Transforming carbon productivity through digital economy and technological innovation

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Abstract

In addressing the pressing challenge of carbon emissions, digital development emerges as a pivotal solution. This study examines data from 30 Chinese provinces spanning 2010 to 2019, employing an intermediary effect model to establish a theoretical framework linking technological innovation, carbon emissions, and the digital economy. Our empirical analysis reveals several key findings: (1) Both digital economy and technological innovation exert a positive influence on enhancing carbon productivity, with the impact of the former significantly surpassing that of the latter. (2) Innovation acts as a crucial intermediary variable, facilitating the transmission of the digital economy's impact on China's carbon productivity. (3) The impact of the digital economy on carbon productivity varies across regions, with the most pronounced effects observed in eastern provinces.

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1. Introduction

The escalating challenge of global climate change spurred by carbon emissions necessitates urgent action. From recurrent extreme weather events to land droughts and forest fires, the environmental ramifications pose profound threats to both livelihoods and societal advancement, resulting in substantial economic losses. China, cognizant of the imperative to balance economic growth with environmental sustainability and social progress, has committed to achieving carbon peak by 2030 and carbon neutrality by 2060. Central to this endeavor is the concept of carbon productivity, serving as a pivotal bridge between economic growth and carbon emissions mitigation.

Against the backdrop of China's rapid economic evolution, characterized by a transition from agrarian and industrial phases to a digitally-driven economy, the emergence of the digital economy assumes paramount significance. This transformative force revolutionizes societal production, lifestyles, and governance, fostering the diversification of low-carbon industrial structures and imbuing the industrial chain with eco-friendliness. Clearly, both carbon productivity and the digital economy are indispensable drivers of sustainable development. This paper seeks to elucidate the nexus between the digital economy and carbon productivity, probing into the mechanisms through which the former influences the latter and discerning regional disparities in this impact. Through empirical inquiry, this study not only enriches our understanding of economic development dynamics but also furnishes empirical insights crucial for navigating the pathway toward achieving dual carbon goals.

2. Enhancing User-Friendliness

In the year 2020, China's digital economy soared to approximately 39.3 trillion yuan, marking a monumental shift in global industrial focus. The proliferation of the digital economy has been attributed to several factors. Firstly, it serves as a potent catalyst for rapid economic expansion. Secondly, scholars argue that the digital economy enhances the efficiency of production resource utilization. Thirdly, it constitutes a pivotal component in fostering ecological green development.

At its core, technological innovation fosters a more judicious allocation of economic resources among industries, continuously elevating economic efficiency levels. Notably, China's technological trajectory is inexorably linked to the ascendancy of the digital economy. Accordingly, scholars have extensively investigated the manifold ways in which the digital economy influences technological innovation. Primarily, it directly stimulates technological innovation through digital industrialization and industrial digitalization. Secondly, the digital economy indirectly spurs technological innovation by reshaping the allocation of capital, innovation, efficiency, and labor across industries. Additionally, some studies posit that the digital economy, as a technology in itself, facilitates the transition from labor-intensive industrial structures to high-tech, low-carbon, and green industrial frameworks.

Technological innovation plays a pivotal role in reducing carbon emission intensity and enhancing carbon productivity. Research by Feng & Wu (2022) emphasizes the significant positive impact of industrial structural upgrades and technological innovation on carbon productivity, particularly in eastern regions. Wang & Feng (2020) utilize total factor productivity estimation methods to demonstrate the efficacy of technological innovation in reducing carbon emission intensity. Similarly, Liu et al. (2021) employ dynamic spatial Dubin models to underscore the role of breakthrough low-carbon technology innovation in alleviating emission pressures. Zhang et al. (2022) explore the internal mechanisms through which high-tech industries bolster carbon productivity, highlighting economies of scale and total factor productivity.

A. Impact of the Digital Economy on Carbon Productivity

The digital economy augments carbon productivity by enhancing information transfer efficiency through technology. Leveraging advanced digital technologies and data integration reduces resource consumption at the production end, thereby curbing energy demand and intensity while fostering carbon emission reduction. Additionally, digital economy-driven optimization of resource allocation and energy utilization bolsters carbon productivity. By facilitating insights into energy market trends and price fluctuations, digital technologies ensure energy supply, guide efficient energy allocation, and optimize energy flow, culminating in enhanced carbon productivity.

B. Influence of Digital Economy on Technological Innovation

From a macro perspective, the digital economy catalyzes the healthy development of digital industrialization and industrial digitalization, infusing industries with new production factors such as information, technology, and data. This spurs industrial technical and innovation efficiencies, fosters emerging industries, and reshapes industrial structures. On a micro level, the digital economy accelerates labor productivity, streamlines industrial chain information transmission, reduces transaction costs, and optimizes production, transportation, sales, and consumption processes, thereby propelling technological innovation.

C. Intermediary Effect of Technological Innovation between Digital Economy and Carbon Productivity

The development of the digital economy augments carbon productivity by fostering unparalleled heights of technological innovation. The symbiotic relationship between the digital economy, technological innovation, and carbon productivity constitutes an indivisible whole. The digital economy's development facilitates industrial sector transformation, engenders new industries, and fosters cross-border integration and mode reconstruction. Technological innovation, as an intermediary variable, regulates the relationship between the digital economy and carbon productivity, exhibiting regional heterogeneity.

3. Index selection and model design

The variable under consideration is carbon productivity, denoting the GDP output per unit of carbon dioxide emissions. This study utilizes pertinent international data and follows the unified standard method endorsed by the IPCC for computing CO2 emissions across all provinces, regions, and cities in China. The calculation formula is outlined as follows:

$$CE_t = E_i \times T_i \times LCV_i \times CEF_i \times O_i \times \frac{44}{12} \quad (1)$$

$$cp = \frac{GDP}{CE} \quad (2)$$

In this formula, CEt signifies the total carbon emissions of a province in year t, whereas Cp represents the carbon production rate, and GDP stands for gross domestic product. The variables Ei, Ti, LCVi, CEFi, and Oi denote the consumption of fuel i, coefficient of standard coal, coefficient of low calorific value, carbon emission coefficient, and oxidation rate of fuel i, respectively. The ratio 44/12 represents the molecular weight ratio of CO2 to C. Energy consumption data are sourced from the energy balance sheet, encompassing coal, coke, crude oil, and gasoline.

The primary explanatory variable is the development level of the digital economy. This study dissects the digital economy index into four dimensions: informatization, Internet development, network industry practitioners, and digital transactions. From these dimensions, 12 measurement indicators are selected, including optical cable density, revenue from electronic equipment manufacturing, density of mobile phone base stations, technical transformation expenditure of industrial enterprises, telecom business volume, software revenue, information technology service income, mobile phone penetration rate, broadband Internet user proportion, e-commerce sales, e-commerce share, and total mobile payments. These indicators collectively form a comprehensive measurement system for assessing the digital economy's level in China's provinces, districts, and cities. Data spanning 2010 to 2020 are sourced from the China Statistical Yearbook.

Utilizing the linear weighting method and integrating the selected 12 indicators, the development level of the digital economy is measured. The calculation formula is presented as follows:

$$de = \sum_{j=1}^{12} M_{it} \times N_j \quad (3)$$

In the given context, "j" signifies the standardized measurement index, while "Nj" represents the weight assigned to the jth measurement index relative to the digital economy level. This study adopts the NBI index weight determination method to establish these weights.

A. Data Source and Descriptive Statistics

The research focuses on 30 provinces, autonomous regions, and municipalities in China (excluding Tibet, Hong Kong, Macao, and Taiwan). Descriptive statistical results of each variable are presented in Table 1. To facilitate the analysis of the trends in the digital economy, technological innovation, and carbon productivity across these regions from 2010 to 2019, the paper computes the average values of these variables for different provinces, autonomous regions, and municipalities, expressing them in logarithmic form.

Table 1: Descriptive Statistical Results of Variables

Variable	Observations	Mean Value	Standard Deviation	Minimum Value	Maximum Value
lncp	300	-0.4169	0.5950	-1.7091	1.2758
lnde	300	0.8095	0.4355	-0.2613	2.0055
lninno	300	8.0024	1.4434	3.7135	10.997
lnurban	300	-0.5832	0.2081	-1.0846	-0.1097
lneef	300	-0.5752	0.1950	-1.1301	0.2510
lnfdi	300	-4.2749	1.1271	-8.4089	-2.5318
lnstr	300	-0.8002	0.2246	-1.3313	-0.1255

Note:
"lncp" represents the logarithm of carbon productivity.
"lnde" represents the logarithm of the development level of the digital economy.
"lninno" represents the logarithm of technological innovation.
"lnurban" represents the logarithm of urbanization level.
"lneef" represents the logarithm of energy efficiency.
"lnfdi" represents the logarithm of foreign direct investment.
"lnstr" represents the logarithm of strategic emerging industries.

B. Regional Heterogeneity Test

The analysis of the digital economy development levels across the 30 provinces reveals a pronounced digital disparity among different regions, suggesting that the impact of the digital economy on carbon productivity may vary across regions. To investigate whether the digital economy significantly influences carbon productivity development in specific regions, this study categorizes the 30 provinces, regions, and cities into three distinct regions: the eastern region, the central region, and the western region.

The findings indicate that the digital economy exerts the most substantial impact on carbon productivity in the eastern region. This outcome can be attributed to the relatively higher levels of digital economy and technological innovation in the eastern regions compared to the central and western regions. The advancement of the digital economy and technological innovation positively contributes to industrial structural transformation, thereby enhancing carbon productivity.

In contrast, the central region exhibits a moderate impact, while the western region experiences comparatively minimal influence. This discrepancy may stem from significant disparities between the central and western regions and the eastern regions in terms of research and development, production, commercialization, and managerial digitalization. Moreover, the scarcity of digital talent in these regions may impede the digital economy's potential to foster technological innovation.

Overall, the observed regional heterogeneity underscores the importance of considering regional contexts and disparities when assessing the relationship between the digital economy, technological innovation, and carbon productivity. By recognizing and addressing regional disparities, policymakers can better formulate targeted strategies to harness the potential of the digital economy for sustainable development across diverse regions.

4. Conclusions and Policy Recommendations

Based on the research findings, it is evident that the digital economy and technological innovation significantly enhance carbon productivity levels, albeit with considerable regional variations. In light of these conclusions, the following policy recommendations are proposed:

Harness the Potential of the Digital Economy: Recognize and capitalize on the growth potential of the digital economy by fostering the development of related industries and expanding the digital economy's footprint. Given the digital economy's increasing prominence on the global stage, it is imperative to bolster its development and competitiveness. This entails expanding the scope of the digital economy, fostering collaboration with the real economy, and introducing novel industries, formats, and models.

Address Regional Disparities: Acknowledge and address the regional heterogeneity in the digital economy and technological innovation landscape, tailoring strategies to suit local conditions. The research underscores the relatively weak role of the digital economy and technological innovation in improving carbon productivity in the western and central regions. This suggests a need for targeted interventions to bolster digital economy development and foster technological breakthroughs in these regions.

Promote Integrated Economic and Low-Carbon Development: Foster synergies between economic development and low-carbon initiatives, taking into account regional disparities and unique characteristics. By leveraging the potential of the digital economy to reduce carbon emissions and enhance carbon productivity, regions can unlock development opportunities and realize the dividends of digital transformation.

In summary, by embracing these recommendations and adopting a nuanced approach to policy formulation, policymakers can effectively harness the transformative potential of the digital economy and technological innovation to drive sustainable development and low-carbon growth across diverse regions.

5. References

1. Feng Y, Wu H. How does industrial structure transformation affect carbon emissions in China: The moderating effect of financial development? Environmental Science and Pollution Research. 2022; 29(9):13466-13477.
2. Wang M, Feng C. Regional total-factor productivity and environmental governance efficiency of China’s industrial sectors: A two-stage network-based super DEA approach. Journal of Cleaner Production. 2020; 273:123110.
3. Liu P, Zhang L, Tarbert H, Yan Z. Analysis on spatio-temporal characteristics and influencing factors of industrial green innovation efficiency-From the perspective of innovation value chain. Sustainability. 2021; 14(1):342.
4. Zhang L, Ma X, Ock YS, Qing L. Research on regional differences and influencing factors of Chinese industrial green technology innovation efficiency based on dagum gini coefficient decomposition. Land. 2022; 11(1):122.
5. Han D, Ding Y, Shi Z, He Y. The impact of digital economy on total factor carbon productivity: the threshold effect of technology accumulation. Environmental Science and Pollution Research, 2022, 1-16.
6. Li K, Kim DJ, Lang KR, Kauffman RJ, Naldi M. How should we understand the digital economy in Asia? Critical assessment and research agenda. Electronic commerce research and applications. 2020; 44:101004.
7. Meng F, Zhao Y. How does digital economy affect green total factor productivity at the industry level in China: From a perspective of global value chain. Environmental Science and Pollution Research, 2022, 1-19.
8. Carlsson B. The Digital Economy: what is new and what is not?. Structural change and economic dynamics. 2004; 15(3):245-264.
9. Fudenberg D, Villas-Boas JM. In the digital economy. e Oxford Handbook of the Digital Economy, 2012, 254.
10. Chernyakov M, Chernyakova M. Technological risks of the digital economy. Корпоративные финансы. 2018; 12(4):99-109.