The Economic Growth Effect and Regional Difference Analysis of Green Technological Innovation Under the Carbon Neutrality Goal

Zhu ZhengYu

Mongolian National University,Ulaanbaatar city Bayangol District 1lth Khoroo National University oMongolia，16060；

Abstract： Against the dual backdrop of the global carbon neutrality transition and China's high-quality economic development, green technology innovation has become a core link connecting ecological environmental protection with economic growth. Moving away from reliance on traditional empirical data, this paper systematically analyzes the driving logic of green technology innovation for economic growth from the dual perspectives of theoretical mechanisms and regional practical cases, as well as the characteristics of effect differentiation formed due to differences in resource endowment, industrial base, and policy environment among China's eastern, central, and western regions. The research finds that green technology innovation empowers economic growth through three pathways: "cost saving - industrial upgrading - demand creation." However, differences in the efficiency of factor allocation, the level of industrial structure, and the intensity of policy support among regions lead to a virtuous cycle of "innovation-growth" in the eastern region, while the central and western regions face dual constraints of "insufficient innovation input - weak growth momentum." Finally, optimization suggestions are proposed from three aspects: regional collaborative innovation, industry-appropriate technology R&D, and precise policy support, providing a theoretical reference for achieving regionally balanced green growth.

Keywords: green technology innovation; economic growth effect; regional differences

DOI:10.69979/3041-0843.25.03.060

1 Research Background

Since the signing of the Paris Agreement, carbon neutrality has become a global consensus. China has explicitly proposed the strategic goals of "peaking carbon emissions before 2030 and achieving carbon neutrality before 2060." This goal requires not only a transformation away from the traditional high-energy-consumption, high-emission development model but also the construction of a green, low-carbon economic system with technological innovation as the core driver. As a key support for achieving the carbon neutrality goal, the relationship between green technology innovation and economic growth is not simply one of "cost constraint." Instead, it creates new growth space through technological iteration and industrial restructuring – encompassing both the green transformation of traditional industries and the rise of emerging industries like new energy and energy conservation/environmental protection, forming a synergistic effect between "green transformation" and "economic growth."

However, China's regional development is characterized by significant imbalance. The eastern region has a strong economic foundation and concentrated innovation resources, while the central and western regions face issues such as a heavy industrial structure and weak innovation capacity. This leads to pronounced differences in the economic growth effects of green technology innovation across regions. Ignoring these differences and simply implementing a "one-size-fits-all" green policy may result in a dual dilemma: wasted innovation momentum in the east and excessive transition pressure in the central and western regions. Therefore, theoretically sorting out the pathways through which green technology innovation drives economic growth, combined with analyzing the causes of differences through regional case studies, is of great significance for formulating precise regional green development policies.

2 Theoretical Mechanisms of Green Technology Innovation Driving Economic Growth

Green technology innovation is a full-chain activity encompassing "R&D - application - expansion." It forms a "technology - industry - growth" transmission loop through three progressive pathways, providing momentum for economic growth.

2.1 Pathway One: Cost Saving Effect – Reducing Costs, Improving Efficiency, Enhancing Competitiveness

Traditional high-energy-consumption industries face "dual cost pressures" from production factors and environmental governance. Green technology innovation can alleviate this bidirectionally: on one hand, it reduces production factor costs through technologies like energy saving (e.g., industrial waste heat recovery) and recycling (e.g., wastewater resource utilization); on the other hand, it reduces environmental compliance costs through emission reduction technologies (e.g., desulfurization and denitrification). Taking a steel enterprise as an example, after introducing "oxygen-enriched combustion + waste heat power generation" technology, energy consumption per ton of steel decreased by 15%, saving over 200 million yuan annually in energy costs, while also receiving environmental subsidies. This forms a "cost saving - profit increase - reinvestment" cycle, directly driving industry efficiency and economic growth.

2.2 Pathway Two: Industrial Upgrading Effect – Optimizing Structure, Promoting Transformation

Green technology innovation promotes industrial upgrading from both "incremental" and "stock" dimensions. Incrementally, technological breakthroughs give rise to emerging industries like new energy and carbon services. For instance, iterations in photovoltaic technology have increased China's PV industry output value from 300 billion yuan in 2015 to over 1.4 trillion yuan in 2023. In terms of stock, technological penetration transforms traditional industries. For example, the chemical industry uses "green catalytic technology" to replace highly polluting processes, reducing emissions while increasing product added value, promoting a shift towards fine chemicals. Under this dual effect, the economic structure upgrades towards "low energy consumption, high added value," making growth more endogenous and stable.

2.3 Pathway Three: Demand Creation Effect – Expanding Demand, Strengthening Feedback

Green technology innovation activates both consumption and investment demand. On the consumption side, products like new energy vehicles and energy-saving appliances align with "low-carbon and healthy" demand. For instance, the annual average growth rate of new energy vehicle sales in China exceeds 50%, which is inseparable from the support of battery and charging technologies. On the investment side, new technologies require supporting infrastructure (e.g., charging piles) and also drive investment across the industrial chain, forming an "innovation - investment - employment" chain reaction. Demand expansion, in turn, provides market feedback for innovation, facilitating an "innovation - demand - re-innovation" cycle, amplifying the economic growth effect.

3 Regional Differences in the Economic Growth Effects of Green Technology Innovation: A Comparative Analysis Based on Cases

Due to differences in resource endowment, industrial base, and policy environment, the "R&D - transformation - growth" chain of green technology innovation shows significant divergence across China's eastern, central, and western regions. The following analysis uses Zhejiang, Hubei, and Gansu as typical cases.

3.1 Eastern Region (Zhejiang): Virtuous Cycle of "Innovation - Transformation - Growth"

Zhejiang, leveraging "agglomeration of innovation resources -Perfect industrial supporting facilities - precise policy guidance," has formed a pattern of high input, high transformation, and high growth. On the innovation front, research institutions like Zhejiang University collaborate with enterprises such as Chint and Alibaba. For instance, Chint collaborated with Zhejiang University to develop high-efficiency photovoltaic modules, building a full industrial chain of "R&D - production - operation," driving the province's PV output value to exceed 200 billion yuan. On the industrial front, light industries like Shaoxing textiles have achieved a win-win situation of green transformation and output value growth through

digital printing technology. On the policy front, the 2019 Green Technology Innovation Plan established green industry funds and implemented a "Carbon Efficiency Code," forcing enterprises to innovate and deeply integrating technology with growth.

3.2 Central Region (Hubei): The Dilemma of "Ample Innovation, Insufficient Transformation"

Although Hubei has research advantages from institutions like Wuhan University and Huazhong University of Science and Technology, leading in R&D in areas like energy storage and battery materials, it is constrained by a "heavy chemical industry base + broken innovation chain," making it difficult to commercialize results. For example, the core technology of Dongfeng's Voyah new energy vehicle relies on sources outside the province, and local battery material technologies struggle to integrate into the industrial chain. Policies focus more on the R&D end, with insufficient support for SME incubation and industrial chain supporting facilities. In 2023, the output value of the green industry accounted for less than 15% of GDP, lower than Zhejiang's 22%, indicating significant transition pressure.

3.3 Western Region (Gansu): Constraints of "Resource Dependence, Weak Innovation"

Gansu lacks innovation resources, with limited university research capacity and a high-end talent loss rate exceeding 20%. Enterprise R&D investment is less than 1%. The economy relies on resource-based industries like coal and non-ferrous metals. The new energy industry remains mostly at the power generation end, lacking downstream supporting industries. In 2023, the output value of the green industry accounted for less than 10% of GDP, indicating weak value-added from technology. Limited finances lead to science and technology expenditure share being below the national average, making it difficult to support large-scale innovation. The green growth effect has not yet materialized.

4 Core Causes of Regional Differences: Summary Based on Theory and Cases

Combining the theoretical mechanisms and regional cases above, the regional differences in the economic growth effects of green technology innovation are essentially the result of the combined action of three factors: "efficiency of factor allocation," "adaptability of industrial structure," and "precision of policy support." This can be summarized into the following three aspects:

4.1 Differences in Factor Allocation Efficiency: Agglomeration and Loss of Innovation Resources

Green technology innovation requires the collaborative input of factors such as "talent, capital, and technology." The eastern region, leveraging its favorable economic environment, well-developed public services, and competitive compensation packages, has created a significant "agglomeration effect" for innovation factors. The close collaboration among universities, research institutions, and enterprises facilitates the rapid commercialization of R&D achievements.Financial institutions have high recognition of green technologies, making it easier for enterprises to obtain credit, venture capital, and other funding. For example, the scale of Zhejiang's green industry fund exceeds 50 billion yuan, providing financial support to over 200 green enterprises in 2023 alone.

The central and western regions, however, face a "loss effect" of innovation factors. The central region, although having some educational and scientific resources, experiences brain drain to the east and insufficient enterprise R&D investment, leading to low factor allocation efficiency. The western region, due to its weak economic base, suffers from severe shortages of talent and capital. The total factor input is insufficient, making it difficult to support the full-chain development of green technology innovation.

4.2 Differences in Industrial Structure Adaptability: Active vs. Passive Technology Demand

The economic growth effect of green technology innovation depends on the "demand intensity" and "adaptability" of the industrial structure to the technology. The eastern region, dominated by light industry and high-tech industries, has a flexible industrial structure. The demand for green technology is not only "compliance-driven" but also "competition-driven" – enterprises proactively invest in R&D to achieve product differentiation and cost savings through green technology innovation. For example, textile and home appliance enterprises in Zhejiang treat green technology as a core means to enhance product competitiveness, forming an active cycle of "technology demand - innovation input - growth

feedback."

The industrial structure of the central and western regions is biased towards heavy industry: The demand for green technology in the central region's heavy chemical industries is primarily "compliance-driven," with passive investment only under environmental pressure, lacking the motivation for active innovation. The resource-based industries in the western region have even lower demand for green technology, often limited to "end-of-pipe treatment," making it difficult to achieve industrial upgrading through technological innovation, resulting in a weak correlation between green technology and economic growth.

4.3 Differences in Policy Support Precision: Comprehensive vs. Singular Guidance Direction

Green policies in the eastern region exhibit characteristics of "full-chain guidance," supporting not only R&D (e.g., R&D subsidies, patent awards) but also focusing on technology transformation (e.g., incubator construction, industrial chain supporting facilities) and market expansion (e.g., green consumption subsidies, carbon market mechanisms), forming policy synergy. For example, Zhejiang's "Carbon Efficiency Code" system links corporate carbon emission intensity with taxation and credit, guiding green technology application from the production end to the consumption end.

Policies in the central and western regions, however, are mostly concentrated on the "R&D end," with insufficient support for technology transformation and market cultivation: Although the central region builds innovation centers, it lacks policy support for SME incubation and industrial chain connection; the western region, due to financial constraints, primarily relies on "project subsidies," making it difficult to form sustained innovation incentives, resulting in limited policy effects.

5 Policy Recommendations for Promoting Regionally Balanced Green Growth

Narrowing the regional differences in the economic growth effects of green technology innovation requires building a "differentiated and coordinated" policy system to promote regional complementary advantages.

5.1 Eastern Region: Lead Innovation, Strengthen Spillover

The eastern region needs to consolidate the "innovation-growth" cycle and promote the flow of resources to the central and western regions: First, focus on cutting-edge fields like photovoltaics and energy storage to strengthen advantages in high-end technology R&D. Second, jointly build collaborative innovation platforms with the central and western regions, such as Zhejiang cooperating with Gansu to establish a joint PV R&D center, achieving technology and resource connection. Third, establish green technology trading platforms to reduce innovation costs in the central and western regions through technology licensing and other means, while expanding the market for eastern technologies.

5.2 Central Region: Address Shortcomings, Activate Demand

The central region should focus on technology transformation as the core,breaking through the "R&D - industry" disconnect: First, promote the joint establishment of green technology laboratories by universities and enterprises to conduct targeted R&D on key industrial pain points. Second, set up green technology transformation funds to provide subsidies and interest discounts for SMEs, reducing transformation costs. Third, advance the greening and high-end upgrading of traditional industries in synergy, guiding enterprises to innovate proactively through green certification and government procurement.

5.3 Western Region: Consolidate the Foundation, Rely on Resources

The western region should cultivate endogenous momentum based on its endowment: First, establish green innovation hubs in central cities, using specialized talent programs to attract talent backflow. Second, develop a "resource development + local supporting industries" model. For example, Gansu's wind and photovoltaic power bases should be supported by local equipment manufacturing to extend the industrial chain. Third, explore the integration of ecological value and technology, using carbon sink income to support R&D and promote water-saving and ecological restoration technologies.

Additionally, at the national level, it is necessary to establish regional coordination mechanisms: Improve the paired assistance system between eastern, central and western regions, central, and western regions, incorporating results into

performance evaluations; unify green technology standards and markets, eliminate barriers, and achieve the nationwide circulation of technology and resources.

6 Research Conclusions and Outlook

6.1 Research Conclusions

This paper analyzes the economic growth effects and regional differences of green technology innovation from theoretical and case perspectives. The core conclusions are as follows: First, green technology innovation drives growth through the three pathways of "cost saving - industrial upgrading - demand creation," forming a "technology - industry - demand" transmission loop. Second, the effects differ significantly across eastern, central, and western regions: the east shows a virtuous cycle of "innovation - transformation - growth"; the central region suffers from "ample innovation but insufficient transformation"; the western region's growth effect has not yet materialized. Third, the differences stem from the triple divergence in "factor allocation, industrial adaptability, and policy precision," forming negative cycles in the central and western regions. Fourth, it is necessary to implement policies based on "differentiation + coordination": the east focuses on leading and spilling over, the central region on transformation and activation, the west on building foundations and breaking bottlenecks, supplemented by national coordination mechanisms.

6.2 Research Limitations and Outlook

Limitations include the difficulty of case studies in capturing sub-regional variations within broader geographic areas, as well as insufficient analysis of dynamic interrelationships. Future research could expand the case scope to refine micro-level characteristics and enhance guidance by combining long-term tracking and "policy impact" analysis. In practice, with the advancement of carbon neutrality and the improvement of coordination mechanisms, the eastern, central, and western regions are expected to achieve complementary advantages, forming a national green growth pattern that supports high-quality development and the "Dual Carbon" goals.

References

[1]Sun Bowen, Yang Xiaofei. Regional Synergy Pathways for Green and Low-Carbon Technology Innovation——Based on the Perspective of Technology Supply-Demand Interaction Mechanism in New Schumpeterian Innovation Theory[J]. Environmental Economic Research, 2024, 9(2): 63-90.
[2]Xie Xiaoxuan. The Impact of Digital Economy Development on Carbon Emissions——Based on the Perspective of Energy Use Efficiency and Green Innovation[D]. Nanjing Audit University, 2023.
[3]Shang Shu. Research on the Impact Path of Digital Economy on Industrial Carbon Emissions[D]. Guizhou University of Finance and Economics, 2023.
[4]Chen Ying. Analysis of the Impact of Digital Economy on Regional Carbon Emissions[D]. Nanjing University of Finance and Economics, 2023.
[5]Jiang Ke. Research on the Effect of Digital Economy Development on Carbon Emissions[D]. Anhui University of Finance and Economics, 2023.