizing green finance as a strategic priority. In 2023, the "Report on the Practice, Innovation, and Development of China's Green Finance" pointed out the need to promote the depth and breadth of green finance, fully stimulating its potential to support the achievement of carbon peak and carbon neutrality targets, and achieving coordinated progress in

carbon reduction, pollution reduction, environmental improvement, and high-quality development of the financial market. It is evident that in recent years, China has attached great importance to the development of green finance and viewed it as an essential mean to achieve "dual carbon" targets. The Yangtze River Delta region has achieved steady and significant progress in multiple key areas in recent years, gradually demonstrating its leadership in achieving basic modernization and regional integration. Against the dual backdrop of green finance gradually entering a fast-track development phase and the urgent need for the steady development of a low-carbon economy, it is of significant importance to deeply analyze the internal mechanisms of how green finance supports the development of a low-carbon economy and to construct a long-term and stable green finance support system.

## 2. Literature review

Green finance has gained significant attention due to its role in promoting green and sustainable development, and has become a current research hotspot. The study of its relationship with carbon emissions stems from the interconnection between financial development, the economy, and carbon emissions. This article reviews relevant literature and summarizes the findings from the perspective of a two-chain relationship as follows.

### *2.1. Research on the relationship between financial development and economic development*

The traditional development model achieves economic growth at the cost of massive resource consumption, while neglecting the importance of ecological and environmental protection, posing significant challenges to the living environment of human beings. With the increasing global awareness of environmental protection and energy conservation, the concept of green finance has gradually gained widespread recognition and promotion internationally.Since the signing of the Kyoto Protocol, green finance has gradually become a new tool for countries to achieve sustainable development goals. On the macroeconomic level, Yao Wang et al. (2016) believe that China's green finance promotes economic structural optimization and supply-side

quality improvement by mobilizing savings to form green investments, stabilizing economic growth, and ultimately optimizing China's macroeconomic development. Ngo et al. (2022) found through the fixed-effects model and generalized method of moments that green finance, capital formation, and government education expenditure have a positive correlation with economic development in ASEAN countries, and green finance has the important ability to improve the global economy, especially during the COVID-19 pandemic. Hong (2023) used the generalized method of moments (GMM) and fixed-effects model (FEM) to discover that renewable energy investments and green finance have a positive impact on economic performance.

### *2.2. Research on the relationship between economic development and carbon emission level*

Zhang et al. (2024) explored the coordination level between economic growth and carbon emissions through the entropy method and coupling coordination model, the research concluded that the coordination level between urban economic growth and carbon emissions is steadily increasing, and cities oriented by consumption continue to lead in this regard. Alam et al. (2016) conducted an empirical analysis using the autoregressive distributed lag (ARDL) bounds testing approach to examine the impact of income, energy consumption, and population growth on carbon monoxide emissions in India, Indonesia, China, and Brazil from 1970 to 2012, and found that in these four countries carbon emissions increase with the rise in income and energy consumption. Lihua He et al. (2015) argue that under the same economic growth rate, the optimization of energy structure reduces carbon emission intensity; conversely, under the same energy adjustment, faster economic growth leads to higher carbon emission intensity. Based on the research of the above scholars, it can be concluded that carbon emission intensity is influenced by both economic aggregate and economic structure. Therefore, how to achieve the minimum carbon emission per unit during economic transformation is a key issue that needs to be addressed at the current stage.

*2.3. Research on the relationship between financial development and carbon emission level*

In the era of low-carbon economy, traditional financial theories and practices have been revealed their limitations, and the financial innovation is needed. In recent years, research on the impact of green finance on low-carbon development has flourished. From the analysis process, some scholars believe that financial development can promote the development of a low-carbon economy directly(Bo Huang et al., 2023). Feng Liu et al. (2022) found that green finance effectively reduces carbon emissions by optimizing energy consumption structure and making substantial green technological innovations (green innovations that follow ecological principles and ecological economic laws). Ren et al. (2023) analyzed the short-term and long-term effects of financial development on carbon emissions in 30 provinces in China from 2000 to 2019 using a pooled mean group estimator. No significant short-term relationship was observed in this progress, but in the long run, financial development significantly reduced carbon emissions. Habiba et al. (2023) concluded through methods such as cross-sectional dependence tests, heterogeneity tests, and Westerlund cointegration tests that financial development increases carbon emission levels, leading to environmental degradation and the environmental harm of financial development tends to be smaller when combined with renewable energy. The study also revealed that financial development can improve environmental quality through green technology channels. As the world's largest carbon emitter, China's excessive carbon emissions not only threaten the health of the ecological environment, but also posing a serious challenge to the sustainable development of the economy and facing a severe situation of energy conservation and emission reduction,the issues such as environmental pollution and resource carrying capacity are becoming more and more serious.Therefore, the implementation of green financial policies is not only an urgent need to address current environmental issues, but also a requirement of the times to achieve economic development and social harmony.

In summary, this paper delineates the research trajectory of the relationship

between green finance and carbon emissions, providing a robust theoretical foundation for subsequent empirical studies. However, despite the literature review encompassing multiple relevant fields, there remains a lack of in-depth analysis regarding specific green finance policies and their practical impact on carbon emissions. Further research could explore the precise content and implementation effects of green finance policies, as well as how these policies influence carbon emissions through various mechanisms, with the aim of offering more concrete and practical guidance to policymakers. Moreover, considering the unique economic and social context of the Yangtze River Delta region, this study could analyse in greater detail the characteristics and efficacy of green finance practices in this area, thereby enriching the theoretical framework of green finance and providing reference cases for other regions.

## 3. Research status and theoretical assumptions

### *3.1. Research status*

The Yangtze River Delta planning region is the first batch of regional planning pilot areas in China, boasting strong comprehensive strength. Particularly, the ecological green integration of the central urban areas of the Yangtze River Delta plays a regional radiation and driving role in achieving "carbon neutrality" and "carbon peaking", innovating low-carbon development paths, promoting the construction of environmental protection projects, and fostering regionally friendly development.

#### 3.1.1. Development status of green finance in the central city area of the Yangtze River Delta

The Yangtze River Delta region is one of the representative areas of economic prosperity in China and an important field for the development of green finance. In the process of enhancing the level of green financial services in Yangtze River Delta cities to improve regional competitiveness and guiding capital flows to promote the transformation and upgrading of traditional industries, regional financial institutions have launched a series of green financial products to expand the financing needs of environmentally friendly projects, strongly supporting the development of green industries and green projects, and promoting the implementation of green financial

policies.

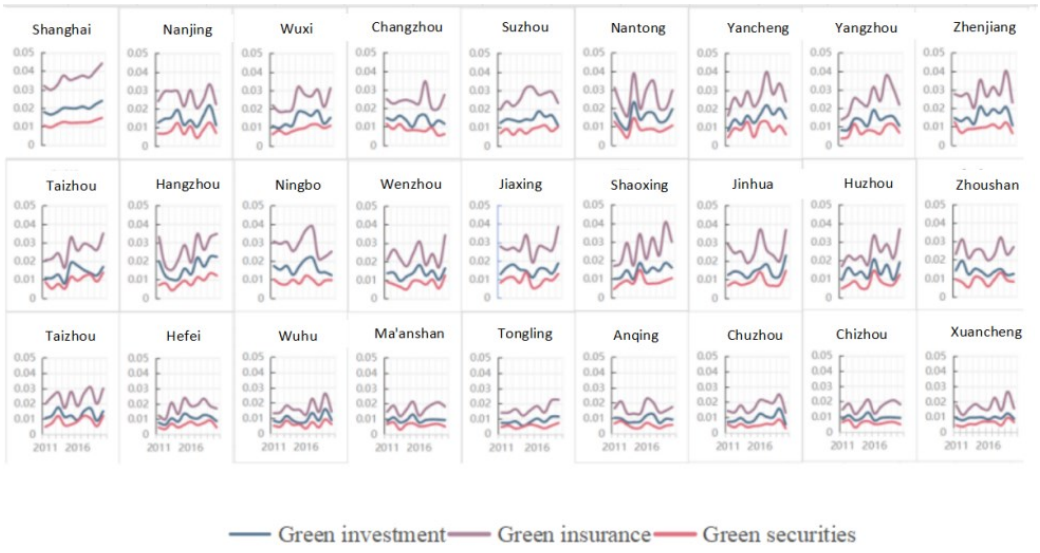



Figure 1 Green finance level of all prefecture-level cities in the Yangtze River Delta from 2011 to 2020

Twenty seven prefecture-level cities in the central cities of the Yangtze River Delta continued to promote the construction of green finance from 2011 to 2020 in Figure 1. With the promotion of green financial products by investment institutions, banks, insurance companies, and other institutions, the promotion of green finance concepts by media departments, and the support of government departments for the development of green finance, regional green investment, green insurance, and green securities have generally shown an increasing trend. From the perspective of cities, Shanghai has made significant achievements in the development level of green finance and has strong leadership. Among different prefecture-level cities, there are varying degrees of differences in the development level of green finance.

3.1.2. Current situation of urban carbon emission intensity in the Yangtze River Delta

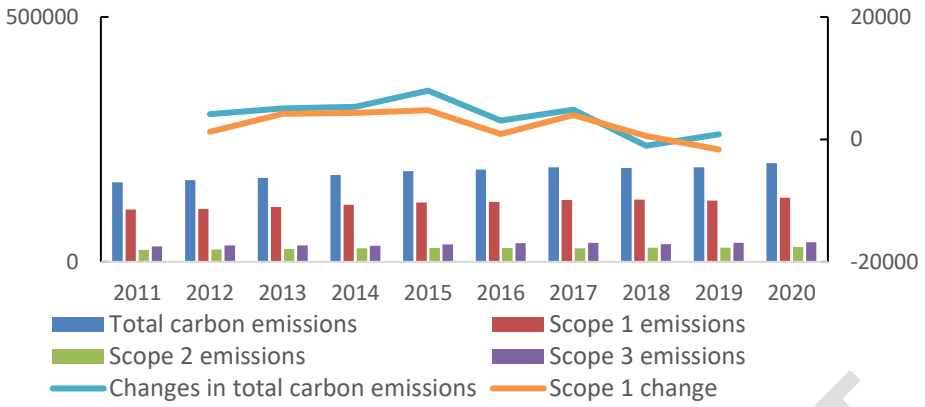



Figure 2 The composition and changes of carbon emissions in central cities in the Yangtze River Delta

As one of the seven major urban agglomerations in China, the Yangtze River Delta has an optimized industrial structure and serves as one of the major economic pillars for China's strong and rapid development. The carbon emission intensity of this urban agglomeration has been at a relatively high level, mainly due to carbon emissions from industries such as industrial production and transportation. Given the impact of COVID-19 in 2020, which led to a recession in the world economy, uncertain development prospects for enterprises, a decline in residents' living standards, and weak environmental awareness among different social entities such as enterprises and residents during this period, this article does not consider the changes in carbon emission intensity in 2020. Scopes 1, 2, and 3 constitute the main sources of carbon emissions, with Scope 1 accounting for the highest proportion, covering all direct emissions generated within the urban area. As shown in Figure 2, the total energy-related carbon emissions in Yangtze River Delta central cities increased from 2011 to 2020. The overall carbon emission intensity and the carbon emission intensity of Scope 1 exhibit strong fluctuations, but both show a decreasing trend in the troughs from 2011 to 2019. Moreover, the decline in Scope 1 exhibits a trend of increasing duration, indicating that the region may have adopted certain environmentally friendly measures in areas such as technological innovation and energy structure adjustment to improve efficiency in transportation and construction, refine industrial production processes, and enhance the safety and sustainability of waste disposal. Adjustments in the carbon emission structure can directly influence the changes in carbon emission levels. With

social and economic progress and development, a lower level of carbon emissions generated by primary energy in Scope 1 will be more conducive to achieving the "dual carbon goals".

### *3.2. Theoretical hypothesis*

After analyzing the actual development trend of green finance and carbon emission intensity in the central cities of the Yangtze River Delta, the following related hypotheses are proposed, which are specified as follows.

Green finance promotes the application of low-carbon technologies and clean energy by providing financing support for environmentally friendly projects, thereby directly reducing carbon emissions. Ren et al. (2023) analysed the long-term impact of financial development on carbon emissions through averaging group estimators, finding that financial development significantly reduces carbon emissions. Additionally, Ren et al. (2023) employed a multi-period Difference-in-Differences (DID) model to examine the impact of green finance policies on carbon emissions at the provincial level in China, revealing that these policies significantly lower carbon emissions at this level, thus confirming the direct effect of green finance on carbon intensity. Furthermore, research by Wang and Zhao (2022) indicates that the issuance of green bonds plays a significant role in reducing regional carbon emissions, particularly in supporting renewable energy projects. Finally, a cross-country comparison by Habiba et al. (2023) found that the development of green finance has a universal effect on curbing carbon emissions, with mechanisms that include providing funding support for low-carbon technologies and clean energy projects. Based on these findings, it is proposed:

**Hypothesis 1:** Green finance has a direct impact on the carbon emission intensity of the central urban areas of the Yangtze River Delta.

The specific forms of green finance influence carbon emission intensity and simultaneously accelerate the green upgrading of infrastructure and the emergence of green services, with the government playing multiple roles in industrial development, such as guiding and supporting, promoting innovation and transformation, and facilitating the development of industrial clusters. Research by Wang et al. (2024) found

that governmental environmental regulations serve as a partial intermediary in the process through which green finance impacts urban carbon emissions. Zhao et al. (2023) further pointed out that green finance enhances the positive effects of changes in industrial structure on the development of renewable energy, indirectly propelling low-carbon growth. Additionally, research by Huang Bo et al. (2023) indicates that green finance indirectly reduces carbon emissions by promoting green technological innovation and optimising energy structure. Habiba et al. (2023) also discovered that financial development improves environmental quality through green technology channels, thereby indirectly facilitating a reduction in carbon emissions. Thus, it is inferred that budgetary expenditures by the government for environmental protection have an intermediary effect in the low-carbon development of the core urban areas of the Yangtze River Delta, meaning that the influence of green finance on carbon emission intensity in these areas exhibits indirect effects. Based on this, it is proposed:

**Hypothesis 2**: Green finance has an indirect impact on the carbon emission intensity of the central urban areas of the Yangtze River Delta.

Due to the fact that the central urban areas of the Yangtze River Delta encompass 27 prefecture-level cities across four provinces—Shanghai, Jiangsu, Zhejiang, and Anhui—there are significant disparities in development not only between these provinces but also among the cities themselves. This includes variations in industrialisation levels and urbanisation processes. Consequently, it can be inferred that the level of development of green finance varies by region, which in turn affects carbon emission intensity differently across regions. Wang et al. (2023) conducted a comparative analysis of various cities in the Yangtze River Delta and found that green finance policies exert a more pronounced suppression effect on carbon emissions in economically developed cities with optimised industrial structures. Similarly, Ren et al. (2023) revealed differences in the impact of financial development on carbon emissions among different provinces. Liu et al. (2021) utilised a spatial econometric model to analyse the effects of green finance policies on carbon emissions across various regions in China, and similarly concluded that the efficacy of these policies exhibits regional heterogeneity. This regional heterogeneity suggests that when formulating green

finance policies, it is essential to consider the specific circumstances of each region and to promote low-carbon development in a tailored manner.

**Hypothesis 3:** The level of green finance has a regionally heterogeneous effect on the carbon emission intensity of the central urban areas of the Yangtze River Delta.

## 4. Empirical analysis

### *4.1.* Study subjects and data sources

#### 4.1.1. Study subjects

The theoretical model of this article aims to explore the internal mechanism of the interaction between the green financial policy measurement indicators and the development of low-carbon economy of the central cities in the Yangtze River Delta. By adding environmental protection support factors to the carbon emission intensity model to analyze the mediating effect and explore the impact of green finance, this article analyzes the mechanism of green finance on carbon emission intensity. Based on the above ideas, this article can systematically analyze the behavioral path of green financial policy affecting the development of low-carbon economy.Based on the four provinces of Shanghai, Jiangsu, Zhejiang, and Anhui, and considering the limited data availability in Shanghai, this paper divides the central urban areas of the Yangtze River Delta into three major regions for better analysis of the regional heterogeneity effect of green finance levels on carbon emission intensity: Jiangsu Province, including Nanjing, Wuxi, Changzhou, Suzhou, Nantong, Yancheng, Yangzhou, Zhenjiang, and Taizhou; Zhejiang Province, comprising Hangzhou, Ningbo, Wenzhou, Jiaxing, Huzhou, Shaoxing, Jinhua, Zhoushan, and Taizhou; and Anhui Province, including Hefei, Wuhu, Ma'anshan, Tongling, Anqing, Chuzhou, Chizhou, and Xuancheng.

#### 4.1.2. Data sources

The construction of the comprehensive evaluation system is based on the samples of prefecture-level cities in the central cities of the Yangtze River Delta from 2011 to 2020, with data sources including national, provincial, and municipal statistical yearbooks, energy and financial yearbooks, and the authoritative websites such as

People's Bank of China.

4.1.3. Analysis of the implementation of green finance policies in prefecture-level cities

This article employs the product of green securities and regional gross domestic product (GDP) to measure the significant contribution of green securities to regional economic development and environmental protection. A higher ratio indicates a greater combined effect of green securities on economic development and environmental protection, which plays a crucial role in guiding industrial development and allocating resources for the government. This is conducive to promoting the progress of environmental protection projects and effectively addressing environmental issues. "Carbon peaking" refers to the situation where carbon emissions reach their peak at a certain point in time and then gradually decline. This implies that economic growth will lead to an increase in carbon emissions before carbon peaking. Therefore, after excluding economic factors, the product of green securities and regional GDP can be used to measure the impact of green finance on carbon emissions.

*4.2 Model setting and variable selection*

4.2.1. Model specification

This paper employs a panel data fixed-effects model. Under the premise of controlling the influence of other variables, the article first utilizes the ordinary least squares method to conduct a benchmark regression analysis on green finance and low-carbon emission reduction in the central urban cities of the Yangtze River Delta region. The following econometric model (1) is constructed:

$$CI = \alpha_1 + \alpha_2 GF_{it} + \alpha_i \sum X_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (1)$$

To explore the indirect mechanism of the carbon emission reduction effect of green finance, models (2) and (3) are constructed. Model (2) examines the relationship between environmental support factors and green finance, while model (3) primarily discusses whether there is a mediating effect of environmental support factors on carbon emissions. The models are as follows:

$$GF_{it} = \alpha_1 + \alpha_2 Sup_{it} + \alpha_i \sum X_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (2)$$



(3)

$$CI = \alpha_1 + \alpha_2 GF_{it} + \alpha_3 Sup_{it} + \alpha_i \sum X_{it} + \mu_i + \gamma_t + \varepsilon_{it}$$

In the above models, the subscript $i$ represents each city, and the subscript $t$ represents time. Dependent variable $CI$ is carbon dioxide emission intensity, and the core explanatory variable $GF$ represents the development level of green finance, $X$ denotes a series of control variables, and the regression coefficient $\alpha_1$ reflects the degree of impact of green finance on regional carbon emissions. $\mu$ represents the cross-sectional fixed effect, $\gamma$ represents the time fixed effect, and $\varepsilon$ is the random disturbance term.

4.2.2. Variable selection

(1) Dependent Variable. The measurement of carbon emissions varies depending on the perspective of measurement. Drawing on the research ideas of Cong et al.(2014), this paper analyzes urban carbon emissions from both production and consumption perspectives, and accurately measures carbon emissions by establishing the relationship between direct measurement, indirect measurement, and life cycle measurement. In this article, the ratio of all direct emissions generated within the urban area, which are referred to as Scope 1, accounting for the total carbon emission intensity, is adopted to represent the explained variable.

(2) Core Explanatory Variable. With the increasing global concern for environmental protection and sustainable development, the green securities market has also undergone rapid development. Many national and local governments have encouraged the issuance of green securities through subsidies and tax exemptions to promote the development of the green economy. To a certain extent,the total issuance of green securities can measure the degree of environmental sustainability. The implementation of green finance policies can facilitate the flow of funds towards low-carbon and environmentally-friendly projects, thereby reducing carbon emissions. For instance, the study by Hao et al. (2021) found that financial instruments such as green credit and bonds can reduce carbon dioxide emissions. Additionally, Zhao et al. (2023) demonstrated that green finance can enhance the positive impact of industrial structural

changes on the development of renewable energy.In this context, the total issuance of green securities can be expressed as a part of the implementation effect of green financial policies. Combining it with regional GDP can be used to measure the balance between environmental protection and economic growth achieved by green financial policies.

(3) Mediating Variable. The government can expand its environmental fiscal expenditure by providing subsidies, tax incentives, and other measures to encourage enterprises to invest and implement environmental protection projects. In turn, enterprises can reduce waste emissions during production through environmental protection measures such as increasing the proportion of clean energy and optimizing resource utilization efficiency, thus promoting the achievement of energy conservation and emission reduction goals. Research by Wang et al. (2024) has identified a link between public environmental concerns and urban carbon emissions, with environmental regulation serving as a partial mediating factor. As green finance develops, governments are investing more financial resources to support green industries and the research and application of low-carbon technologies, such as clean energy projects and energy-saving technological upgrades. These initiatives require substantial funding, and the extent of government support directly affects the effectiveness of their implementation.In this paper, the proportion of fiscal environmental protection expenditure is selected to reflect the government's support for green financial policies and serves as a mediating variable for the impact of green financial policies on carbon emission.

(4) Control Variables. Drawing on the research of Zhao et al. (2020), this paper controls the characteristic variables that may affect carbon emission intensity. It adopts indicators such as industrial structure, level of opening up, industrialization level, urbanization ratio, and financial development degree as control variables.

Table 1 The definitions of the variables and their measures

| Variable type | Variable name | Variable code | Variable measure |
|---|---|---|---|
| Core explanatory | Green finance level | GF | ln（the proportion of |

| | | | |
|---|---|---|---|
| variables | | | environmental securities * regional GDP) |
| Dependent variable | Carbon emission intensity | CI | Range 1 / total carbon emissions |
| Mediating variable | Environmental support | Sup | Financial and environmental protection expenditure / general budget expenditure |
| Control variables | industrial structure | Stru | added value of the tertiary industry / regional GDP |
| | Open to the outside world | Open | Total import and export volume of goods / regional GDP |
| | Industrialization level | Ind | Industrial added value / regional GDP |
| | Urbanization ratio | Urban | Urban population / permanent resident population |
| | Financial development degree | Finance | Total deposits of financial institutions / regional GDP at the end of the year |

4.2.3. Descriptive Statistics

The twenty seven cities in Shanghai, Jiangsu, Zhejiang, and Anhui are defined as the coverage of the central urban areas of the Yangtze River Delta in the "Outline of the Development Plan for the Integration of the Yangtze River Delta Region". The research data covers the time dimension from 2011 to 2020, which is obtained from authoritative institutions such as local statistics bureaus' statistical yearbooks, and the People's Bank of China. The missing values in the data are processed using interpolation methods. The descriptive statistics of the variables are detailed in Table 2.

Table 2 Descriptive statistics

| Variable code | Observed value | Mean value | Standard deviation | Minimum value | Maximal value |
|---|---|---|---|---|---|
| CI | 270 | 0.654 | 0.028 | 0.603 | 0.695 |
| GF | 270 | 3.245 | 1.151 | 1.142 | 5.272 |
| Stru | 270 | 0.454 | 0.0915 | 7.31e-05 | 0.727 |
| Open | 270 | 0.0294 | 0.0185 | 0.000421 | 0.0932 |
| Ind | 270 | 0.422 | 0.076 | 0.206 | 0.697 |
| Urban | 270 | 0.656 | 0.103 | 0.381 | 0.896 |
| Finance | 270 | 2.900 | 0.990 | 1.400 | 6.275 |
| Sup | 270 | 0.008 | 0.004 | 0.001 | 0.020 |

As shown in Table 2, the average proportion of Scope 1 in total carbon emissions

is 0.695, indicating that the proportion of Scope 1 in the overall carbon emission structure of the central urban areas of the Yangtze River Delta exceeds the sum of Scope 2 and Scope 3. The standard deviation of 0.028 for the proportion of Scope 1 suggests that there is little difference in the composition of carbon emission intensity among the central urban areas in the Yangtze River Delta. The average level of green financial development is 3.245, with a minimum of 1.142, a maximum of 5.272, and a standard deviation of 1.151, indicating variations in the level of green financial development across different years and regions. The relatively large standard deviation of 0.990 for the level of financial development suggests that while the central urban areas of the Yangtze River Delta are generally economically developed, there is still considerable unevenness in the level of financial development among different prefecture-level cities.

*4.3 Results analysis and discussion*

4.3.1. Analysis of the benchmark regression results

Table 3 Estimation results of carbon emission intensity based on green finance development level

| | （1） | (2) | (3) | (4) | （5） |
|---|---|---|---|---|---|
| Variable | CI | CI | CI | CI | CI |
| GF | -0.002 | -0.004** | -0.004** | -0.004** | -0.006** |
| | (-1.54) | (-2.55) | (-2.37) | (-2.45) | (-3.12) |
| Stru | | 0.034* | 0.031 | 0.037 | 0.011 |
| | | (2.07) | (1.62) | (1.18) | (0.58) |
| Open | | | -0.070 | -0.081 | -0.127 |
| | | | ( -0.63 ) | (-0.68) | (-1.16) |
| Finance | | | -0.001 | -0.001 | -0.002 |
| | | | (-0.22) | (-0.06) | (-0.81) |
| Ind | | | | 0.016 | -0.010 |
| | | | | (0.659) | (-0.31) |
| Urban | | | | | 0 .064* |
| | | | | | (2.03) |
| Constant | 0.66*** | 0.651*** | 0.655*** | 0.645*** | 0.641*** |

| | | | | | |
|---|---|---|---|---|---|
| | (127.46) | (81.10) | (102.07) | (26.67) | (41.04) |
| Observations | 270 | 270 | 270 | 270 | 270 |
| Number of id | 9 | 9 | 9 | 9 | 9 |
| R-squared | 0.0096 | 0.0166 | 0.0175 | 0.0183 | 0.0347 |
| Time fixed effect | control | control | control | control | control |
| City fixed effect | control | control | control | control | control |

*** p<0.01, ** p<0.05, * p<0.1 (similarly hereinafter)

The final regression results in Table 3 show that for every unit increase in the level of green financial development, the carbon emission level decreases by 0.006 units. This indicates that the implementation of green financial policies has an inhibitory effect on carbon dioxide emissions, which is highly consistent with previous research conclusions (Chen et al., 2023). It suggests that the conclusion is universal, and thus Hypothesis 1 is supported.

First, a benchmark regression was conducted to examine whether the implementation of green financial policies promotes low-carbon emission reduction in the central urban areas of the Yangtze River Delta. The results are shown in Table 3. Using a step-by-step regression method, the core explanatory variable was first added to the model, and the regression results are presented in column (1) of Table 3. The results indicate that the implementation of green financial policies reduces regional carbon emissions, but the effect is not significant. Column (5) of Table 3 reflects the regression results after adding other control variables. It can be seen that the direction of the impact of green financial policies on carbon emission intensity remains unchanged after adding other control variables. However, for every unit increase in the level of green financial development, the carbon emission level decreases from 0.002 units to 0.006 units, significantly promoting low-carbon development in the central urban areas of the Yangtze River Delta. Data analysis shows that an increase in the urbanization rate inhibits low-carbon development in the central cities of the Yangtze River Delta, indicating that an increase in the urban population leads to an increase in total carbon emissions. This may be attributed to the increased demand for public and

private transportation caused by the growing urban population, which leads to increased automobile exhaust emissions. Additionally, to meet the increased housing demand, forests that absorb carbon dioxide are cut down, and waste disposal, especially incineration, also generates a certain amount of carbon emissions. Overall, an increase in the urbanization rate primarily leads to an increase in carbon emissions through Scope 1. Furthermore, the industrial structure has a positive effect on carbon emissions, while the level of openness, financial development, and industrialization have negative inhibitory effects on carbon emissions, but the regression results are not significant. The insignificant promotion of the industrial structure on carbon emissions may be due to the fact that the industrial structure in the Yangtze River Delta region is no longer dominated by heavy industry, but has formed a new structure led by the service industry and high-tech industries, leading to a reduction in carbon emissions. However, traditional manufacturing and energy-intensive industries still account for a certain proportion in some regions, especially in some urban and industrial areas, and the total energy consumption in the Yangtze River Delta region is still increasing. There is a high dependence on fossil fuels such as coal, and with the rapid development of information technology, the popularity of electronic devices has greatly increased. These devices may generate carbon emissions during production, use, and disposal, especially when equipment is frequently updated. Therefore, the impact of the industrial structure on carbon emissions is influenced by multiple factors.

4.3.2. Mediator effect analysis

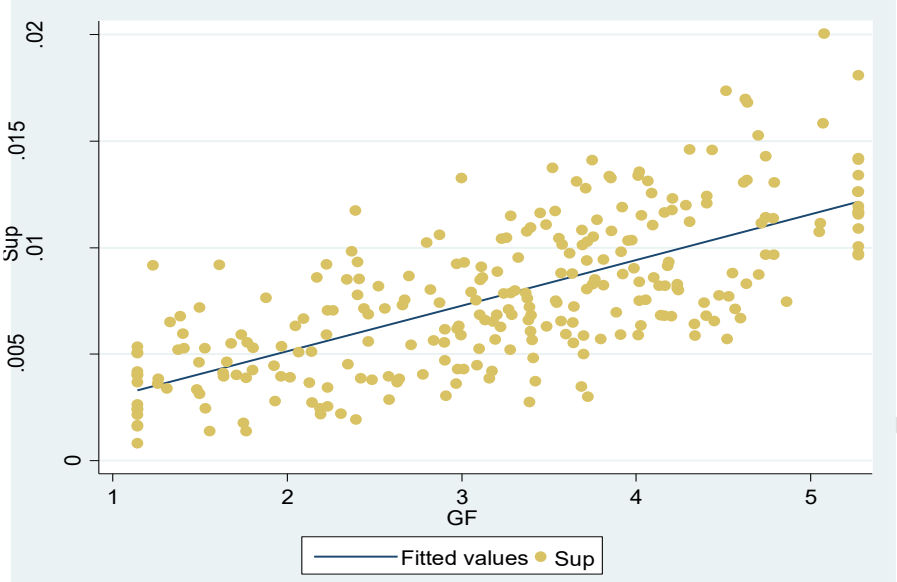



Figure 3 Scatter plot and fitting curve of green finance level and environmental protection support

Based on the fitting curve and scatter plot of green finance level and environmental protection support in Figure 3, it can be concluded that there is a positive correlation between the development level of green finance and environmental protection support. Wang et al.(2024)found through their research on the behavioral strategies and interactive relationships among the government, enterprises, and financial institutions in promoting emission reduction that government encouragement plays a crucial role in environmental sustainability. This paper empirically explores whether there is a mediating effect between the level of financial development and carbon emissions through Sobel test and Bootstrap test.

Table 4 Sobel mediation effect test for environmental protection support

| | Benchmark regression results without mediators | Environmental support | |
|---|---|---|---|
| | | Intermediary factor test | Contains intermediary factors |
| | | Environmental support | CI |
| | (1) | (2) | (3) |
| GF | -0.003*<br>(-2.00) | 0.002*** | 0.0004 |

| | | | |
|---|---|---|---|
| | | (15.2) | (0.19) |
| Environmental support | | | -1.446** (2.07) |
| Control variables | control | control | control |
| Time fixed effect | control | control | control |
| City fixed effect | control | control | control |
| R-squared | 0.0144 | 0.5095 | 0.0310 |
| Sobel test | | -0.036** (z=-2.103) | |
| Goodman test1 | | -0.036** (z=-2.098) | |
| Goodman test2 | | -0.036** (z=-2.107) | |
| Intermediary effect coefficient | | -0.0036 | |
| Direct effect coefficient | | 0.0004 | |
| Total effect coefficient | | -0.0031 | |
| Mediator effect ratio | | 1.1527 | |

As can be seen from Table 4, the mediation effect coefficient of the Sobel test is -0.0036, the direct effect coefficient is 0.0004, and the total effect is -0.0031. The z-value is -2.103, indicating that environmental protection support significantly promotes low-carbon development through green finance at a 95% confidence level.

Table 5 Test of Bootstrap mediation effect for environmental support

| | Coef. | Std. Err. | z | P>z | [95% Conf. Interval] |
|---|---|---|---|---|---|
| _bs_1 | -0.0035946 | 0.0017239 | -2.09 | 0.037 | [-0.006973, -0.0002158] |
| bs_2 | 0.0004761 | 0.0024573 | 0.19 | 0.846 | [-0.0043402, 0.0052923] |

This method is based on the Bootstrap sampling principle. As can be seen from Table 5, the confidence interval of the mediating effect of environmental protection support is [-0.0069735, -0.0002158], which does not include 0. This indicates that environmental protection support has a significant mediating effect in the process of

green finance promoting low-carbon development.

The results of both Sobel test and Bootstrap test indicate that environmental protection support has a significant mediating effect in the process of green finance promoting low-carbon development. However, after including environmental protection support, the level of green finance has an insignificant positive effect on carbon emission intensity. After systematic analysis, the reason may be related to the definition of green finance level in this paper. This paper defines the level of green finance as a dual variable reflecting both economic and environmental aspects. With economic growth, the level of carbon emissions may increase, but the regression results between this variable and carbon emission intensity show that it has a negative effect on carbon emission intensity. Therefore, it can be concluded that before reaching the peak of carbon emissions and without adding mediating variables, this indicator's negative impact on the environment outweighs its positive impact on the economy, promoting low-carbon development. When mediating variables are included, this indicator shows a promoting effect on carbon emissions, indicating that at this time, its negative impact on the environment is less than its positive impact on the economy. Therefore, the reason for this change may be that the government's increased spending on environmental protection has a greater effect on promoting economic development than on supporting green development. Based on the above analysis, it can be concluded that environmental protection support has a significant mediating effect in the process of green finance promoting low-carbon development, i.e., green finance has an indirect impact on carbon emission intensity in the central urban areas of the Yangtze River Delta. Therefore, Hypothesis 2 is valid.

4.3.3. Further discussion

（1）Analysis of the regional heterogeneity

In previous studies, Feng et al. (2022) analyzed the heterogeneity between China's southern and northern regions and found that the development of green finance in China can significantly reduce carbon emissions, with notable regional heterogeneity. Wang et al. (2023) analyzed the heterogeneity in China's eastern, central, and western regions and concluded that green finance can reduce carbon emissions in the central and

western regions, while its impact on eastern provinces is not significant, demonstrating regional heterogeneity. This paper, drawing on the research of the aforementioned scholars, takes the central urban areas of the Yangtze River Delta in southeast China as the research object and explores the regional heterogeneity of green finance's impact on carbon emissions by internally dividing the region. In Hypothesis 3, the central urban areas of the Yangtze River Delta have been divided into Shanghai, Jiangsu Province, Zhejiang Province, and Anhui Province based on provincial regions. However, given the limited data availability of Shanghai, this paper excludes it from the analysis of regional differences to ensure the accuracy and reliability of the analysis results.

Table 6 Test of regional heterogeneity of carbon emission intensity

| Area | Variable | Coefficient | SE | T value | P value |
|---|---|---|---|---|---|
| Jiangsu Province | GF | 0.016* | 0.0077 | 2.09 | 0.071 |
| | Ind | 0.0489 | 0.2332 | 0.21 | 0.839 |
| | Urban | -0.2307 | 0.1504 | -1.53 | 0.164 |
| | Number of obs | 90 | | | R-squared 0.1298 |
| | Variable | Coefficient | SE | T value | P value |
| Zhejiang Province | GF | -0.0132 | 0.01 | -1.32 | 0.223 |
| | Ind | -0.233 | 0.1803 | -1.29 | 0.232 |
| | Urban | 0.0563 | 0.2517 | 0.22 | 0.829 |
| | Number of obs | 90 | | | R-squared 0.1594 |
| | Variable | Coefficient | SE | T value | P value |
| Anhui Province | GF | -0.0027 | 0.0151 | -0.18 | 0.862 |
| | Ind | 0.1781 | 0.1065 | 1.67 | 0.139 |
| | Urban | 0.0373 | 0.0471 | 0.79 | 0.455 |
| | Number of obs | 80 | | | R-squared 0.1600 |
| Time fixed effect | | | | control | |
| City fixed effect | | | | control | |

Regression results from Table 6. In Jiangsu Province, the development level of green finance exhibits a significant positive influence on carbon emission intensity. The development level of green finance in Jiangsu has a notable positive effect on carbon emission intensity. This might imply that while the level of green finance development

in Jiangsu can promote economic growth, it concurrently accompanies an increase in carbon emission intensity. This could be because certain green finance projects are not yet fully mature, or the implementation effects of green finance policies have not fully manifested, leading to a short-term increase in emissions from economic growth that surpasses the reduction effect brought by green finance. In contrast, in Zhejiang and Anhui provinces, the impact of green finance development levels on carbon emission intensity is not significant, with negative coefficients. This might suggest that these two provinces have not yet fully realised the potential emission reduction effects of green finance, or their development is still in the early stages. The analysis shows that the impact of green finance development levels on carbon emission intensity varies between regions, confirming Hypothesis 3: that green finance levels have a heterogeneous regional effect on the carbon emission intensity of central urban areas in the Yangtze River Delta.

According to the study by Wang et al. (2023), green finance can reduce carbon emissions in the central and western regions, while its impact on the eastern provinces is not significant, consistent with the regression results for Zhejiang and Anhui provinces in Table 6. This suggests that in eastern provinces such as Zhejiang, where green finance policies were implemented earlier, their effect on carbon emission intensity has stabilised. In contrast, Anhui is undergoing rapid industrialisation, and the development of green finance has not yet sufficiently offset the increase in carbon emissions arising from this industrialisation process.

In summary, the results in Table 6 indicate significant regional heterogeneity in the impact of green finance development on carbon emission intensity across Jiangsu, Zhejiang, and Anhui provinces. In Jiangsu Province, the development of green finance has a notable, positive effect on carbon emission intensity, potentially linked to the province's economic development model. Conversely, in Zhejiang and Anhui provinces, the influence of green finance on carbon emission intensity is insignificant, possibly reflecting the degree of implementation of green finance policies and the developmental stage these provinces are in. These findings suggest that differentiated policies should be adopted based on the characteristics of each province to more effectively leverage

green finance in promoting low-carbon economic development.

（2）Robustness test

The robustness test aims to examine the stability and reliability of empirical results by adjusting or changing a key parameter or assumption in the research and repeating the experiment or analysis. This article will investigate whether the empirical results and explanatory power of the green finance level on carbon emission intensity remain robust from three perspectives.

Table 7 The robustness test

| | Replace explanatory variables | Avoid outliers | Replace the dependent variable |
|---|---|---|---|
| | (1) | (2) | (3) |
| | -0.0001** | -0.006*** | 0.003** |
| | (-2.18) | (-3.07) | (2.60) |
| Control variables | control | control | control |
| _cons | 0.656 | 0.640 | 0.3168 |
| | 44.81 | 40.89 | 19.91 |
| Time fixed effect | control | control | control |
| City fixed effect | control | control | control |
| R-squared | 0.011 | 0.036 | 0.0197 |

Column (1) of Table 7 tests the robustness of the model by replacing the explanatory variable, following the research approach of Chen et al. (2023). Specifically, the ratio of the total green credit at the end of the year in prefecture-level cities to the regional GDP is used to measure the level of green finance development. The results show that the replaced explanatory variable can significantly inhibit carbon emissions at the 95% level. In regression analysis, excluding outliers can optimize data quality. Column (2) of Table 7 borrows from the robustness test approach of Li et al. (2024) by performing a 5% tail truncation on the data to avoid unrealistic regression results. The regression results do not change substantially. Column (3) of Table 7 conducts a robustness test by replacing the explained variable, specifically by replacing it with the

sum of the proportions of Scope 2 and Scope 3. The empirical results indicate that the level of green finance development has a positive effect on the sum of the proportions of Scope 2 and Scope 3, while total carbon emissions are composed of these three categories. This suggests that the level of green finance development significantly inhibits the original explained variable, and the original conclusion remains valid.

The robustness test is passed through the methods of replacing the explanatory variable, excluding outliers, and replacing the explained variable. Therefore, the promoting effect of the level of green finance on low-carbon development is robust.

## 5. Conclusion and policy recommendations

### *5.1. Main conclusion*

Based on the data from 27 cities in the central urban areas of the Yangtze River Delta from 2011 to 2020, this study conducted in-depth empirical analysis to explore the specific impact of the development level of green finance on carbon emissions, employing panel regression analysis and mediation effect models. To ensure the general adaptability and stability of the research results, this paper also conducted regional heterogeneity test and robustness test to comprehensively validate the regression results. The main conclusions of this paper are as follows: Firstly, green finance can significantly inhibit carbon emissions. With the increasing severity of global environmental issues, the importance of green finance is constantly rising, which is not only a necessary measure to respond to global environmental protection challenges, but also an inevitable choice to promote long-term, stable, and sustainable economic development. Green finance serves as a crucial driving force for energy conservation and emission reduction, as well as a key step in optimizing economic development paths and achieving sustainable development. Secondly, environmental protection support has a significant mediation effect on the impact of green finance on carbon emissions. The greater the government's fiscal budget expenditure on environmental support and protection, the stronger the inhibitory effect on carbon emissions. Through the analysis of regional heterogeneity in carbon emissions, it is found that there are significant differences in the development of green finance in the central cities of the Yangtze River

Delta, and regions with higher levels of green finance have a more significant impact on carbon emission intensity. Thirdly, after conducting robustness tests using three methods: replacing explanatory variables, avoiding outliers, and replacing explained variables, the conclusion that green finance has a significant inhibitory effect on carbon emissions remains valid, indicating the robustness of the empirical results.

### *5.2. Policy proposal*

Firstly, establish a comprehensive green and low-carbon financing system to enhance the accessibility and convenience of financing for green projects. To further increase financial institutions' enthusiasm for participating in green finance, the green finance policy framework should be improved. This includes, but is not limited to, increasing banks' financial support for green and low-carbon projects, developing unified green finance standards and certification systems, and clarifying the definitions and assessment criteria for green projects. Concurrently, financial institutions should prepare high-quality environmental information disclosure reports to boost market confidence in green financial products. They should also be encouraged to collaborate with other stakeholders to jointly construct a healthy and sustainable financial ecosystem.

Secondly, leverage green finance to support energy structure transformation and promote the research, development and application of clean and efficient energy technologies. Gradually expand the role of green finance in supporting energy industry development and energy structure transition, optimise financial resource allocation, and intensify support for R&D and application of clean and efficient energy technologies. Implement stricter controls on financing for high-pollution industries and raise financing thresholds to restrict high energy consumption and high-emission projects. Concurrently, provide preferential financing policies to strongly support the R&D and application of clean and efficient energy technologies. Moreover, enhance the promotion of green finance concepts, raise public environmental awareness, and drive the shift of consumption habits towards greener and lower-carbon alternatives. This will indirectly facilitate the optimisation of energy consumption structures by encouraging

high-pollution and high energy-consuming products to exit the market.

Thirdly, substantive green technological innovation should be encouraged, with enhanced financial support for key areas such as pollution control, green energy promotion and ecological restoration. The government ought to actively introduce relevant environmental regulations and policies, effectively coordinate environmental resource planning, fulfil its supervisory and management responsibilities, and establish an ecological compensation mechanism. Considering the characteristics and developmental stages of different enterprises, a value-based screening process should be implemented. This process should guide the green financial development of optimised enterprises and projects, strengthening the role of green finance in promoting tangible economic projects. Particular emphasis should be placed on increasing capital investment in crucial sectors such as pollution control and green energy promotion.

Fourth, deepen financial regional reform, strengthen financial cooperation and coordination within the region, and establish a unified green finance market and regulatory mechanism. To promote the standardisation of carbon emissions management, a unified carbon emissions system should be established. Under the effective regulation of market mechanisms, a national carbon market should be constructed to facilitate the achievement of the "dual carbon" goals. Simultaneously, develop a green finance standards system, clarifying the standards and requirements for green investments to reduce associated risks. With the unified construction of the national carbon market, enterprises can engage in carbon emission rights trading on a fair and transparent platform, thereby optimising the cost-effectiveness of carbon emissions and promoting the research, development and application of green technologies and low-carbon products.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## CRediT authorship contribution statement

**Chuanhui Wang:** Conceptualization, Data curation, Methodology, Investigation, Writing - original draft, Funding acquisition. **Yu Chao:** Validation, Visualization, Formal analysis, Software, Writing - review & editing. **Weifeng Gong:** Formal analysis, Writing - review & editing.


## Acknowledgments

The work is supported by the National Social Science Foundation of China under grants 22BJY174.


## References


[1] Alam, Md. Mahmudul, Md. Wahid Murad, Abu Hanifa Md.Noman and Ilhan Ozturk. Relationships Among Carbon Emissions, Economic Growth, Energy Consumption and Population Growth:Testing Environmental Kuznets Curve Hypothesis for Brazil, China, India and Indonesia. Econometric Modeling: Agriculture, 2016 (70): 466-479.

[2] Bo Huang, Xiangbing Liu, Yihui Xu, Xiaowei Liu, Su Yan, Jia Li. The Impact Mechanism and Empirical Test of Green Finance Promoting the Transition of Low-Carbon Economy. Gansu Finance, 2023, (12): 46-55.

[3] Chen Xi, Chen Zhigang. Can Green Finance Development Reduce Carbon Emissions? Empirical Evidence from 30 Chinese Provinces. Sustainability, 2021,13 (21): 12137.

[4] Feng Langang, Shang Shu, An Sufang, Yang Wenli. The Spatial Heterogeneity Effect of Green Finance Development on Carbon Emissions. Entropy, 2022, 24 (08): 1042.

[5] Feng Liu, Ping Huang, Dan Tang. Research on the Carbon Emission Reduction Effect and Impact Channels of Green Finance. Journal of Financial Economics Research, 2022, 37 (06): 144-158.

[6] Hong Wu. Evaluating the role of renewable energy investment resources and green finance on the economic performance:Evidence from OECD economies. Resources Policy, 2023, (80):103149.

[7] Huiming Zhang, Lu Xu, Peng Zhou, Xiaodong Zhu and Dan Cudjoe. Coordination between Economic Growth and Carbon Emissions:Evidence from 178 Cities in China. Economic Analysis and Policy, 2024, (81):164-180.

[8] Jianhui Cong, Xuemin Liu, Xueru Zhao. The Boundary Definition and Measurement Method of Urban Carbon Emission Accounting. China Population, Resources and Environment, 2014, 24 (04): 19-26.

[9] Jiaqi Wang, Jiaxin Tian, Yuxin Kang , Kun Guo. Can green finance development abate carbon emissions: Evidence from China. International Review of Economics & Finance, 2023, (88):73-91.

[10] Jingjun Hao, Peng Zhang, Wei Yu and Xiaorong Mou. Causes of Spatial Patterns of Livability in Chinese Cities: MGWRL Analysis Based on Didi's Big Data.

Journal of Urban Planning and Development-asce. 2021,147 (03): 04021025.
[11] Jun Zhao, Chunyan Liu. Does Green Finance Policy Promote Low-Carbon Development? — Taking Key Chinese Provinces along the "Belt and Road" as an Example. Finance and Economy, 2020, (05): 45-52.
[12] Lihua He, Pan Yang, Yanlin Meng, et al. The Potential Contribution of Energy Structure Optimization to Low-Carbon Shandong. China Population, Resources and Environment, 2015, 25 (06): 89-97.
[13] Miao Zhao, Lei Zhou, Yuchao Wang. Green finance and the renewable energy industry: A dynamic panel data analysis. Energy Policy, 2023, (178): 113576.
[14] Ngo Quang Thanh, Tran Hoa Anh, Tran Hai Thi Thanh. The impact of green finance and Covid-19 on economic development:capital formation and educational expenditure of ASEAN economies. China Finance Review International, 2022, 12 (02): 261-279.
[15] Shixiu Zhao, Xiaoyi He, Kenjayeva Umriya Faxritdinovna. Does industrial structure changes matter in renewable energy development? Mediating role of green finance development. Renewable Energy, 2023, (214): 350-358.
[16] Shuhua Zhao, Xiaobo He, Ulasheva Kamola Faxritdinovna. Does industrial structure changes matter in renewable energy development? Mediating role of green finance development. Renewable Energy, 2023, 214: 350-358.
[17] Umme Habiba, Cao Xinbang, Shahid Ali. Investigating the impact of financial development on carbon emissions:Does the use of renewable energy and green technology really contribute to achieving low-carbon economies? Gondwana Research, 2023, (21), 472-485.
[18] Wei Wang, Shaojie Hao, Hua Zhong, Zhi Sun. How to promote carbon emission reduction in buildings?Evolutionary analysis of government regulation and financial investment. Journal of Building Engineering, 2024, (89):109279.
[19] Xiaosong Ren, Min Zhao, Rong Yuan and N. Li. Influence mechanism of financial development on carbon emissions from multiple perspectives. Sustainable Production and Consumption, 2023, (39): 357-372.
[20] Xiaowei Liu, Erliang Wang, Yanli Zhang. Spatial Spillover Effects of Green Finance on Carbon Emissions in China. Journal of Cleaner Production, 2021, 315: 128184.
[21] Yafei Wang, Zihan Zhao, Ming Shi, Jing Liu and Zhixiong Tan. Public environmental concern,government environmental regulation and urban carbon emission reduction-Analyzing the regulating role of green finance and industrial agglomeration.The Science of the total environment, 2024, (924): 171549.
[22] Yanchao Wang, Shuanglian Zhao. The Role of Green Bonds in Promoting Low-Carbon Development: Evidence from China. Journal of Cleaner Production, 2022, (355): 131973.
[23] Yangran Chen, Yuru Zhang. The driving force of carbon emissions reduction in China: Does green finance work. Journal of Cleaner Production, 2023, (421): 138502.
[24] Yao Wang, Dongyang Pan, Xiao Zhang. Research on the Contribution of Green Finance to China's Economic Development. Comparative Economic and Social

735 Systems, 2016, (06): 33-42.
736 [25] Yi Wang, Yan Zhang, Shengnan Li. Public environmental concern and city carbon
737 emissions: The mediating role of environmental regulation. Journal of
738 Environmental Policy & Planning, 2024, 26 (2): 123-135.
739 [26] Zhiguo Hao, Jianqiu Wang, Huiming Li. The impact of green credit and bonds on
740 CO2 emissions: Evidence from China. Energy Economics, 2021, (94): 105074.
741 [27] Zhiguo Li, Weijia Kong, Zhaozhe Li. Division or Integration: How Does the Digital
742 Economy Affect the Urban-Rural Labor Employment Market in China? Journal of
743 Guizhou University of Finance and Economics, 2024, (02): 31-40.
744 [28] Zhonghua Wang, Chuanwang Xu, Baosheng Chen. Regional heterogeneity of
745 green finance in promoting low-carbon development: Evidence from China.
746 Energy Policy, 2023, (178): 113576.