Digital Economy Empowers Green Innovation Efficiency - An Empirical Study at the Provincial Level

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Abstract. With the accelerated advancement of the new technological revolution, the rapid rise of the digital economy has injected new vitality into China's economy for high-quality development. This study focuses on 30 provinces in China from 2011 to 2022, using the Super-SBM model and entropy weight method to construct indicators for green innovation efficiency and digital economic development, and the panel data model is utilized to explore whether digital economic development has a promotional effect on regional green innovation efficiency. The findings indicate that the digital economy can significantly enhance regional green innovation efficiency overall, with its marginal benefits in an increasing phase. Heterogeneity tests reveal a significant positive promotion effect of the digital economy on the green innovation efficiency of the eastern and economically developed regions, with a notably higher promotion effect in the central region compared to the eastern region. Conversely, the digital economy exhibits a significant inhibitory effect on the green innovation efficiency of the western and underdeveloped regions. Based on these results, this paper proposes accelerating China's digital economic development and implementing a differentiated digital development strategy to promote regional green innovation efficiency.

Keywords: Digital economy; Green innovation efficiency; Super-SBM model; Panel data model.

1. Introduction

Currently, China's economy has gradually transitioned from a high-speed growth stage to a high-quality development stage, with the digital economy playing a crucial role in this process. In contrast to the traditional agricultural and industrial economy based on material resources, land, and labor, face-to-face transactions, the digital economy relies on data resources as a key element, modern information networks as the main carrier, and the digital transformation of all production factors as an important driving force. Restructuring production factors brings about a comprehensive improvement in social efficiency, making it the mainstream economic form of the present era. Nowadays, the digital economy has deeply integrated with various aspects of politics, economy, and culture, bringing unprecedented changes to the social culture, enterprise management, and residents' lives. According to the "Research Report on the Development of China's Digital Economy (2023)" released by the China Academy of Information and Communications Technology, in 2022, the scale of China's digital economy reached 50.2 trillion yuan, with a nominal year-on-year growth of 10.3%, significantly higher than the nominal GDP growth rate for the 11th consecutive year. The proportion of the digital economy to GDP is equivalent to the proportion of the secondary industry to the national economy, reaching 41.5%. The "14th Five-Year Plan for Digital Economy Development" issued by The State Council also explicitly emphasizes the need to promote deep integration between the digital economy and the real economy and strive to establish a unified, fair, orderly, competitive, mature, and complete modern market system for the digital economy.

With the improvement of economic levels, breaking the traditional growth model of high input and high pollution to achieve green sustainable development has become an important topic of concern for the government, academia, and the public. The production model of green innovation not only enhances production efficiency but also reduces pollution emissions and lowers energy consumption, contributing to achieving the unity of economic, social, and environmental benefits. Likewise, it is an essential part of the “new quality productive forces” and a top priority for future development. The "China's Green Development in the New Era" white paper issued by The State

Council in 2023 clearly states that the concept of "Lucid waters and lush mountains are invaluable assets" should be practiced, resolutely adhering to the path of ecological priority and green development, and promoting comprehensive green transformation of economic and social development. The “14th Five-Year Plan” also proposes to establish a market-oriented system for green technological innovation, and encourage the research and development of green, low-carbon technologies as part of a series of specific guidelines to accelerate green transformation.

Does the development of the digital economy drive the efficiency of green innovation in provinces? If so, how does the marginal benefit brought by the digital economy change? Considering the differences in economic levels, infrastructure construction, and industrial structure among different regions in China, how does the impact of the digital economy on the efficiency of green innovation in different regions vary? Exploring this topic will provide a scientific basis for the deep integration and synergistic efficiency improvement of the digital economy and green innovation, which makes a critical contribution to achieving the goals of “carbon peak and carbon neutrality” and promoting the high-quality development of the national economy.

2. Literature Review

2.1. Research on the Digital Economy

Existing literature on the digital economy mainly includes the construction of digital economy indicators and the impact of the digital economy on various macro indicators such as the economy and the environment. At present, there is no established recognized indicator system for measuring the digital economy. Quantitative research on the digital economy in China mainly focuses on the provincial and prefectural levels. For instance, Wang et al. constructed a primary evaluation indicator system with three dimensions: digital infrastructure, digital industry, and digital environment, measuring the level of digital economic development in 31 provinces in China [1]. From an economic perspective, Jing et al. theoretically discussed how the digital economy at the macro level promotes high-quality economic development through new input factors, new resource allocation methods, and new total factor productivity [2]. Zhang et al., from an empirical perspective, used a spatial Durbin model to verify that China's digital economy and the level of high-quality economic development are showing an overall upward trend, but both exhibit significant spatiotemporal differences [3]. From an environmental perspective, Guo et al. pointed out that the digital economy helps reduce urban carbon emissions, and this carbon reduction effect is more significant in Chinese eastern regions, cities with high human capital and non-resource-based cities [4].

2.2. Research on the green innovation efficiency

In recent years, research on the influencing factors and theoretical mechanism of green innovation efficiency has been continuously emerging. Scholars mainly discuss from the perspectives of industry and economic transformation. Regarding the industry, studies by Cheng et al. using the Tobit model to investigate the influencing factors of industrial green innovation technology efficiency in China found that the degree of marketization, degree of openness to foreign markets, and environmental regulation intensity are the main influencing factors [5]. Li et al. argued that encouraging policies have a limited promotion effect on the green total factor productivity of the manufacturing industry, with restrictive policies showing a "U" shaped relationship [6]. Lei et al. pointed out that environmental regulations can indirectly promote the green transformation of the manufacturing industry through technological innovation, foreign direct investment, and industrial structure [7]. Xie et al. explained that rural inclusive finance mainly improves local agricultural green total factor productivity by enhancing farmers' acceptance of financial services, and the improving financial service efficiency contributes to spatial spillover effects [8]. From the perspective of economic transformation, She et al. combined propensity score matching and DID models to verify that low-carbon pilot policies indirectly enhance the green total factor productivity of cities by improving urban innovation levels and promoting industrial upgrading [9]. Liu et al. concluded from their research that when environmental pollution levels are low, fiscal decentralization will help adjust industrial structures, thereby driving the improvement of green total factor productivity [10].

2.3. Research on the Impact of Digital Economy on Green Innovation

The digital economy, as an important component of new quality productive forces, plays a critical role in driving green innovation. Scholars widely acknowledge the positive impact of the digital economy on enhancing green innovation efficiency across various industries. They also further analyze its influence mechanisms and effects. For instance, Cheng et al. confirmed through dynamic panel models and threshold models that the digital economy significantly promotes the improvement of China's industrial green total factor productivity, and they identified a single threshold effect based on regional industry scale and institutional environment, demonstrating marginal increasing non-linear characteristics, U-shaped relationships, and regional disparities [11]. Zhou et al. discussed the "siphon effect" caused by the significant improvement in the green total factor productivity of central cities due to the digital economy, which hinders the development of peripheral cities [12]. In contrast, Zhu et al. argued that through the increase of regional innovation output and optimization of capital allocation, the digital economy can empower cities' green development, and it can also drive neighboring cities' green development through positive spatial spillover effects [13].

After reviewing the above research, this paper's marginal contributions may include: 1) In terms of research data, selecting a wide range and the most recent data can present a comprehensive picture of the impact of the digital economy on green innovation efficiency. 2) In terms of indicator construction, digital financial inclusion has been included in the evaluation index of digital economic development. Green innovation efficiency considers technology, economic, and environmental benefits in expected output and is calculated using the Super-SBM model. Therefore, the construction of the indicators is more scientifically sound. 3) In terms of research content, this paper examines the promoting effect of the digital economy on green innovation efficiency in different periods, regions, and economic scales through robustness tests and heterogeneity analysis. It also investigates potential marginal benefit changes, providing references for how different regions can promote high-quality green development.

3. Methodology

3.1. Model

To test the hypothesis above, the study constructs the following panel data model to examine the promotion effect of the digital economy on green innovation efficiency:

$$Gie_{it} = \alpha_0 + \alpha_1 Dig_{it} + \alpha_2 Edu_{it} + \alpha_3 Fin_{it} + \alpha_4 Eco_{it} + \alpha_5 Gov_{it} + \alpha_6 Indu_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

In equation (1), i and t represent provinces and years respectively. The response variable Gie_{it} stands for green innovation efficiency. The explanatory variable Dig_{it} represents the level of digital economic development. Edu_{it} denotes human capital. Fin_{it} signifies financial development level. Eco_{it} indicates the economic development level. Gov_{it} measures government support. $Indu_{it}$ represents the level of industrial upgrading. μ_i and δ_t respectively denote regional effects and time effects, and ε_{it} represents the random error term.

3.2. Description of variables

3.2.1 Green Innovation Efficiency

The variable comprehensively considers economic benefits, innovation output, environmental impact and other aspects, measuring whether a region can achieve more expected outputs with fewer inputs and fewer undesired outputs during its development process. Data Envelopment Analysis (DEA) is a common method for measuring efficiency values. Traditional DEA models do not consider issues such as variable slack and undesired outputs. However, non-radial DEA SBM model can effectively address these shortcomings [14]. Additionally, when all decision-making units are on the frontier, the traditional SBM model cannot calculate efficiency value growth across periods. This paper draws on the research results of Deng et al. and establishes the Super-SBM model [15]. The environmental pollution indicators are calculated using the entropy weight method, and Maxdea9 software is used to calculate the green innovation efficiency of various provinces. The specific details of the index construction are shown in Table 1.

Table 1 Construction of green innovation efficiency index system

First-level Indicator	Second-level Indicators	Third-level Indicators
Input Indicators	Human Capital Input	Full-time Equivalent of R&D Personnel in Industrial Enterprises Above Designated Size (Person-years)
	Capital Input	Total Investment in Research and Pollution Control by Industrial Enterprises Above Designated Size (10,000 yuan)
	Energy Input	Electricity Consumption (100 million kWh)
Expected Output	Technological Output	Number of Patent Applications by Industrial Enterprises Above Designated Size (Pieces)
	Economic Output	Sales Revenue of New Products by Industrial Enterprises Above Designated Size (10,000 yuan)
	Environmental Output	Green Coverage Rate in Built-up Areas
Undesired Output	Environmental Pollution Indicators	Industrial SO2 Emissions (10,000 Tons)
		General Solid Waste Generation (10,000 Tons)

3.2.2 Digital Economic Development Index

To scientifically and comprehensively measure the level of digital economy development in each province, digital infrastructure, digital industry development and digital financial inclusion are selected as second-level indicators [16, 18]. According to Guo et al., the third-level indicator composition of digital financial inclusion has been determined [19]. The indicators at all levels of digital economic development are calculated using the entropy weight method. The specific details as shown in Table 2.

Table 2 Construction of China's digital economy development index system

First-level Indicator	Second-level Indicators	Third-level Indicators
Digital economy development	digital infrastructure	Number of domain names
		Number of IPV4 addresses
		Number of Internet access ports
		Mobile phone penetration rate
		Length of long-distance optical cables per unit area
	digital industry development	Number of information technology enterprises
		Number of websites per hundred enterprises
		E-commerce transaction volume (billion yuan)
		Proportion of enterprises engaged in e-commerce transactions
		Software business revenue (10,000 yuan)
	digital financial inclusion	Index of digital financial coverage breadth
		Index of digital financial usage depth
		Level of digitalization of digital finance

3.2.3 Control Variables

Drawing on relevant studies, the following control variables are selected [20]: Human capital (Edu) is measured by the ratio of local university students to the permanent population. Financial development level (Fin) is represented by the ratio of the balance of loans and deposits in each province to the local GDP. Economic development level (Eco) is calculated by taking the logarithm of the per capita GDP of each province. Government support (Gov) is measured by the proportion of general public budget expenditure in each province to the local GDP. The level of industrial upgrading (Indu) is represented by the ratio of the third industry to the second industry in each province.

3.3. Data source

Considering the availability and completeness of data, the study focuses on 30 provinces in China (excluding Xizang, Hong Kong, Macau and Taiwan) from 2011 to 2022. The main data sources include the "China Statistical Yearbook", "China Environmental Yearbook", "China Industrial Statistical Yearbook", "Peking University Digital Inclusive Finance Index", and the statistical yearbooks of each province. Descriptive statistics of the variables used are shown in Table 3.

Table 3 Descriptive Statistics Results

Variables	Mean	Std. Dev.	Min	Max
Gie	0.6029	0.3775	0.0538	2.9999
Dig	0.1853	0.1542	0.0025	0.8829
Edu	0.0209	0.0059	0.0016	0.0436
Fin	3.4321	1.0963	1.6776	7.6095
Eco	10.8684	0.4614	9.6818	12.1564
Gov	0.2557	0.1051	0.0256	0.7583
Indu	1.2659	0.7221	0.5183	5.3101

4. Empirical Results and Analysis

4.1. Benchmark Regression Results

The study utilized Stata 18 software to conduct regression analysis on fixed effects and random effects models. In order to eliminate potential multicollinearity among variables, a method of sequentially adding control variables was employed for regression analysis. The Hausman test rejected the null hypothesis, indicating that the regression results of the fixed effects model were more ideal, as shown in Table 4.

Upon adding control variables one by one, the regression results from Column (1) to Column (6) all indicate that the coefficients of the core explanatory variables are positive and statistically significant at the 1% level. This is attributed to the widespread application of technologies such as big data technology and artificial intelligence in enterprise decision-making processes with the development of the digital economy. Through technological guidance, it is possible to enhance production efficiency, efficiently allocate labor and natural resources, and reduce waste and the generation of pollutants. Furthermore, the development of the digital industry can significantly reduce transaction costs, empowering regions for green and high-quality development. Taking Column (6) as an example, for every unit increase in the level of digital economic development, the average regional green innovation efficiency index is promoted by 0.7501, indicating a significant positive promotion effect of the digital economy on green innovation efficiency.

From the regression results from column (6), the estimated coefficient of human capital (Edu) is positive but not significant. Human capital level is the foundation for regions to engage in innovative activities. The enhancement of human capital often leads to more patented technologies and improved management efficiency. However, it did not pass the significance test, indicating that this part of human resources has not been effectively utilized in green innovation activities, thus not promoting the development of regional green innovation endeavors.

The level of financial development (Fin) is significantly positive at the 5% level, suggesting that financial development injects vitality into regional green innovation activities to a certain extent. With the gradual advancement of the national "green finance" strategy, the capital market's support for green innovation industries and enterprises continues to strengthen. Through forms such as green funds and green bonds, a large number of low-cost funds are provided to green enterprises, aiding them in conducting clean production, green technology research and development, and other innovative activities, directly enhancing the efficiency of regional green innovation.

The estimated coefficient for the level of economic development (Eco) is 0.173 and is significant at the 5% level. It is because as the level of economic development increases, the overall environmental awareness and sustainable development concepts of the society are gradually improving, which enhances public attention to local government and corporate green innovation activities, stimulating the enhancement of regional green innovation efficiency. At the same time, a developed economic level can create a "siphon effect," attracting more high-quality, socially responsible enterprises, which contributes to the improvement of the regional industrial chain and the formation of industrial clusters, reducing unnecessary resource waste and adding momentum to regional green innovation.

The estimated coefficient for government support (Gov) is negative but not significant, indicating that general public budget expenditures by the government have not been effectively invested in the development of regional green innovation initiatives. Local governments still need to strengthen the allocation, management, and utilization of budget funds to promote the progress of regional green development.

The level of industrial upgrading (Indu) is positively correlated with green innovation efficiency at a 1% level. It indicates significant potential for the tertiary industry to promote regional green innovation efficiency. This is because provinces with a well-developed tertiary industry attract more talent, have a higher public awareness of environmental protection, engage in frequent green innovation activities, possess a solid foundation for digital economic development, and are more conducive to leveraging the guidance role of the digital economy in green development. Additionally, the resource consumption and pollution emissions of the tertiary industry related to digital commerce are lower, which also contributes to the region's green development.

Table 4 Benchmark Regression Results

Variables	Green Innovation Efficiency					
	(1)	(2)	(3)	(4)	(5)	(6)
Dig	1.6244*** (13.85)	1.6058*** (13.97)	1.3320*** (10.89)	0.9755*** (5.41)	0.8347*** (3.85)	0.7501*** (3.47)
Edu		12.2570*** (4.00)	8.6821*** (2.87)	4.3778 (1.29)	2.3140 (0.6)	1.5950 (0.42)
Fin			0.0862*** (5.28)	0.0806*** (4.94)	0.1006*** (4.27)	0.0561** (2.01)
Eco				0.1854*** (2.67)	0.1619** (2.24)	0.1730** (2.42)
Gov					-0.3115 (-1.17)	-0.2692 (-1.02)
Indu						0.0994*** (2.92)
Cons	0.3019*** (11.17)	0.0487 (0.71)	-0.1217* (-1.65)	-1.9615*** (-2.83)	-1.6251** (-2.17)	-1.6997** (-2.29）
Regional fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effect	No	Yes	Yes	Yes	Yes	Yes
R^2	0.3559	0.3844	0.4304	0.4419	0.4442	0.4577
Observations	360	360	360	360	360	360
Region	30	30	30	30	30	30

4.2. Robustness Test

To ensure the reliability of the research conclusions, the study conducts robustness tests using three methods, with regression results presented in Table 5. Firstly, the calculation method for the digital economy was altered by adjusting the three-level indicators of digital economic development and reconstructing Dig2 using the coefficient of variation method. Secondly, the method of replacing indicators was employed by substituting human capital input for green innovation efficiency with the number of employees at the end of the year, and replacing technical output with the number of effective invention patents, resulting in Gie2. Thirdly, time periods were divided to ensure that over time, the regional digital economy development consistently promotes green innovation efficiency. Green innovation efficiency was divided into two time periods: 2011-2016 and 2017-2022.

Results in column (1) indicate that the coefficient of the digital economy and its significance show no substantial changes compared to the benchmark regression results. Column (2) demonstrates a significant positive effect of digital economic development on regional green innovation efficiency at the 5% level, with the research conclusions remaining unchanged. Results from column (3) to column (4) all indicate a positive effect, but the impact coefficient of the digital economy in the period 2017-2022 is larger than in the period 2011-2016, suggesting that with the continuous development of the digital economy, its marginal contribution to regional green innovation efficiency has an upward trend.

Table 5 Robustness Test Results

Variables	Gie1	Gie2	Gie1 (2011-2016)	Gie1 (2017-2022)
Dig1		0.5942^{**} (2.34)	0.4823^{***} (3.08)	1.2240^{***} (4.33)
Dig2	0.8307^{***} (3.31)			
Control	Yes	Yes	Yes	Yes
Cons	-1.6504^{**} (-2.19)	-3.3430^{***} (-3.84)	-2.2021^{**} (-2.23)	-1.8503 (-1.63)
Regional fixed effect	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	No
R^2	0.4560	0.4716	0.4702	0.5192
Observations	360	360	180	180
Region	30	30	30	30

4.3. Heterogeneity Analysis

4.3.1. Geographical Heterogeneity

The development of China's digital economy shows a clear trend of hierarchical differentiation, resource endowment, and geographical disparities, resulting in significant spatial heterogeneity. To further investigate the regional differences in the efficiency of green innovation brought about by the digital economy, the study divides 30 provinces into three regions: eastern, central, and western, for group regression analysis. The results, as shown in columns (1) to (3) of Table 6, indicate that in both the eastern and central regions, the effect of the digital economy on green innovation efficiency is significantly positive, with a more prominent effect observed in the central region. It could be attributed to the more advanced stage of digital economy development in the eastern region compared to the central region, causing diminishing marginal benefits of green innovation efficiency for each unit increase in digital economy development. The western region shows a significant negative effect at the 5% level, possibly due to the threshold effect of digital economy development on green innovation [21]. The western region lags behind in digital economy development, with substantial initial investments required for digital infrastructure, involving the upgrading of industries, commercial application delays, and significant resource consumption like electricity. These reasons may hinder the full realization of development dividends in the initial stages of digital economy development, consequently impeding the enhancement of green innovation efficiency.

4.3.2. Economic Disparity

The development dividend of the digital economy will be influenced by the economic size and regional development level. The study divides the total GDP rankings of 30 provinces into economically developed and underdeveloped areas from the perspective of economic scale, with the top 15 and bottom 15 rankings respectively. The regression results in columns (4) and (5) of Table 6 show that in economically developed areas, the coefficient of digital economic development is significantly positive at the 1% level, while in underdeveloped areas, the coefficient is significantly negative. It also indicates the likely presence of a threshold effect of economic size on the development of the digital economy.

Table 6 Heterogeneity Test Results

Variables	Green Innovation Efficiency				
	Eastern region	Central region	Western region	Economically developed region	Economically underdeveloped region
Dig	1.3427***	6.7017***	-1.5318**	0.9924***	-3.6306***
	(5.07)	(2.91)	(-2.15)	(3.91)	(-2.95)
Edu	9.3297	-47.6505***	-27.9676***	-20.8630***	16.4955**
	(1.60)	(-3.25)	(-4.09)	(-3.21)	(2.52)
Fin	0.0728**	-0.1602	0.3015***	-0.0770	0.0424
	(2.00)	(-1.46)	(4.33)	(-1.57)	(0.86)
Eco	0.2017*	1.2174***	0.3463**	0.2565**	0.2237**
	(1.68)	(3.42)	(2.5)	(2.02)	(2.05)
Gov	1.1027*	8.0300***	-2.4533***	2.0911**	-0.5577
	(1.92)	(3.51)	(-5.21)	(2.06)	(-1.35)
Indu	0.0228	-0.3136	0.0483	0.2726***	-0.0203
	(0.52)	(-1.47)	(0.31)	(5.14)	(-0.36)
Cons	-2.6124**	-13.4149***	-2.7966*	-2.4227*	-1.8125
	(-2.05)	(-3.41)	(-1.76)	(-1.75)	(-1.61)
Regional fixed effect	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	No	No	Yes	No
R^2	0.6086	0.3825	0.2230	0.6443	0.1903
Observations	156	72	132	180	180
Region	13	6	11	15	15

5. Research Conclusion and Recommendation

5.1. Conclusion

Applying digital technology, digital industries, and digital inclusive finance to regional green construction and sustainable development is of critical practical and strategic importance for China to achieve "dual carbon" goals and promote high-quality economic development. This paper utilizes provincial panel data from China between 2011 and 2022. By constructing indicators for digital economic development and regional green innovation efficiency, the study examines the promoting effect of the digital economy on green innovation efficiency using panel data models. The main conclusions present as follows:

Firstly, the digital economy can significantly enhance regional green innovation efficiency, and the conclusion remains valid after conducting robustness tests. In addition, upon dividing the time period, it is found that with the development of the digital economy, the marginal benefits of the digital economy on regional green innovation efficiency are on the rise.

Secondly, the impact of the digital economy on green innovation efficiency varies based on geographical location and economic size. The digital economy has a significant positive effect on green innovation efficiency in the eastern and central regions as well as economically developed areas, with a notably higher impact on the central region compared to the eastern region. Conversely, it exerts a significant inhibitory effect on the western regions and economically underdeveloped areas.

5.2. Recommendation

Based on the above conclusions, the following policy suggestions are proposed:

1) Accelerate the development of China's digital economy. Speed up the construction and development of digital infrastructure, digital industries, and digital financial inclusion in China, which will overall help improve the regional green innovation efficiency. Governments should promote the application of digital technologies such as the Internet of Things, big data technology, and artificial intelligence in traditional industries to enhance the resource allocation and utilization efficiency of traditional industries. Moreover, encouraging businesses to undergo digital transformation can reduce production and transaction costs, thereby driving the development of new quality productive forces. They could also establish official platforms for digital technology innovation and exchange to facilitate transaction linkage and resource sharing among enterprises in the industrial chain. At the policy level, government at all levels should have relevant talent to provide guidance and improve laws and regulations regarding data security and intellectual property rights to promote healthy and orderly digital economy development.

2) Implement precise and targeted regional digital economic policies to address the imbalances and regional disparities brought about by development, namely pay attention to the development of the digital economy in central regions and steadily promote the digital economy in western regions. On the one hand, central region is currently experiencing the dividends of digital development and should focus on the development of relatively weak digital industries, actively promoting the commercial application of digital economy. For example, it can explore the application of digital technology in new fields such as smart manufacturing and intelligent healthcare. Central region can also play a prominent role in the strategic project that channels computing resources from the east to the west. By strengthening the utilization of computing resources and intelligent scheduling, central region is expected to synergistically drive the digital economic development of the eastern and western regions. On the other hand, although the current digital economy development in the western region does not directly enhance green innovation efficiency, in the long run, it is still more beneficial than harmful. Local governments should establish relevant funding policies to encourage businesses to invest in digital infrastructure. The western region can also learn from the experience of digital economic development in the eastern and central regions, adapting measures to local conditions. For instance, local governments in the western region can lead inter-regional technical cooperation and exchanges to achieve coordinated development among the eastern, central, and western regions.

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