

Analysis on the Impact of Digital Economy Development on Carbon Emissions in Anhui Province

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Abstract: On February 2, 2021, the central government issued the guiding opinions of the State Council on accelerating the establishment and improvement of a green low-carbon circular development economic system. The opinions pointed out that it is necessary to follow the deployment, implement the new development concept, develop green in all directions, effectively control greenhouse gas emissions, establish and improve a green low-carbon circular development economic system, and promote China's green development to a new level. Under the guidance of policies, Anhui Province has taken active actions to seriously implement the low-carbon emission reduction strategy. This paper first analyzes the mechanism of the development of digital economy in Anhui Province on carbon emissions, and then empirically analyzes the impact of the development of digital economy in Anhui Province on carbon emissions based on the relevant data from 2015 to 2020. Finally, the paper puts forward some suggestions on the development of digital economy and carbon emissions in Anhui Province.

Keywords: Digital economy; Carbon emissions; Green development; Static panel model.

1. Introduction

In the past few decades, with the rapid development of the global economy, human beings have paid more and more. Air pollution, water pollution, land pollution and other environmental pollution problems have become increasingly serious. Among them, a large number of greenhouse gases such as CO₂ cause global warming, and then cause extreme weather such as glacier melting, drought and flood polarization, which seriously harm people's physical and mental health. Driven by economic growth, carbon emissions are also increasing rapidly. It is urgent to solve the contradiction between economic growth and green development. On the increasingly fierce climate issue, all walks of life have also proposed to promote low-carbon environmental protection and green innovation development. Since the reform and opening-up, China has paid close attention to environmental protection while its economy has been developing rapidly. Among them, low-carbon emission reduction, as an important means of environmental protection in China, has attracted the attention of all walks of life. China has always been a responsible world power at the World Congress and has actively participated in the solution of the carbon emission problem. Chinese leaders proposed at the joint conference that China's carbon dioxide emissions should strive to achieve the "double carbon" goals of carbon peaking and carbon neutralization by 2030 and 2060 respectively. Undoubtedly, the carbon emission reduction has been raised to an unprecedented level. The proposal of the "double carbon" goal will accelerate the implementation of China's green innovation development strategy, help build a green China with beautiful mountains and rivers, and contribute to the reduction of greenhouse gas emissions and green development in the world. It shows China's determination to reduce carbon emissions, mitigate the greenhouse effect and achieve sustainable development, which is in line with China's high-quality road. For a long time, the government of Anhui Province has been actively addressing the issue of

carbon dioxide emissions. In 2022, the Interim Measures for the preparation and verification of greenhouse gas emission reports in Anhui Province proposed to provide data support for carbon emission reduction. By strengthening the inspection of the data accuracy of key greenhouse gas emission units, data analysis and capture, using the digital economy to solve the problem of local carbon emission reduction, optimize the local resource structure and use efficiency, adhere to the concept of green development, accelerate the sustainability of green low-carbon cycle, Realize energy conservation and emission reduction, promote green and sustainable development in Anhui Province, and accelerate the process of green development and construction in urban and rural areas.

With the continuous innovation of network information technology, a new economy -- digital economy, with its new driving force, new business forms and rapid development of digital economy technology, has been derived, which has triggered profound changes in the whole society and economy. The economic effect brought by the development of digital economy has made China the second largest digital economy developing country in the world. Relevant data in the white paper on the development of China's digital economy show that from 22.6 trillion yuan in 2016 to 3.92 billion yuan in 2020, the digital economy will account for 38.6% of GDP in 2020, and the scale of China's digital economy will account for an increasing proportion of GDP, showing a rising trend. Despite the epidemic and the downward pressure of the global economy, China's digital economy still maintains a high growth rate. All these show that the development of the digital economy is increasingly becoming the main driving force for stable economic development. China's development and construction cannot be separated from the connecting role of the digital economy. The construction of digital economy has penetrated into all aspects of life, and the role of green innovation development is undoubtedly. More and more construction is linked to digital economy, and the development of digital economy promotes the green

revolution.

The rapid development of the digital economy has received continuous attention from more and more academic circles. Can the great role of the digital economy, combined with carbon emission reduction, achieve the goals of energy conservation and emission reduction, green innovation and double carbon? Can the continuous development of digital economy reduce the pressure of carbon emission in Anhui Province? Scholars have studied and discussed the important role of digital economy in reducing carbon emissions from different perspectives. From the existing research documents, we are mainly concerned about the discussion of digital economy and its economy, and the research and discussion of carbon emissions, double carbon goals and green development. For example, Xu Weixiang and other scholars pointed out (2022) that the digital economy has an important impact on the exertion of urban carbon emission effect, which is reflected in the digital innovation ability, digital Inclusive Finance, digital economy and the development of digital industry, which significantly reduce the regional carbon emission intensity. Xie Yunfei (2022) analyzed the impact of blockchain on industrial green development, Xu Zhao et al (2021) analyzed the impact of digital Finance on pollution emissions, but such research cannot fully prove the substantial impact of digital economy on carbon emissions, and the theory of the effect of digital economy development on carbon emissions still needs to be improved. This study introduces the variable of digital economy development into the theoretical research framework of influencing factors of carbon emission reduction in Anhui Province, and systematically examines the role of digital economy in urban carbon emission reduction in Anhui Province. The academic research on the mechanism of the development of digital economy and carbon emissions is not perfect. At the same time, the role of digital economy on the development of green innovation is rarely involved, and there are still shortcomings. On the basis of such theories, this study will focus on the impact of digital economy development on carbon emission intensity? Whether there is a linear relationship between the two, and the implementation effect of carbon reduction and emission reduction in the future development of the city. The development of digital economy promotes the revolution of green innovation development, energy conservation and emission reduction. To sum up, this study provides scientific basis and theoretical reference for reducing urban carbon dioxide emissions and promoting green, high-quality and sustainable development of urban areas in Anhui Province from the perspective of green innovation and digital economy development through rigorous empirical research.

2. Theoretical Analysis and Research Hypothesis

2.1. Digital economy and carbon emissions

With the development of Chinese economy, digital economy has become an indispensable part of people's life. The digital economy has also made great contributions to promoting carbon emissions.

First of all, from a macro perspective, the government analyzes the data through the effectiveness, accuracy and timeliness of digitizing specific information, so as to better and timely understand the resource market conditions such as

price fluctuations and energy flows, better allocate energy market resources, and effectively achieve the carbon emission target. Secondly, the government can also better digitally operate the resource trading market through the digital economy to effectively manage the total amount of carbon emissions.

From the perspective of industrial structure, economic digitization leads to the comprehensive upgrading of the industrial structure dominated by the third economy. This will lead to the improvement of industrial structure, improve production efficiency, and promote the flow of production factors to capital intensive industries. Resource driven production sectors and industries will also undergo digital transformation, ultimately reducing carbon emissions and significantly improving energy efficiency.

From the perspective of micro enterprises, economic digitization enables enterprises to reduce carbon emissions by innovating production process tools, reducing the carbon content used, and optimizing carbon emission end treatment technology. In addition, enterprises can better understand the market energy flow data and make more timely and appropriate decisions according to the market energy flow, which will help to make more effective and rational use of resources. In addition, digital companies often pay more attention to their environmental benefits based on their strong economic strength. For example, Tencent announced the launch of the carbon neutral plan in January 2021, actively responding to China's carbon neutral goal. In March 2021, ant group, a subsidiary of Alibaba, promised to achieve net zero emissions by 2030. As the industrial foundation of digital economy, digital industry can effectively promote other industries to reduce carbon emissions and promote green and intelligent development. Increase the added value of industry and industry.

From the perspective of energy structure, digital enterprises can help other enterprises reduce energy consumption through technology and transportation. The development of the digital economy has also optimized our production and lifestyle, promoted the "virtualization" of the economy, and reduced the use of traditional energy and carbon emissions in economic life. From the perspective of energy conservation, the digital economy enables data from different spaces and different times to converge, accelerates the flow of production factors, reduces the energy consumption rate, and effectively suppresses carbon emissions. Based on this, we draw the hypothesis 1:

H1: The development of the digital economy has an obvious positive effect on reducing carbon emissions.

2.2. Digital economy, carbon emission and innovation

Miller and Wisdon once pointed out that the digital economy represents the technological revolution and is the decisive factor of technological innovation. The digital economy constantly optimizes the social infrastructure. The development and application of digital technology makes it more convenient for enterprises, universities and other economic entities to obtain and manage information, and reduces the cost of time and energy spent on information acquisition, thus improving the efficiency of economic entities. In addition, the digital economy has broken the barrier of information flow, making it more convenient for economic entities to obtain information, and their information exchanges are more frequent and timelier. It can also enable

the market innovation subject to capture the innovation and R & D needs in the market faster, improve the team management efficiency and improve the innovation efficiency.

Innovation efficiency is mainly manifested in the process of production factors from input to output. The early input of factors to the output of factors must go through a process from quantitative change to qualitative change, which has a certain lag. In the early stage of green technology innovation, a large amount of human, material and capital must be invested. The development of the digital economy will make the innovation subject increase the research and development of green innovative products, and they will form a large demand for talents in relevant aspects, a large amount of capital investment and a large amount of demand for relevant innovation elements, leading to a large amount of investment in relevant innovation elements. In the initial stage, the input of a large number of innovation factors will not directly lead to the increase of innovation efficiency, but the innovation efficiency will show a downward trend. When the input reaches a certain level, the digital economic benefits will lead to the rapid growth of output, thus leading to the obvious increase of innovation efficiency. Based on this, hypothesis 2 is put forward:

H2: The development of digital economy can inhibit and promote innovation efficiency.

The digital economy has a significant impact on innovation efficiency through its unique digital technology. Improving innovation efficiency will drive the rapid development of green technology. The wide use of green technologies, such as environmental protection materials, recycling technologies and waste pollution treatment equipment, can reduce carbon emissions by improving production efficiency and carbon emission regulations. Improving innovation efficiency will alleviate the energy consumption problem caused by the shortage of new energy, optimize the energy structure, reduce carbon emissions through technological innovation, and better collect new energy. The goal can also be achieved. Based on this, hypothesis 3 is obtained:

H3: The development of digital economy has an indirect impact on reducing carbon emissions through innovation efficiency.

3. Study Design

3.1. Model setting

3.1.1. Static panel model

Based on the existing data analysis, this paper first establishes a regression model to analyze the impact of digital economy on carbon emissions and environmental pollution. Considering that the data fluctuates greatly under the influence of different time and variables, representative data are selected for processing, and the benchmark model is set as follows:

$$Inceit = \alpha_0 + \beta_1 digeit + \beta_2 sdigeit + \beta_3 lnincomeit + \beta_4 lnpopuit + \beta_5 lnpollit + \beta_6 lncoalit + \beta_7 goverit + \mu_i + \sigma_t + \epsilon_{it} \quad (1)$$

Where, $ceit$ represents the electricity consumption in the t -th year, $digeit$ and $sigeit$ are the digital economic index and its square term respectively, $incomeit$ represents the per capita disposable income, $popuit$ represents the resident population at the end of the year, $pollit$ measures the environmental pollution, $coalit$ is the coal consumption, $governit$ is the local government's science and technology expenditure, μ_i , σ_t , ϵ_{it}

individual and time effect and random interference factor.

3.1.2. Mediation model

Based on previous studies, carbon emissions and innovation efficiency have a nonlinear negative correlation, and the improvement of innovation efficiency can not be separated from the development of digital economy. It can be concluded that promoting the development of the digital economy can promote the reduction of carbon emissions. In order to verify the above assertion, the mediation model is used here. Based on the possible impact of the parallel development of innovation and digital economy on carbon emissions, the distributed regression method is used for regression estimation:

$$Inceit = \pi_0 + \pi_1 digeit + \pi_2 sdigeit + \gamma controlit + \epsilon_{it} \quad (2)$$

The regression estimation takes the impact factor of digital economy as the core variable, supplemented by scientific and technological innovation factors as the explanatory variable:

$$ieit = \theta_0 + \theta_1 digeit + \theta_2 sdigeit + \gamma controlit + \epsilon_{2it} \quad (3)$$

Finally, the linear related factors affecting the development of digital economy, carbon emissions and green innovation are put into the model for regression estimation:

$$Inceit = \pi_0 + \pi_1 digeit + \pi_2 sdigeit + \phi ieit + \gamma controlit + \epsilon_{3it} \quad (4)$$

3.2. Variable selection

With regard to the digital economy index, in the rapid development process of economic development, the key index is selected, and the influence of electricity consumption on carbon emissions is introduced by using the key variables such as per capita disposable income and resident population of Anhui Province. In addition, environmental pollution, government science and technology expenditure and other factors are fully considered to calculate the impact of the digital economy on carbon emissions. The existing data and results show that the digital economy promotes the development of economic innovation, and at the same time, it promotes the low-carbon development due to the strong investment of science and technology to a certain extent.

The carbon emission pollution index analyzes and compares the values of sulfur dioxide, ammonia nitrogen gas and particulate matter in the exhaust gas and the indicators of chemical oxygen demand in the waste water. Considering the interference of various factors, the data selects the per capita disposable income of residents to represent the local affluence of Anhui Province; Based on the employment situation of information transmission, software and information technology service industries, this paper discusses the promotion of the efficiency development of scientific and technological innovation on the reduction of low-carbon emissions in the digital economy.

3.3. Data source

The selected data are authentic and complete. The whole province of Anhui Province is taken as the research object, and the relevant factors of the impact of the digital economy on carbon emissions in Anhui Province from 2015 to 2020 are mainly collected. The data are from the National Bureau of statistics of China. It covers the digital economy, energy consumption and government financial expenditure of Anhui Province, aiming to study the impact of green innovation development on carbon emissions under the digital economy in many aspects.

Table 1. Relevant factors of the impact of digital economy on carbon emissions in Anhui Province from 2015 to 2020

	2015	2016	2017	2018	2019	2020
Disposable income of residents (yuan)	18363	19998	21863	23984	26415	28103
Permanent resident population at the end of the year (10000)	6011	6033	6057	6076	6092	6105
Emission of main pollutants in waste gas						
Sulfur dioxide emission (10000 tons)	48.01	27.20	19.54	16.27	15.10	10.86
Nitrogen oxide emission (10000 tons)	72.10	70.08	58.37	58.77	57.34	46.43
Particulate matter emission (10000 tons)	—	97.92	58.88	48.04	55.97	12.99
Discharge of main pollutants in Wastewater						
Chemical oxygen demand emission (10000 tons)	87.11	33.84	32.39	34.61	34.19	118.60
Ammonia nitrogen emission (10000 tons)	9.68	2.04	1.96	2.06	1.97	4.43
Coal consumption (10000 tons)	15671.32	15728.68	16084.62	16673.06	16699.7	—
Power consumption (100 million kwh)	1640.00	1794.98	1921.48	2135.07	2301.00	2428.00
Local fiscal expenditure on science and Technology (100 million yuan)	147.94	259.50	260.41	294.81	377.95	369.98
Local fiscal expenditure on environmental protection	124.83	133.64	198.64	209.32	312.12	190.83
Urban employees in information transmission, software and information technology services (10000)	9.2	9.1	8.9	9.3	10.6	11.1

4. Empirical Research Results and Analysis

The digital economy (dige), per capita disposable income (income), the number of permanent residents at the end of the year (popu), environmental pollution status (poll), coal consumption (coal), government science and technology expenditure (gover) and other data are substituted into the regression model, and the following regression results are obtained.

At this time, the coefficient of digital economy to carbon emissions is -0.235. It is speculated that the digital economy may have a negative correlation with carbon emissions, but it fails to pass the significance test, indicating that the model fitting is low.

Considering whether there is a nonlinear relationship between the digital economy and carbon emissions, the quadratic term of the digital economy is added to the model to obtain the regression results. At this time, the quadratic term coefficient of the digital economy is negative, and the significance test of 5% indicates that under the influence of the digital economy, the carbon emissions level shows a trend of first positive increase and then negative decrease, which confirms the previous conjecture. That is, with the development of the digital economy, the carbon emissions caused by industrial upgrading in the initial stage are still high, and even due to further energy input in the process of

industrial transformation and upgrading, the carbon emissions have a rising trend. When the development of the digital economy transits to the mature stage, industrial optimization and upgrading, capital, technology and human resources are fully utilized, which promotes the improvement of energy use efficiency, produces positive effects and reduces carbon emissions.

Among the other control variables, the coefficient of per capita disposable income is positive, which indicates that the carbon emissions are higher at the high-income level. From the analysis, the increase of income level will lead to the increase of consumption level. Consumption will react on the production process, further expand the supply, and lead to the increase of carbon emission level. However, this result has not passed the significance test, indicating that the impact on the final result is not obvious. The regression coefficient of the number of permanent residents is positive, which indicates that with the increase of population size, the carbon emissions will increase, including the pollutants generated by daily production and consumption activities and the carbon dioxide generated during breathing. The regression coefficient of coal consumption is positive, indicating that the greater the coal consumption, the greater the carbon emissions. The regression coefficient of government science and technology expenditure is negative, indicating that government expenditure has a positive effect on energy conservation and emission reduction.

Table 2. Results of basic regression analysis

Model	R	R ²	Adjusted R ²	Error in SE	Change statistics					Debin Watson
					Variation of R ²	Change of F	Freedom 1	Freedom 2	Change of F	
1	0.823	0.677	0.597	0.0958	0.677	8.392	1	4	.044	
2	1.000	1.000	.0		0.323	.	4	0	.	0.818

Table 3. Test results of nonlinear relationship

Model		Nonstandard coefficient		Standard coefficient	t	Significance
		B	SE	Beta		
1	constant	6.092	.525		11.594	.000
	sdige	29.454	10.167	.823	2.897	.044
2	constant	-44212.517	.000		.	.
	sdige	-8.302	.000	-.232	.	.
	lnpopu	-33.191	.000	-1.301	.	.
	lnpoll	.288	.000	.638	.	.
	lncoal	4607.680	.000	3.646	.	.
	gover	-.113	.000	-.634	.	.

5. Conclusions and Suggestions

China has long been committed to economic transformation and promoting multi-faceted development. Now, China has ushered in a new stage of economic adjustment and optimization, transformation and upgrading. Accelerating institutional change and innovation, and promoting the transformation and upgrading of the economic structure have become an important reform direction of China. The rise of the Internet, big data and new media has made the digital economy play a significant role in promoting economic structural reform. At the same time, the penetration of digital economy in the implementation of energy conservation and emission reduction policies is also increasing. Among the means of implementing the national "double carbon" goal, low-carbon emission reduction through industrial Internet and digital transformation stands out. Digitization is an important tool for national sustainable development and a long-term plan that must be implemented. Based on the panel data of relevant factors of the impact of the digital economy on carbon emissions in Anhui Province from 2015 to 2020, this paper objectively analyzes the impact of the digital economy on the regional carbon emissions in Anhui Province, and concludes that the digital economy can promote the reduction of carbon emissions and sustainable green development in Anhui Province. The in-depth study of digital economy will help Anhui Province to find a mutually beneficial relationship between digital economy and green development, better understand the obstacles and bottlenecks encountered in green development in Anhui Province, and give birth to new methods to provide an optimized and upgraded path for green development in Anhui Province, thus having a far-reaching impact on Environmental protection and long-term development in Anhui Province. Based on the above research conclusions, this paper puts forward the following suggestions:

First, strengthen the development of digital economy and integrate with low-carbon industries. At present, China's digital economy is booming and has a broad market prospect. Anhui Province should take advantage of this east wind to vigorously develop the digital economy, correctly judge the situation, dialectically view and comprehensively grasp the relationship between development and security, and improve and optimize the digital economy. Focus on the construction of digital infrastructure and low-carbon industrial infrastructure, such as 5g network base stations, cloud computing, blockchain services and other digital economic infrastructure, and low-carbon economic infrastructure

measures such as public transport, new energy development and green coverage, to comprehensively promote economic digitization and low-carbon development. Master the autonomy of digital economy and promote the integration of digital economy and low-carbon economy. Accelerate the coverage and penetration of digital economy technology and interconnection with low-carbon industries, promote efficiency reform, reduce the consumption of traditional resources, and catalyse the low-carbon emission reduction effect of technological innovation. We will guide enterprises in digital and low-carbon transformation, establish a clear network of rights such as data ownership, operation rights, use rights and income rights, expand the market advantage of "low-carbon industry digitization", and support the healthy and green development of the digital economy.

Second, promote the innovation of digital economy and improve the quality of green development. Liu He, member of the Political Bureau of the CPC Central Committee and vice premier of the State Council, pointed out at the 2022 National Committee of the Chinese people's Political Consultative Conference that the development of the global digital economy seems to show a trend of intelligence, quantization and cross-border integration. We must carry out all-round reform of the digital economy and improve the quality and level of the digital economy. Only in this way can the rate of return support the input cost. It is not an obvious move to be complacent. Anhui province needs to make good preparations for tackling key technologies, optimize and transform traditional industries through big data, cloud computing, blockchain, artificial intelligence and other technologies of the digital economy, and improve the operation efficiency and energy efficiency of multiple industries. Open up the multi-path development of the digital economy, promote competition through opening up, and promote innovation through competition. Focus on research and development of low-carbon energy and carbon capture technologies, and improve the emission reduction effect of technological innovation and the economic capacity of technological innovation. Implement the development concept of "innovation, coordination, green, openness and sharing", integrate technology into the new green pattern, and promote high-quality development.

Third, the combination of energy and digital economy should be reformed, and efforts should be made to realize the integration of energy revolution and digital revolution. The digital revolution is an important driving force to promote the development and reform of the energy system. Anhui Province should implement the new development strategy of

"four revolutions and one cooperation", use digital technology to improve energy use methods, improve energy utilization efficiency, optimize and adjust energy structure, actively explore new ideas, innovate new technologies and open up new methods for energy planning in the digital economy era, and meet the new future. Integrate the Internet thinking concept with the energy market, carry out the energy revolution through production, transmission, storage, consumption, recycling and other channels in combination with digital tools, reduce the share of traditional energy consumption, optimize the structure of energy production, transmission, storage and consumption, based on long-term development, and actively respond to the requirements of low-carbon emission reduction policies.

Fourth, based on regional development differences, promote the transformation of urban and rural governance. The endowment difference between cities and villages and the impact of the digital economy on carbon emissions are different. Anhui province needs to formulate and implement different digital economy development strategies to achieve the promotion and reduction of carbon emissions. Compared with rural areas, urban energy consumption is higher and carbon emissions are more serious. Meanwhile, carbon reduction measures have greater impact on life and economy. The government needs to formulate targeted energy-saving and emission reduction policies and measures for different situations, adjust the pace of urban and rural digital economy development, remove industrial barriers and regional restrictions, and improve the diversity and synergy of digital

economy governance in different regions.

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