



# Research on the Impact of Digital Economy on Urban Carbon Emissions

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**Abstract.** In recent years, the rapid development of the digital economy has become a new endogenous driving force for economic growth. Digital technologies are providing important support for sustainable development and addressing global climate change. Considering this, this paper focuses on exploring the relationship between the development of the digital economy and carbon emissions in different urban areas in China, based on the differences in the application of digital technologies and the status of carbon emissions. The study concludes that the carbon emission effects of China's digital economy are regionally unbalanced and influenced by complex factors. Based on this, policy recommendations are provided for the development of China's digital economy.

**Keywords:** Digital economy · Urban regional analysis · Carbon emissions

## 1 Introduction

With the development of the economy and the improvement of people's living standards, China's energy consumption and carbon emissions have been continuously increasing, making it the world's largest carbon emitter. The total amount of carbon emissions accounts for one-third of the global total, which has placed China in a crucial role in global climate change and carbon reduction challenges. Reducing China's carbon emissions is key to achieving global emission reduction targets [1]. According to the statistical data of the "World Energy Statistical Yearbook 2022," China's carbon emissions reached 10.58 billion tons in 2021, accounting for 31% of the global total, leading to global warming and climate change. The specific problems include rising sea levels, frequent extreme weather, and a reduction in biodiversity. The situation of energy conservation and emission reduction is becoming increasingly severe and achieving the "dual-carbon" goals is a daunting task. To respond to climate change, China has made a solemn commitment to strive for carbon peaking before 2030 and carbon neutrality before 2060. Therefore, reducing carbon emissions has become an important task for achieving sustainable development goals.

With the rapid development of digital technologies such as the Internet and artificial intelligence, the digital economy has become a new endogenous driving force for global

economic development [2]. The digital economy is becoming an important strategic direction for national development, and more and more governments and enterprises are paying attention to its development. The 20th National Congress of the Communist Party of China proposed “promoting the formation of a green and low-carbon production method” and “accelerating the development of the digital economy, promoting the deep integration of the digital economy and the real economy”. The “14th Five-Year Plan” and the Long-Range Objectives Through the Year 2035 set forth the goal of “creating new advantages in the digital economy”, promoting the deep integration of the digital economy and the real economy, empowering the transformation, and upgrading of traditional industries, and fostering new industries, new formats, and new models. According to the 2022 Digital Carbon Neutrality White Paper, taking the coordination of digitization and greenization as the starting point, digitizing and greening various fields such as economic, social production and living, can promote both economic and environmental benefits, achieving comprehensive and high-quality development. Currently, the digital economy is focusing on green innovation, utilizing methods such as sensing control, digital modeling, and decision optimization to achieve optimal use of resources, and to promote energy conservation, pollution reduction and carbon reduction, ultimately leading to sustainable development. In the future, the digital economy will be an important support for achieving green emissions reduction.

## 2 Literature Review

In recent years, China’s digital economy has been rapidly developing, bringing about upgrading and transformation in various industries and drawing widespread attention from academia. Research in the field of digital economy has mostly focused on its nature and characteristics, economic and social benefits, and environmental impacts. However, with President Xi Jinping announcing in the 2020 United Nations General Assembly that China aims to peak its carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060, the relationship between the digital economy and carbon emissions has become a new research direction for scholars.

However, there is currently no consensus on the relationship between the digital economy and carbon emissions. The “dual carbon” goal presents both opportunities and challenges for the digital economy. The main disagreement in the general direction of the relationship between the two is whether the digital economy can achieve carbon reduction. Some scholars believe that the development of the digital economy will increase carbon emissions, while others argue that the digital economy can directly achieve carbon reduction. There are also studies that suggest a non-linear relationship between the two, such as a “U-shaped” relationship, with carbon reduction achieved through changes in energy and industrial structures [3]. After further subdivision of the research, more scholars focus on urban, industrial, and regional studies due to data collection and practical application of digital technology [4].

For example, Yu Xinghui and others found through various econometric analyses that the development of the digital economy can significantly reduce urban carbon dioxide emissions and has spatial spillover effects, with a greater carbon reduction effect in the eastern region. Meanwhile, Yu Chang and others used over 130,000 industrial enterprise

big data samples to comprehensively measure the level of digital transformation and found that the level of digital economy can significantly suppress energy intensity and carbon emission intensity, with indirect effects greater than direct effects. However, some scholars, such as Xie Yunfei, believe that the carbon reduction effect of the digital economy is more significant in the central and western regions.

In summary, this article will classify Chinese cities, infer the influencing factors of the relationship between the digital economy and carbon emissions based on actual carbon emission data, industrial distribution, and digital application status, and provide theoretical support for the impact of the digital economy on city carbon emissions.

### **3 Research Analysis**

#### **3.1 Current Status of Digital Economy Development**

In recent years, China's digital economy has made significant progress, with new models and new forms emerging constantly. The digital economy has become one of the new engines driving China's sustained high-quality economic development. Currently, the digital economy is continuously integrating and penetrating with the real economy, striving to jointly enhance China's economic development space. However, it is important to note that China's existing objective conditions cannot be ignored. The uneven economic development levels and mismatched economic conditions in different regions of China also have a significant impact on the current state of development of the digital economy among regions. This section will focus on the differences among the eastern, central, western, southern, and northern regions of China, with a particular emphasis on exploring the regional differences in the status of digital economy development.

##### **1) Current Status of Digital Economy Development in Eastern, Central, and Western China**

The distribution of digital economy development in different regions of China is uneven, with three tiers of digital economy development. The first tier has a higher level of digital economy development, mainly concentrated in the eastern region, while the second and third tiers have lower levels of digital economy development, mostly concentrated in the central and western regions of China [5].

The digital economy in the eastern region of China is relatively mature, with Beijing, Shanghai, Guangdong, and other cities as representatives, possessing sound digital infrastructure and industrial ecology, with a high proportion of the digital economy. The digital economy in the central region of China is developing rapidly, with Hunan, Chongqing, Sichuan, and other places as representatives, benefiting from strong policy support and emerging digital technology companies. However, the overall level still needs improvement. The digital economy in the western region of China is relatively underdeveloped, especially in the Qinghai-Tibet Plateau region where the digitalization level is low, facing difficulties in infrastructure construction and talent shortage. However, under the guidance of policies, there is enormous potential for the development of the digital economy.

## 2) **Current Status of Digital Economy Development in Southern and Northern China**

Surveys have found that the northern region of China lags the southern region in both digital industrialization and industrial digitization.

The southern region of China has more internet infrastructure and digital talent, and a larger scale of digital economy. Cities such as Shanghai, Shenzhen, and Guangzhou are in a relatively leading position in the field of digital economy. The development of the digital economy in the northern region of China is relatively slow, but it is gradually accelerating with the support of national policies and technological innovation. For example, the new generation of information infrastructure established in Beijing, Tianjin, Hebei, and other places will provide support for the development of the digital economy. Overall, the gap in the development of the digital economy between southern and northern China is smaller than the gap in traditional industries, and there is still great potential and space for the development of the digital economy within regions [6].

Overall, there are regional disparities and imbalances in the current state of development of China's digital economy. Due to the obvious differences in economic foundation, network infrastructure, and corresponding industrial facilities in different regions of China, the level of development of the digital economy is also gradually weakening from east to west and from south to north, just like this infrastructure.

### 3.2 **The Impact of the Digital Economy on Carbon Emissions**

#### 1) **Discussion of the Impact of the Digital Economy on Carbon Emissions Based on Regional Divisions of the East, Central, and West**

In the western region, the effect of the digital economy on carbon reduction is not significant. The author believes that this is because the western region is rich in natural resources, and there is a "hollowing-out" phenomenon between heavy and light industries, resulting in a strong resource dependency of relevant industries and a prominent homogenization phenomenon, which leads to insufficient sharing of diversified intermediate inputs and a lack of a safe industrial chain as support. In addition, homogenized competition is not conducive to technology exchange and diffusion, resulting in insufficient innovation motivation, making it difficult to reduce carbon emissions through green and low-carbon technologies [7].

In the central region, due to the relatively developed traditional industries centered around coal mines, the development of the digital economy will depend more on the consumption of traditional energy, thus increasing carbon emissions. In addition, the level of urbanization in the central region is relatively low, and there is a certain "siphon effect" in the metropolitan area. The increase in transportation demand for the urban area and the high planning costs of incorporating people outside the urban area into the radiation range of the digital economy are also reasons for the increase in carbon emissions.

In the eastern region, research has found that while the digital economy has become a new engine of economic development, the widespread use of digital technology in the eastern region has improved green production efficiency and further reduced carbon emissions at the same production capacity. In-depth research has

found that the reason for this phenomenon lies in the good digital infrastructure in the eastern region and its efficient use of data network systems - a relatively complete modern infrastructure that is easy to connect with digital technology and can effectively exert the effectiveness of digital technology, reducing the senseless loss of resources. At the same time, benefiting from the advanced concepts and relatively high level of scientific and technological development in the eastern region, the application of digital technology is maximized to achieve resource innovation and green use. That is, the digital economy breaks the production mode of the traditional economic era, and the collaborative production and innovation data network mode fully meets the social operation and industrial structure needs of the eastern region. At the basic level of social operation in industries, the digital economy further breaks the barriers of time and space, directly promoting the improvement of production capacity and service quality in areas such as intelligent life, online education, smart healthcare, and modern e-commerce. Meanwhile, its vast data algorithms penetrate into various production processes of modern industries, gradually perfecting the rationalization requirements of production factors, vigorously optimizing industrial structure, saving management and operation costs, enhancing resource allocation efficiency, further reducing carbon emissions generated by production and life, and realizing the low-carbon and efficient development of modern digital cities.

## 2) Discussion of the Impact of the Digital Economy on Carbon Emissions Based on the North-South Regional Division

In the southern region, the combination of the digital economy and new energy is more closely linked, so carbon emissions can be better controlled. For example, Guangdong Province and Fujian Province in the southern region are regions with relatively rapid development of new energy industries and can use clean energy to reduce carbon emissions. Moreover, the level of urbanization in the southern region is relatively high, and digital technology can be used to optimize urban transportation and logistics, thereby reducing carbon emissions.

In the northern region, research has found that the digital economy cannot effectively control carbon emissions. The reason may be due to the lack of an ecological environment suitable for digital technology development, insufficient innovation, weak regional economic coordination, and a lack of effective industrial policies. As a result, the digital economy has difficulty replacing.

## 3) Factors Influencing Carbon Emissions in the Digital Economy

**Industrial Structure:** Different regions have different industrial structures, and the impact of the digital economy on different industries varies. For example, in the Midwest, traditional heavy industry and coal mining consume a large amount of energy, and the development of the digital economy may exacerbate this energy consumption and carbon emissions. In contrast, in the eastern region, where the economy is more developed and high-tech industries grow faster, the digitalization of technology can effectively reduce carbon emissions. In the northern region, where mineral resources are abundant and traditional heavy industry and coal mining dominate, widespread use of digital technology may increase energy development efforts, leading to excessive consumption of energy resources and a corresponding increase in carbon emissions.

In the southern region, the rapid development of new energy industries, combined with the digital economy, can effectively reduce carbon emissions.

**Level of Urbanization:** Regions with higher levels of urbanization face issues such as concentrated population, traffic congestion, and logistics transportation, which can increase carbon emissions. The development of the digital economy can optimize urban transportation and logistics, thus improving the rational use of energy resources and effectively reducing carbon emissions.

**Energy Structure:** The energy structure determines the type and quantity of energy consumption. If the development of the digital economy relies on traditional energy consumption such as coal and natural gas, it will increase carbon emissions. However, if the development of the digital economy is combined with the application of clean energy, it can effectively reduce carbon emissions.

**Technological Level:** The development of the digital economy requires a large amount of power and technological support, mainly driven by high-tech innovation, which can promote the rational allocation of resources and reduce carbon emissions.

**Policy Environment:** The policy environment plays an important role in the relationship between the digital economy and carbon emissions. For example, governments can encourage low-carbon development of the digital economy through tax incentives, reducing emission standards, and other measures, thereby reducing carbon emissions.

Therefore, the factors influencing carbon emissions in the digital economy are diverse, requiring guidance and measures at both the policy and market levels to promote the balance between the development of the digital economy and carbon emissions control.

## 4 Policy Recommendations

Considering the impact mechanism and regional differences of the digital economy on carbon emissions, the author believes that overall regulation and regional coordination should be conducted simultaneously to synergistically support the realization of the vision of “peak carbon and carbon neutrality”.

### 4.1 Overall Regulation

#### 1) Government Support

**Multi-departmental collaboration to strengthen energy transformation and promote green digitalization:** The government can support new energy technologies through policy formulation, taxation, and other incentives, thereby promoting the transformation of energy structure. At the same time, the government can further encourage the application of digital technology in energy conservation, emission reduction, and resource utilization to promote the integration of digital technology and green technology.

**Develop low-carbon industries:** The government can support sustainable development of low-carbon industries by guiding investment, establishing industry funds, etc. In addition, the government can encourage enterprises to strengthen cooperation

to promote the greening and low carbonization of the industrial chain. The government can also guide and support the innovation and development of small and medium-sized enterprises, encourage the adoption of green digital technology, and promote the simultaneous development of the digital economy and the low-carbon economy.

Accelerate the construction of digital cities: Effective use of large-scale digital technology will bring cluster effects and is an effective path to unleash the carbon reduction effect of the digital economy. The government can further build digital cities by improving infrastructure and increasing the digital technology application rate of public facilities.

## 2) Enterprise Adjustment

Clarify positioning and find direction: Enterprises, as an important part of social operations, should be clear about their social responsibilities, actively respond to government calls, and actively seek energy conservation, emission reduction resources, and apply green digital technology to minimize carbon emissions.

Keep up with the times and actively update: Enterprises can achieve quality changes, power changes, and efficiency changes driven by innovation by promoting the application of advanced green technology, improving green low-carbon management capabilities, accelerating the greenization upgrade of networks, and increasing the use of green electricity [8].

## 4.2 Regional Coordination

Regions should promote regional coordinated development and complementary advantages. By building a data center, cloud computing, and big data integrated network system, the demand for computing power in the east can be orderly guided to the west, optimizing the layout of data center construction and promoting the coordinated linkage between the east and west. By moving the data center from the east to the west, the cost of operating the digital economy in the east can be effectively reduced, stimulating the growth of digital economy applications in the west, and achieving the goal of accelerating the digital transformation and green low-carbon transformation of traditional industries [9].

Therefore, the relationship between the digital economy and carbon emissions requires the joint cooperation of policy and enterprise levels and the coordinated development of regions to promote the balance between the development of the digital economy and the control of carbon emissions and form a good situation of coordinated development of the digital economy and green economy.

## 5 Conclusion

Under the condition of a comprehensive theory, the continuous penetration and integration of digital technology and economic life have greatly improved the labor productivity of industries and the efficiency of business decision-making, thereby reducing internal consumption in all aspects, and promoting carbon reduction. However, due to differences

in regional structure, infrastructure development, and the application level of digital technology, the carbon reduction effect of China's digital economy shows a decreasing trend from east to west and from south to north, and even a carbon increase effect in western regions. At the same time, considering the complementary situation of heavy data computing resources in developed areas of the digital economy and the need for progress in the utilization level of digital technology in underdeveloped areas, overall regulation and regional coordination can be carried out to achieve a positive trend of carbon reduction effect of the digital economy in all regions, creating value for social development.

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