



In-depth Exploration and Future Trends of Green Finance, Urban Low-Carbon Economies and Regional Harmonious Growth

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Abstract. Against the backdrop of the 3060 goal, China is accelerating the green transformation of its economic and social development. Environmental finance channels capital into eco-friendly and decarbonized initiatives and performs a vital function in metropolitan carbon economies and balanced regional growth. This paper focuses on green finance, urban low-carbon economies, and regional coordinated development. Based on recent literature by various scholars, this paper compiles panel data on urban low-carbon transformation and coupling degree levels for each city in China from 2016 to the first half of 2026 and compares these data with green loan data across 31 provinces and municipalities nationwide for analysis. Findings indicate that China's city-based low-carbon advancement exhibits a spatial pattern of "greater eastern levels and lesser western ones, elevated southern values and diminished northern ones," whereas central, western, and northeastern areas trail somewhat owing to elements like capital, administrative strategies, and infrastructural gaps. This paper proposes future research directions to provide theoretical support and policy implications for improving the green financial system, accelerating urban low-carbon transformation, and implementing coordinated regional development strategies.

Keywords: Green Finance, Urban Low-Carbon Economy, Regional Coordinated Development, Dual Carbon Goals.

1 Introduction

Under the dual backdrop of global climate change and domestic high-quality development, China has proposed the "3060" goal and implemented the regional coordinated development strategy. Green finance, as a core tool for low-carbon development, plays a significant role in promoting urban low-carbon economic transformation and addressing regional development imbalance. Currently, green finance, urban low-carbon economies, and regional coordinated development have become important interdisciplinary research areas in economics, environmental science, and regional science. Mainstream research focuses on their impact,

mechanisms, and policy paths and has yielded rich results. Existing studies have confirmed the positive impact of urban low-carbon economic transformation on regional sustainable development.

Firstly, the academic community has widely verified that green finance promotes urban low-carbon transformation. Wang demonstrated that a low-carbon economy can deliver dual benefits to the regional environment and economy [1]. Wang et al. found that green finance reform promotes green development through industrial structure upgrading and technological innovation, with a more prominent effect in the east [2]. On this basis, Ma et al. further pointed out that the two are in an "eastern region superior to the central and western regions" coupling coordination relationship [3]. Li et al. proved that green finance reduces carbon emissions through green technological innovation and industrial optimization, and it collaborates with the digital economy [4]. In addition, Jin et al. discovered that it can optimize capital allocation and enhance green innovation performance [5]. Jiang Runnan et al., based on the analysis of 31 provinces, revealed a "U-shaped" nonlinear relationship [6]. Song Wenqian used data from 263 prefecture-level cities to confirm that green finance enhances the economic performance of carbon emissions through innovation investment and industrial structure upgrading [7].

Furthermore, current academic research has produced significant insights regarding the linkages, underlying processes, and geographical disparities connecting green finance with low-carbon progress and has reached analogous favorable outcomes, providing valuable references for subsequent research. However, four gaps remain: the lack of systematic coupling analysis of the three, insufficient attention to the central and western regions and the northeastern region, weak cross-regional collaborative mechanisms, and lagging risk prevention research.

Based on this, this paper systematically reviews relevant domestic and foreign literature, summarizes research methods, core achievements, and existing limitations, and looks forward to future research directions, to provide theoretical support and policy implications for green finance to contribute to the realization of the dual carbon goals and regional coordinated development.

2 Coupling Coordination Benefits of Green Finance and Low-Carbon Economy

Against the backdrop of accelerated worldwide climate shifts and the shift toward China's high-quality economic progress, the "dual carbon" objective has emerged as the primary strategic target for China's regional sustainable evolution. Green financing, serving as a fundamental market-driven mechanism for directing capital toward sustainable sectors, is intimately tied to the growth of the decarbonized economy and its regulatory impacts and has emerged as a focal point of inquiry within ecological and monetary economics. Existing literature has conducted multidimensional discussions on the low-carbon driving effect, dynamic correlation characteristics, internal transmission mechanism, and spatial heterogeneity of green finance, yielding rich

theoretical achievements and empirical evidence, thereby laying a solid academic foundation for this study.

2.1 Examining the Essential Impact of Green Financing on the Advancement of Carbon-Light Economy

Current mainstream research generally agrees that green finance has a significant positive enabling effect on regional low-carbon economic transformation, and related studies have built a mutually corroborating research system from both theoretical and empirical perspectives.

At the theoretical level, Wang constructed a systematic analysis framework for low-carbon economic development and proposed that low-carbon economic development can simultaneously achieve the improvement of regional environmental and economic benefits, which is the core path for realizing the coordinated development of resources, environment, and economy, providing core theoretical support for the identification of the effect of green finance [1]. At the empirical level, existing studies have verified the low-carbon driving effect of green finance from multiple dimensions. Li et al. found that green finance has a direct and significant positive effect on reducing regional carbon emission intensity, and when linked to digital economy policies, it can yield more pronounced and more sustainable synergistic emission-reduction dividends [4]. Song Wenqian's empirical analysis, based on panel data for prefecture-level cities in China, further verified the enhancing effect of green finance on cities' economic output efficiency per unit of carbon emissions, providing reliable empirical evidence for the improvement and efficiency-enhancing effect of green finance [7]. Meo and Abd Karim also confirmed in a cross-national study of ten major economies that green finance has a significant negative impact on CO₂ emissions, providing cross-national evidence for the universal effect of green finance [8]. Moreover, numerous studies have confirmed that green finance helps alleviate regional development imbalances and promote coordinated regional development.

2.2 Research on the Non-linear Relationship between Green Finance and Low-carbon Economy

Existing studies, based on the positive driving effect of green finance, have moved beyond the traditional view of a static, linear relationship and have explored the dynamic, non-linear correlation between the two. They clarified the phased characteristics of green finance's driving effect.

Jiang Runnan conducted a systematic examination of the non-linear relationship between green finance and the low-carbon economy using a threshold-effect model and clearly identified a significant "U"-shaped dynamic correlation between the two [6]. This study pointed out that in the early stage of green finance development, due to the long-term nature of the environmental protection industry, the high investment nature of the industry, and strict credit standards, green finance would have a short-term "crowding-out effect" on traditional high-carbon enterprises, thereby temporarily suppressing regional low-carbon economic development. Only when the scale of green finance expands to a critical level and the relevant institutional barriers are effectively

broken down will its positive pulling effect on the low-carbon economy truly emerge and gradually become the dominant effect. Meo and Abd Karim (2022) discovered through quantile-quantile (QQR) regression that the driving force of green finance on carbon reduction varies across quantiles of the two variables, depending mainly on the green financial market conditions at that time and the specific macroeconomic cycles of each country [8]. Wu further found that this promoting effect has a dual-threshold structure with respect to regional GDP, and that the marginal benefit increases after crossing the threshold [9]. These conclusions provide important empirical references for understanding the dynamic effects of green finance and a theoretical basis for differentiated policy formulation.

2.3 Research on the Transmission Mechanism of Green Finance in Driving the Development of the Low-Carbon Economy

Based on the fundamental premise that sustainable finance bolsters the decarbonized economy, current academic research has developed a sophisticated theoretical structure. It mainly elaborates and conducts empirical tests from two core transmission paths: technological innovation incentives and industrial structure optimization.

Pathways of Technological Innovation Transmission. Existing studies generally hold that green finance can effectively alleviate the financing constraints faced by green technology research and development by providing targeted capital and designing risk-sharing systems, thereby providing core financial support for green innovation activities. Jin et al. conducted an empirical test from the perspective of innovation performance, clarifying the mechanism by which green finance optimizes capital allocation and expands green R&D investment, thereby enhancing green innovation at the regional level. They also confirmed that its incentive effect on the research and development of core carbon-reduction technologies is particularly pronounced [5]. This view was also supported by Li et al., who stated that green finance policies, by reducing the risks and costs of carbon reduction technology research and development, activate the innovation vitality of enterprises [4]. Song Wenqian's mechanism test results further confirmed that technological innovation investment is the core mediating variable through which green finance enhances the economic performance of carbon emissions reduction [7]. Wu's empirical study showed that innovation capability played a partial mediating effect of approximately 5.4% in this process [9]. Green finance can stimulate technological innovation, accelerate the industrialization of clean energy and energy-saving technologies, and ultimately promote the transformation of the regional low-carbon economy.

Transmission Pathway of Industrial Structure Optimization. Existing studies have shown that green finance, by setting differentiated investment and financing thresholds, can promote the optimal reallocation of financial resources among industries, thereby guiding the industrial structure to transform and upgrade towards a low-carbon, advanced direction. Wang et al. used a natural experiment based on the green finance

reform and innovation pilot program and employed a difference-in-differences model for empirical analysis. They clearly demonstrated that green finance policies can effectively guide funds to shift from high-energy-consuming and high-pollution industries to modern service and high-tech industries, thereby significantly promoting the advancement and rationalization of the regional industrial structure [2]. Moreover, optimizing industrial layout can directly and stably reduce the region's overall energy consumption and carbon emissions, making it the most reliable core driver of urban low-carbon transformation.

2.4 Spatial Heterogeneity Research on the Low-Carbon Driving Effect of Green Finance

Owing to substantial disparities in fiscal bases, natural assets, and stages of monetary advancement throughout various provinces in China, the catalytic impact of ecological finance upon the decarbonized economy demonstrates obvious geographic diversity. Relevant literature has discussed its manifestations, causes, and boundary conditions from multiple dimensions.

In terms of the overall spatial pattern, Ma et al. used a coupling coordination degree model to systematically calculate the synergy relationship between green finance and regional sustainable development, confirming a high degree of coupling and coordination between the two, with the overall level showing a spatial distribution of "eastern regions superior to the central and western regions" [3]. This research likewise discovered that greater degrees of green financial advancement are linked with more robust beneficial spillover impacts on local sustainable progress. Wang et al. further supplemented this by proposing that the eastern region, with a more complete financial system, has a more prominent implementation effect of green finance policies [2]. Wu's regional regression also confirmed a gradient pattern in the emission reduction effect of green finance: "eastern regions greater than central and western regions" [9].

Regarding the causes and boundary conditions of heterogeneity, Jiang Runnan constructed a multidimensional analytical framework, clearly indicating that regional economic scale, population density, and resource dependence jointly determine the core threshold for the green finance low-carbon driving effect [6]. The study found that provinces with strong economic foundations and non-resource-dependent characteristics can cross this threshold earlier and enjoy emission reduction benefits sooner. By contrast, underdeveloped and resource-based regions face greater resistance to industrial transformation and imperfect institutional environments, so the effects of green finance policies take longer to emerge. Lee's research explained these differences in the adaptation period. The promotion of green finance in China faces problems such as "lack of unified green asset classification standards" and "lag in local financial institutions and government capacity building", which are key shortcomings that restrict the effectiveness of regional green finance [10]. Additionally, Jin et al. found that in resource-poor regions, because enterprises lack resource path dependence, they exhibit greater willingness to innovate technologically and more outstanding green innovation performance when facing green finance supply, which further demonstrates the greater resistance to industrial transformation in resource-based regions [5]. Song

Wenqian's empirical research further revealed the "demand-oriented" law of the release of green finance's effectiveness: in cities with higher total carbon emissions and greater emission-reduction pressure, the marginal promoting effect of green finance on low-carbon economic development is more significant [7].

3 Discussion

Previous studies typically validate that green finance exerts a substantial beneficial influence upon the evolution of the urban low-carbon economy. It has also established a relatively mature analytical framework regarding transmission mechanisms, such as technological innovation and industrial structure optimization. However, there are still gaps in theoretical integration and policy adaptation. To begin with, current academic research primarily concentrates on two-way connections, like green finance alongside the low-carbon economy, or green finance and regional balanced growth. Few cases incorporate all three elements into a unified framework to examine their deep coupling and mechanisms of collaborative evolution. These studies still lack sufficient theoretical explanatory power. Second, empirical samples are highly concentrated in the eastern developed regions and green finance pilot cities. Insufficient focused investigation exists regarding difficulties encountered during the low-carbon shift within central and western areas, plus the old industrial zones of Northeast China. Challenges include capital constraints, institutional inertia, and industrial path dependence. Policy implications are also limited. Lee pointed out that the central and western regions still lack standards and assessment capabilities. Third, research on cross-regional green finance collaborative governance, national carbon market linkage mechanisms, and horizontal ecological compensation within macro-institutional design is extremely weak. This makes it difficult to support the needs of factor mobility and coordinated regional carbon reduction in a unified national market. The coordinated mechanism called for by Lee is precisely the gap. Fourth, current research focuses too much on the positive effects of green finance. There is no mature risk identification or early warning mechanism for potential systemic financial risks. Additional issues remain, such as resource misallocation driven by companies' greenwashing and negative impacts stemming from policy uncertainty. Lee also emphasized that the lack of information disclosure is key. Upcoming studies ought to construct a unified structure regarding green financing, low-carbon industries, and regional balanced growth. Scholars must reinforce micro-empirical analyses within underprivileged areas and resource-oriented municipalities. It is also important to explore institutional innovations for cross-regional collaborative governance and to improve the quantitative assessment and prevention system for transformation risks. This work will provide more solid academic support for achieving the dual-carbon goals.

4 Conclusion

This paper systematically reviews the panel data on China's urban low-carbon transformation from 2016 to 2026 and the regional coupling and coordination levels.

By integrating green credit information from all 31 provincial-level regions, this research examines the complex connections between green finance, urban low-carbon economies, and regional balanced growth. This investigation discovers that green finance exerts a substantial beneficial influence on the evolution of urban low-carbon structures, but it exhibits a "U" shaped non-linear characteristic. There may be a short-term inhibitory effect initially, and the promoting effect strengthens after crossing the threshold. The urban low-carbon outcomes in China exhibit a geographic variation trend of "high in the east while low in the west, and high in the south while low in the north". The transformation effect in the eastern region is prominent, while the central, western, and northeastern regions lag due to constraints such as limited funds, underdeveloped infrastructure, and industrial path dependence. Green financial services mainly advance decarbonization efforts via two routes: encouraging ecological technological breakthroughs and fostering industrial restructuring. The innovative intermediary effect has been confirmed. There is a high degree of coupling and synergy among the three, but current research mainly focuses on pairwise analysis. Currently, there is insufficient attention to the potential financial risks, "greenwashing" behavior, and policy uncertainties in the low-carbon transformation, including the lack of standards mentioned by Lee and insufficient disclosure.

Based on the above conclusions, this paper presents the following policy recommendations and future outlooks. First, a differentiated, phased green finance policy framework should be established. The eastern region should focus on product innovation and deepening the carbon market, while the central and western regions, as well as the northeast, should strive to fill infrastructure gaps and accelerate the crossing of efficiency thresholds. Second, a cross-regional collaborative governance mechanism should be improved to promote the cross-regional flow of green financial resources, accelerate the construction of the national carbon market, and organically connect horizontal ecological compensation. Third, an identification and early warning mechanism for low-carbon transition risks should be established, incorporating climate risks into macro-prudential management and strictly controlling "greenwashing" behavior. Fourth, green finance should be strengthened in coordination with technological innovation, industrial policies, and the digital economy. Future research should focus on the micro-empirical analysis of differentiated transformation paths in the central and western regions, the quantitative model of the systematic coupling of the three, the institutional design of cross-regional collaborative governance, and the assessment system for transformation risk prevention.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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