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LITERATURE REVIEW ON INSTITUTIONAL QUALITY, GREEN INNOVATION AND THE DEVELOPMENT OF CHINA'S GREEN ECONOMY

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Abstract:

Against the backdrop of growing tensions among economic development, energy use, and environmental pollution, the green economy has become a core strategic path for China to achieve high-quality development and meet the "dual carbon" goals, with institutional quality and green innovation as key drivers. This paper reviews empirical studies on the links between the green economy, institutional quality, and green innovation, clarifying that green economic growth centers on the coordinated development of "economy-ecology-society" and uses green total factor productivity (GTFP) as a key evaluation indicator. It summarizes how green innovation boosts green economic growth at regional, enterprise & industrial, and international levels, along with the mediating paths, and analyzes the moderating effects of institutional quality on the relationship between the green economy and green innovation. The study notes shortcomings in existing literature, such as theoretical framework integration, institutional quality research dimensions, green technology transformation studies, regional heterogeneity analysis, and international comparisons. Thus, it proposes that future research should build a comprehensive theoretical framework for the three, deepen multi-dimensional institutional synergy research, enhance green technology transformation analysis, refine regional heterogeneity exploration, and expand international comparative studies to provide solid theoretical and practical support for China's green economy development.

Keywords:

Institutional Quality, Green Innovation, Development of Green Economy, Green Total Factor Productivity, Literature Review

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Introduction

Amid growing tensions between economic development, energy consumption, and environmental pollution, green economy development has become a global choice for sustainable development. For China, it is even a must to break free from traditional economic growth models and advance high-quality development.The Report to the 20th National Congress of the Communist Party of China clearly states the need to "accelerate the green transition of development modes". It also calls for "implementing a comprehensive conservation strategy, developing green and low-carbon industries, advocating green consumption, and promoting the formation of green and low-carbon production and lifestyle". This elevates green economy development to a core national strategic position.In 2024, the State Council issued the Opinions on Accelerating the Comprehensive Green Transition of Economic and Social Development. It further points out that efforts should be guided by peaking carbon emissions and achieving carbon neutrality. It also urges promoting coordinated progress in carbon reduction, pollution reduction, green expansion, and growth. Additionally, it calls for deepening the reform of the ecological civilization system and improving the green and low-carbon development mechanism.The document emphasizes two time-bound goals. First, by 2030, key industries and fields should see positive phased results in green transition. Green production and consumption lifestyles should be basically formed, and the synergistic effects of pollution reduction and carbon reduction should be significantly enhanced. Second, by 2035, a modern economic system featuring green, low-carbon, and circular development should be initially established. All sectors of the economy and society should fully embark on the path of green and low-carbon transition.Nevertheless, China currently faces multiple challenges in green economy development. On the one hand, some regions are constrained by the traditional "high energy consumption, high pollution" development model. This leads to insufficient momentum for green and low-carbon transition. On the other hand, green technology R&D requires high capital investment, has long R&D cycles, and carries high risks. As a result, market entities' enthusiasm to participate in green innovation activities has not been fully stimulated.To effectively address these constraints, institutional safeguards are urgently needed. These safeguards should form strong synergy and mutual support with technological innovation activities.

Green innovation is the core driving force for green economy development. It is a key means to achieve the synergistic effects of "carbon reduction, pollution reduction, green expansion, and growth," and provides inexhaustible impetus for the sustainable development of the green economy.From the technological dimension, there are innovations in the new energy field. These include technologies to improve photovoltaic power generation efficiency and enhance wind power generation stability. There are also breakthroughs in energy conservation and environmental protection technologies, such as those for industrial waste resource utilization. These technologies can significantly reduce carbon emission intensity and resource consumption in production and daily life. They also accelerate the clean and low-carbon transition of the energy system, laying a solid technological foundation for green economy development.From the industrial dimension, green innovation has spawned strategic emerging industries. Examples include new energy vehicle manufacturing, green building construction, and ecological agriculture development. At the same time, it promotes the green transformation of traditional high-energy-consuming industries like iron and steel and chemical engineering. This optimizes and upgrades the industrial structure, increases the proportion of green industries in the economic structure, and forms new drivers of economic growth.From the resource and environmental dimension, green innovation strengthens the capacity for

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ecological environment protection and restoration. It does so through measures such as smart environmental monitoring network construction and large-scale application of carbon capture and storage technologies. This realizes positive interaction between economic development and ecological protection, ensuring the sustainability of green economy development. Ultimately, it provides strong support for the comprehensive green transition of the economy and society, as well as the achievement of carbon peaking and carbon neutrality goals.

Institutional quality plays a crucial regulatory role in green innovation driving green economy development. The level of its improvement directly affects the effectiveness and depth of this driving effect.Specifically, when institutional quality is high, a sound intellectual property protection system works. It creates a stable innovation environment for green innovation entities, including enterprises and research institutions. This fully stimulates their enthusiasm for R&D investment and prevents innovation momentum from weakening due to infringement of innovation achievements.Scientific and reasonable environmental regulation policies also play a part. These include differentiated carbon emission standards and targeted green subsidy measures. They guide innovation resources to gather in low-carbon technologies and environmental protection industries. This ensures green innovation aligns closely with the actual needs of the economy's green transition.Meanwhile, an efficient market supervision mechanism and government service system exist. They effectively reduce transaction costs for the transformation of green innovation achievements. For example, they simplify the certification process for green products and build an exchange platform for industry-university-research cooperation. This accelerates the application of innovative technologies from the laboratory to the market.In turn, this more efficiently promotes the expansion of green industries and the green upgrading of traditional industries. It maximizes the driving effect of green innovation on green economy development.Conversely, low institutional quality brings problems. For instance, there may be a lack of policy stability and unfair supervision and law enforcement. This may inhibit the vitality of green innovation and hinder the transformation and application of innovation achievements. As a result, it weakens the driving role of green innovation in the green economy.

Against this background, systematically exploring the internal logic and mechanism of action among institutional quality, green innovation, and green economy development has important theoretical value and practical significance.From the theoretical perspective, existing studies have two main focuses. One is the direct impact of institutional quality on the green economy. The other is the independent analysis of green innovation’ s driving effect. However, integrating the three into a unified analytical framework matters. It helps reveal the transmission path: institutional quality affects the green economy by influencing green innovation. This is conducive to improving the theoretical system of green economy development.From the practical perspective, clarifying the synergy mechanism between institutional quality and green innovation is useful. It can provide policy insights for China in three aspects: optimizing institutional design, enhancing green innovation capabilities, and promoting high-quality development of the green economy. It also helps the organic integration of two goals: peaking carbon emissions and carbon neutrality, and the sustainable development of the economy and society.Based on this, this paper does two key things. First, it systematically sorts out empirical research results on the relationships among institutional quality, green innovation, and green economy development. Second, on the basis of comprehensively summarizing existing literature, it puts forward forward-looking prospects

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for future research directions. The paper aims to provide valuable insights for academic research and practical exploration in this field.

Concept Definition

As an innovative development model, green economic growth differs from the traditional economic growth path characterized by "high consumption, high pollution, and high emissions". Its core essence lies in, while promoting the growth of total economic output, expanding employment scale, and improving social welfare, strictly controlling the degree of natural resource consumption and ecological environment damage caused by economic activities within the carrying capacity threshold of the global ecosystem through means such as technological innovation, institutional reform, and industrial transformation and upgrading. Ultimately, it achieves the coordinated development of economic development, ecological protection, and social equity, thereby realizing the established goal of sustainable development. Therefore, when evaluating green economic growth, four dimensions−economic growth quality, resource utilization efficiency, environmental damage control, and sustainable development potential−must be considered. Davicl (1996), Lucas (1988), Wang Bing et al. (2015), and Xie Tingting et al. (2019) all argue that the growth of the green economy can be measured by whether green total factor productivity (GTFP) shows an upward trend.

Up to now, in the field of academic research, there has not yet been a unified and clear definition of the specific meaning of green total factor productivity. On the basis of sorting out a large number of references, this paper finally selects and adopts the definition of green total factor productivity proposed by scholars such as Qian Zhengming et al. (2013). Green total factor productivity refers to the input-output efficiency measured from a green perspective; it is a total factor productivity that pursues the maximum possible economic growth under the premise of fully considering resource consumption and environmental costs.

Domestic and International Research Status

Scholars worldwide have confirmed that technological innovation plays a positive role in promoting green economic growth based on different research objects and spatial scales, and this impact shows significant heterogeneity across regions, industries, enterprise ownership and other dimensions. At the regional level, Zhao Jinguo et al. (2025) studied 76 prefecture-level cities in the Yellow River Basin from 2009 to 2021 and found that technological innovation has a significantly positive effect on the basin’s economic development, with variations across sub-regions, while noting that adjusting environmental regulations fails to significantly improve green economic development efficiency; Lu Jin et al. (2022) emphasized that green innovation positively promotes regional green economic efficiency improvement, with notable regional differences; Wu Chuanqing et al. (2021) analyzed 11 provinces and cities in the Yangtze River Economic Belt using a panel data model and found that scientific and technological innovation significantly drives green economic development, with varying effects across provinces and cities; Cheng Zhonghua et al. (2021) selected the Yangtze River Delta region as the research object and empirically verified through a panel data model that technological innovation promotes green economic development; Chen Chaofan et al. (2020) used a fixed-effect model and a spatial econometric model to conduct an empirical study on Chinese provinces and found that green technological innovation has a significant impact on enhancing green economic growth, with a more pronounced effect in eastern China than in western China; Liu Huajun et al. (2021) used a spatial econometric model and found that green technological innovation significantly drives the green economic efficiency of various regions

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in China, with a spatial spillover effect where an increase in the green technological innovation level of neighboring regions can drive the growth of local green economic efficiency. At the enterprise and industrial level, Zhang Feng et al. (2023) conducted an empirical analysis on listed Chinese manufacturing enterprises and found that digital transformation significantly enhances enterprises' green competitiveness, with green technological innovation playing a crucial mediating role (digital transformation strengthens green competitiveness by increasing enterprises' investment in and output of green technological innovation), and this impact varies across enterprises with different ownership types, industry categories and regional distributions; Li Bin et al. (2022) found that technological innovation significantly promotes green economic growth, while environmental uncertainty plays a moderating role; Zhao Tao et al. (2023) pointed out that artificial intelligence technological innovation contributes to green economic development, with regional and industrial heterogeneity; Zhou Pengfei et al. (2022) used data from China's industrial sectors and found that institutional quality (reflected by environmental regulation enforcement intensity) has a positive moderating effect on the "environmental regulation-green technological innovation" path, and when environmental regulation enforcement intensity reaches a threshold, the promotional effect of environmental regulations on green technological innovation increases from 0.18 to 0.35, making the "strict environmental regulations-high-level green technological innovation-high-quality green development" transmission chain smoother; Wang Yulin et al. (2023) found that as green finance development improves, technological innovation's role in promoting enterprises' green output growth becomes more significant, and in different industries, green finance's moderating effect on technological innovation is more prominent in high-polluting enterprises than in low-polluting ones; Gong Jianjiao et al. (2024) took listed enterprises in the Yangtze River Economic Belt as an example and found that the green finance pilot zone policy significantly promotes enterprises' green transformation, with institutional quality playing a positive moderating role in this process to further enhance technological innovation's positive effect on enterprises' green transformation. At the international level, Xu, Y. et al. (2021) examined the green development level of 32 "Belt and Road" countries from 2010 to 2018 and found that most countries have low green development efficiency with significant room for improvement, that foreign trade and technological innovation are important drivers of green development, and that technological innovation's promotional effect on green development shows a threshold effect (non-linear relationship); Qiu, W. et al. (2021) pointed out that innovation investment effectively improves the green total factor productivity (GTFP) of "Belt and Road" countries, and as the quality of overall institutions, political institutions, economic institutions and legal institutions improves, innovation investment's positive promotional effect is further strengthened, with significant variations across different countries and regions along the route; Zhao, X. et al. (2022) conducted an empirical study on BRICS countries and found that institutional quality and green technological innovation have a synergistic promotional effect on green growth—both have a direct positive impact on green growth, and their interaction term is also significantly positive, meaning high-quality institutions can amplify green technological innovation's positive effect; Putri Ayu Ramdhani et al. (2024) argued that technology and digitalization processes have a significant and important impact on both green economy advancement and rural economic growth.

The driving effect of technological innovation on green economic growth is not a single direct impact, but is transmitted through mediating variables such as industrial structure optimization, green technological innovation, industrial agglomeration, and energy structure optimization,

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with some studies focusing on mediating paths in specific fields. Wu Chuanqing et al. (2021) found that industrial structure optimization plays a key mediating role in technological innovation driving green economic development—technological innovation promotes industrial structure upgrading toward high-end and green directions, thus driving green economic growth. Zhang Feng et al. (2023) pointed out that green technological innovation is a core mediating variable when digital transformation enhances enterprises' green competitiveness: digital transformation indirectly strengthens enterprises' green competitiveness by increasing investment in and output of green technological innovation. Liu, X. et al. (2024) selected data from China's coastal provinces from 2011 to 2021, conducted empirical analysis using a fixed-effect model, a mediating effect model, and a threshold effect model, and found that digital transformation significantly drives high-quality marine economy development, while green technological innovation partially serves as a mediating bridge between the two and plays an important transmission role. Cheng Zhonghua et al. (2021)'s study on the Yangtze River Delta region showed that industrial agglomeration mediates between technological innovation and green economic development—technological innovation drives the formation of industrial agglomeration, which effectively improves green economic development level by promoting resource sharing and technology diffusion. Qi Shaozhou et al. (2022) pointed out that green technological innovation has a significantly positive promotional effect on regional green economic development, and can further drive regional green economic development by optimizing energy structure.

Environmental regulations and institutional quality (including property rights protection, government governance, marketization level, green financial systems, etc.) do not simply linearly regulate the relationship between technological innovation and green economic growth; instead, they show complex characteristics such as a "U-shaped" curve, double thresholds, and single thresholds, and the moderating effect is affected by regional conditions, industrial characteristics, and institutional development level. Yang Qian et al. (2020) used China's provincial panel data for research and found that environmental regulations have a double-threshold characteristic in the relationship between technological innovation and green economic growth: when environmental regulation intensity is below the first threshold, the driving effect of technological innovation on green economic growth is not significant; when it is between the two thresholds, the promotional effect is significantly enhanced; when it exceeds the second high threshold, the promotional effect tends to weaken. Zhang Tongbin et al. found that green technological innovation significantly drives enterprises' green growth, and environmental regulations play a moderating role: reasonable environmental regulation intensity can stimulate enterprises' green technological innovation activities to promote green growth, while too high or too low intensity will weaken the promotional effect. Li Ruiqin (2024) constructed a comprehensive institutional quality index using "property rights protection intensity", "government governance efficiency", and "marketization level", and the results showed that the moderating effect of environmental regulations on green technological innovation presents a "U-shaped" relationship. Zhou Pengfei et al. (2022) pointed out that institutional quality (specifically the enforcement intensity of environmental regulations) has a positive moderating effect on the "environmental regulation-green technological innovation" path, with a threshold effect. Dai Lina et al. (2025) analyzed 286 prefecture-level cities in China and found that the digital economy significantly improves urban innovation capabilities; institutional quality can regulate the green transformation of technological innovation by "optimizing capital allocation efficiency", and the moderating effect of institutional quality

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differs across regions. Sun, Y. et al. (2021) used China's provincial panel data and found that the improvement of institutional quality dimensions such as intellectual property protection and environmental regulation intensity significantly promotes enterprises' green technological innovation activities. Li, Z. et al. (2022) confirmed that environmental regulations and the overall improvement of institutional quality are crucial for driving technological innovation to transform toward green and energy-saving directions, and ultimately effectively promote GTFP growth. Abbas, S. (2023) emphasized that building a strong institutional framework is a core prerequisite for ensuring that technological innovation is effectively transformed into improvements in environmental quality and economic growth performance. Chen, Y. (2023) found that a high-quality institutional environment can significantly strengthen the positive effect of green technological innovation on carbon emission performance, and this effect is particularly prominent in industries with high environmental regulation intensity. Shen Neng et al. (2023) found that financial development can promote the effective transformation and wide application of green technological innovation achievements through capital supply and risk diversification mechanisms, thereby improving green economic efficiency; moreover, the moderating effect varies significantly under different levels of financial development and financial structures. Li Run et al. (2024) pointed out that the synergistic integration of the digital economy and green finance (the "digital green financial system") has a significantly positive effect on promoting high-quality green innovation development, with a double-threshold effect: when the digital economy development level is below 5.2%, the moderating effect of green finance is not significant; after exceeding 12.8%, the digital green financial system can significantly enhance the driving effect of technological innovation on green development, with the elasticity coefficient increasing to 0.51. Wang Yulin et al. (2023) found that the higher the green finance development level, the more significant the role of technological innovation in promoting enterprises' green output growth; in addition, the moderating effect is more prominent in high-polluting enterprises than in low-polluting ones.

Literature Review

Currently, research on institutional quality, green innovation, and the development of China's green economy has achieved phased progress, but there are still several shortcomings and research gaps, specifically as follows:

First, the integration of theoretical frameworks is insufficient. Existing studies mostly focus on exploring the direct impact of institutional quality on the green economy or analyzing the driving effect of green innovation in isolation, while systematic research that integrates institutional quality, green innovation, and green economy development into a unified analytical framework is relatively scarce. A clear and comprehensive theoretical system has not yet been established for the transmission mechanism through which institutional quality affects green economy development by influencing green innovation, making it difficult to fully explain the internal logic and operational mechanism among the three.

Second, the research dimensions of institutional quality are relatively single. Although existing studies on institutional quality cover multiple aspects such as environmental regulation, property rights protection, government governance, marketization level, and green financial systems, they are mostly limited to examining the impact of a single institutional dimension on green innovation or the green economy in isolation, lacking analysis of the synergistic effects among various dimensions of institutional quality. For example, the collaborative interaction

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between environmental regulation policies and green financial systems to jointly promote green innovation and green economy development has not been fully explored.

Third, research on the transformation of green technological innovation achievements is relatively weak. Most existing studies focus on the driving factors of green technological innovation and its contribution to green economic growth, but there is insufficient research on the problems existing in the transformation process of green technological innovation achievements. Issues such as the incomplete top-level institutional design of the green low-carbon technological innovation system, low transformation rate of green technological innovation achievements caused by an imperfect market-oriented mechanism, and the need for optimization of innovation models and organizational systems have not been thoroughly and systematically analyzed.

Fourth, research on regional heterogeneity is not in-depth and detailed enough. Although existing studies have pointed out that the impact of green innovation on green economy development exhibits regional differences, there is a lack of more detailed analysis on how differences in institutional quality across regions affect the relationship between green innovation and green economy development. For instance, significant differences exist in institutional environment, market development level, and technological innovation capabilities among the eastern, central, and western regions of China; the paths and effects through which institutional quality influences green economy development via green innovation may vary drastically across these regions, but existing studies have not conducted in-depth exploration of this aspect.

Fifth, international comparative research is relatively scarce. At present, research on institutional quality, green innovation, and green economy development mainly focuses on the domestic context, with a lack of comparative studies with other countries. Through international comparisons, successful experiences and lessons learned by other countries in institutional design and promoting green economy development through green innovation can be drawn, providing more targeted policy recommendations for China. However, current research in this area is still insufficient.

Future Prospects

Research Recommendations

Construct a Comprehensive Theoretical Framework Aligned with China's Institutional System

Based on China's strategic direction of "advancing the modernization of national governance system and governance capacity" and combined with policy practices under the "dual carbon" goals, a three-dimensional comprehensive theoretical framework covering "institutional quality-green innovation-green economy development" should be constructed. This framework must fully consider China's unique institutional environment—for example, incorporating China-specific institutional elements such as the strategic guiding role of the "Five-Year Plan", the division of powers and responsibilities between the central and local governments, and the responsibility of state-owned enterprises in green development into the analysis, avoiding the direct application of Western theoretical models. Meanwhile, it is necessary to focus on analyzing the transmission mechanism through which institutional

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quality affects the green economy via green innovation. For instance, clarifying how environmental regulations drive enterprises' green technology R&D through a "reverse constraint mechanism", and how green finance solves innovation financing difficulties through "capital guidance", thereby forming a theoretical logic in line with China's national conditions and filling the gap in existing research regarding the integration of the three elements.

Deepen Research on Multi-Dimensional Synergy of Institutional Quality

In response to the systematic characteristics of China's institutional system, breakthroughs should be made in the limitations of single-dimensional institutional research, with a focus on the synergy mechanism among various institutional dimensions. On one hand, research can be conducted around "policy combinations"—for example, analyzing the synergistic effects of environmental regulations (e.g., carbon market policies) and green finance (e.g., green credit, green bonds), and exploring how the combination of carbon pricing mechanisms and green financial instruments reduces the green transformation costs of high-energy-consuming enterprises while encouraging them to increase investment in green innovation. On the other hand, attention should be paid to the synergistic interaction of "institution-policy-market". For example, studying how the coordination of intellectual property protection systems and industry-university-research cooperation policies improves green innovation efficiency by reducing the risk of innovation achievement infringement and establishing technology transformation platforms. In addition, combined with regional institutional differences in China, the differentiated choices of institutional synergy models in different regions should be analyzed to provide a theoretical basis for regional institutional optimization.

Strengthen Research on the Transformation of Green Technological Innovation Achievements

To address China's practical problem of "strong R&D capability but weak transformation capability" in green technology, research on transformation mechanisms should be deepened from both institutional and market perspectives. At the institutional level, focus on analyzing institutional obstacles in the existing transformation process—such as inconsistent green technology standards, cumbersome certification procedures, and insufficient pilot test platforms—and study how to open up the "last mile" from laboratory to industrial application by improving "special policies for green technology transformation", "pilot test subsidy systems", and "rules for cross-regional technology trading markets". At the market level, pay attention to the role of market entities with Chinese characteristics—for example, studying the "demonstration effect" of state-owned enterprises in the large-scale application of green technology, and the path for small and medium-sized enterprises to reduce transformation costs through "green technology sharing platforms". Meanwhile, combined with the development trend of the digital economy, explore the integrated transformation model of "digital technology + green technology", such as realizing the precise matching and efficient promotion of green technology through industrial Internet platforms.

Refine Research on Regional Heterogeneity

Based on the significant differences in resource endowments, industrial structures, and institutional environments among China's four major regions (eastern, central, western, and northeastern), refined research on regional heterogeneity should be conducted. For the eastern region (e.g., the Yangtze River Delta, the Pearl River Delta), focus on analyzing how high

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institutional quality (e.g., high marketization level, optimized business environment) strengthens the driving role of green innovation (e.g., digital green technology, low-carbon technology) in the green economy, and explore the high-level synergy path of "institution-innovation-economy". For the central region (e.g., the Yellow River Basin), focus on the green transformation needs of traditional industries (e.g., iron and steel, chemical engineering), and study how to stimulate green innovation through institutional optimization (e.g., differentiated environmental regulations, industrial transformation subsidies) to promote the development of "traditional industry upgrading-oriented" green economy. For the western region (e.g., the southwest ecological barrier area), combined with the strategic positioning of prioritizing ecological protection, analyze how ecological compensation systems and preferential green finance policies guide green innovation (e.g., ecological restoration technology, clean energy technology) to achieve "win-win between ecological protection and economic development". For the northeastern region, amid the context of revitalizing old industrial bases, study how to solve the problem of insufficient green innovation momentum through institutional reforms (e.g., incentives for green transformation of state-owned enterprises, policies for introducing technical talents) to promote the "breakthrough development" of the green economy.

Expand International Comparative and Cooperative Research

Combined with China's international cooperation needs under the "dual carbon" goals, international comparative research on institutional quality, green innovation, and green economy development should be strengthened. On one hand, select different types of countries (e.g., developed countries such as the EU and the US, and developing countries along the "Belt and Road") for comparison, analyze their experiences and lessons in institutional design (e.g., carbon tax policies, green financial systems), green innovation models (e.g., enterprise-led, government-led), and green economy paths (e.g., industry-upgrading-driven, technology-breakthrough-driven), and provide references for China's institutional optimization. For example, draw on the EU carbon market's "MRV (Monitoring, Reporting, Verification) system" to improve China's carbon market construction, and refer to Germany's "dual-system" vocational education model to train green technology talents. On the other hand, focus on the "Belt and Road" Green Development Initiative, study the paths for China and countries along the route in institutional synergy (e.g., mutual recognition of green technology standards, alignment of green investment rules) and green innovation cooperation (e.g., joint R&D of clean energy technology, co-construction of green technology transformation centers), promote the international dissemination of China's green technology and institutional experience, and at the same time, solve technical bottlenecks in China's green innovation (e.g., high-end low-carbon equipment, carbon capture technology) through international cooperation to inject international impetus into green economy development.

Future Prospects

Based on the shortcomings and research gaps in existing studies, future research can conduct in-depth exploration from the perspectives of theoretical integration, method optimization, comparative analysis, and research dimension expansion. This aims to further improve the research system among institutional quality, green innovation, and green economic development. The specific research directions are as follows:

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Theoretical Framework: Constructing a Multi-Dimensional Integrated Model and Clarifying the Transmission Mechanism

Future research should break through the limitations of existing single-variable analysis. It needs to incorporate institutional quality (covering elements such as environmental regulation, property rights protection, green finance, and government governance), green innovation (including technology R&D and achievement transformation links), and green economic development (involving green total factor productivity and industrial green transformation) into a unified and systematic theoretical framework.On the one hand, emphasis should be placed on analyzing the "synergistic mechanism" among various dimensions of institutional quality. For instance, explore how environmental regulation and green finance reduce the capital costs and risks of green innovation through policy synergy; and how property rights protection and government governance jointly create a stable innovation environment, thereby forming a chain transmission path of "institutional synergy – green innovation – green economy".On the other hand, combined with classic theories such as the "Porter Hypothesis" and "Innovation Ecosystem Theory", a multi-agent interaction model covering "institutional environment – innovation subject – industrial carrier – economic output" can be constructed. This model clarifies the role positioning of different subjects in the transmission process (e.g., the government undertakes the role of institutional supply, enterprises perform the role of innovation implementation, and the market exerts the role of resource allocation). It fills the gap in existing studies regarding insufficient interpretation of the internal logic among the three, thus building a more comprehensive theoretical system.

Research Methods: Introducing Interdisciplinary Technologies and Enhancing Analytical Accuracy

At the level of research methods, multi-dimensional improvements can be made to enhance the scientificity and applicability of research conclusions.First, to address the relative weakness in research on green technology innovation achievement transformation, the "process tracing method" can be introduced. Combined with specific case studies (e.g., new energy enterprises, green technology industrial parks), it analyzes the institutional constraints faced by green innovation in the whole process from "R&D – pilot test – industrialization", and quantifies the impact coefficients of different institutional factors (e.g., technical certification standards, market access mechanisms) on the transformation rate.Second, in view of the relatively rough analysis of regional heterogeneity, "spatial heterogeneity analysis models" (such as Geographically Weighted Regression (GWR) and Multiscale Geographically Weighted Regression (MGWR)) can be adopted. These models refine the differences in institutional quality across eastern, central, western China, and key regions (e.g., the Yellow River Basin, the Yangtze River Delta). They accurately identify the "path thresholds" through which institutional quality affects the green economy via green innovation in different regions (e.g., eastern regions need to strengthen property rights protection, while western regions need to optimize green financial support). Third, combined with big data technology and micro-data, a multi-level panel database of "enterprise – industry – region" can be constructed. Machine learning algorithms (such as random forest, LASSO regression) are introduced to screen key institutional variables. This avoids the simplification of complex relationships by traditional linear models and more truly reflects the non-linear regulatory characteristics of institutional quality and green innovation (e.g., "U"-shaped, multiple threshold effects).

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Comparative Perspective: Deepening Domestic and International Comparisons and Expanding Research Boundaries

Future research needs to break through the limitation of focusing mainly on domestic studies. It should expand the research scope from the dual perspectives of "international comparison" and "domestic regional subdivision comparison".At the international level, countries with different institutional environments and development stages can be selected (e.g., EU member states among developed countries, countries along the "Belt and Road" among developing countries, BRICS countries). Cross-country panel data can be constructed to compare and analyze the differences in the impact of institutional quality (e.g., the perfection of the legal system, the implementation efficiency of environmental regulation) on green innovation-driven green economy. It summarizes replicable international experiences (e.g., Germany’s green technology property rights protection system, Denmark’s synergy mechanism between green finance and environmental regulation) and proposes localized policy optimization plans combined with China’s institutional characteristics.At the domestic regional level, the focus can be on subdivided units such as "urban agglomerations" and "basin economic belts" (e.g., the Guangdong-Hong Kong-Macao Greater Bay Area, the upper, middle and lower reaches of the Yangtze River Economic Belt). It analyzes the differences in the implementation effects of the same institutional policy in different regions, and explores the influencing factors of institutional "implementation efficiency" (e.g., the executive capacity of local governments, the degree of market development). This provides a basis for formulating "location-adapted" institutional policies.

Research Dimensions: Focusing on Achievement Transformation and Emerging Fields to Respond to Practical Needs

Targeting the weak links of existing research, in-depth exploration can be carried out from two dimensions:First, strengthen research on "green technology innovation achievement transformation", with a focus on analyzing how institutional quality breaks through transformation bottlenecks. For example, study the guarantee role of institutions in the "industry-university-research collaborative innovation mechanism" (e.g., the profit distribution system for university-enterprise cooperation, the rules of green technology trading markets), quantify the promotion effect of institutional factors on transformation efficiency, and at the same time pay attention to the enabling role of digital transformation in transformation (e.g., how digital platforms reduce the matching cost of green technology supply and demand).Second, expand research on "emerging institutional fields". With the in-depth integration of the digital economy and the green economy, focus can be placed on exploring the impact of new institutional forms such as "digital green finance system" and "smart environmental regulation" on green innovation. For instance, analyze how digital technology improves the accuracy of green finance (e.g., big data-based credit evaluation of green enterprises) and how smart monitoring enhances the implementation efficiency of environmental regulation. This further reveals the interaction mechanism between new institutions and green innovation, and provides theoretical support for addressing new challenges in green economic development in the digital era.

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