

Research on the Impact of Digital Finance on Carbon Emission Intensity

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Abstract: *In the context of the constraints of the "dual carbon" goal and the era of high-quality development empowered by financial technology, the research on the carbon emission reduction effect of digital finance has become an important academic frontier issue, and this paper systematically reviews the relevant research literature. Carbon emission intensity comprehensively reflects the economic benefits and carbon dioxide emissions generated in production and life, and is an important indicator to measure the level of regional green economic development. As a new form of financial services, the relationship between digital finance and carbon emission intensity is rarely discussed. Therefore, this paper will review the relevant research progress from the perspective of the impact of digital finance on carbon emission intensity.*

Keywords: *Digital Finance, Carbon emission intensity, Green Finance, Sustainable development*

1. Introduction

Since the reform and opening up, China's economy has achieved steady and rapid development. However, extensive economic development has led to high energy consumption, high pollution, and high emissions. The pursuit of high quality and sustainable development has become the basic foothold of China's economic construction in the new era. In order to actively respond to the challenge of climate change, China proposed the "3060" goal of carbon peak and carbon neutrality in 2020. In order to promote the construction of ecological civilization, the Chinese government has also proposed a carbon intensity reduction target of 60%~65% by 2030 compared with 2005. However, with the rapid advancement of industrialization and urbanization, China's energy consumption and carbon emissions will continue to grow in the coming period, and simply emphasizing the absolute reduction of total carbon emissions is not a reasonable standard to measure the effect of emission reduction.

In recent years, with the development of the Internet and the use of innovative technologies such as cloud computing, big data, block chain, and artificial intelligence, the digital economy has gradually become an important engine to lead global economic and social changes and promote the high-quality development of China's economy. At present, China's digital economy is in the period of formation and development. According to the White Paper on the Development of China's Digital Economy (2021) released by the China Academy of Information and Communications Technology, the scale of China's digital economy reached 39.2 trillion yuan in 2020, accounting for 38.6% of GDP, becoming a key driving force for stable economic growth. Finance is an important cornerstone of the modern market economy, and the sound development of the financial market is of great significance to the sustained and healthy development of China's economy. In addition, digital finance is the core of the digital economy, and it is necessary to study how it can continue to develop healthily. Digital finance is a model for financial institutions and Internet platforms to realize financial services such as payment, settlement, financing and investment through digital technology, which is the inevitable result of the development of the traditional financial industry in line with the times, and at the same time meets the people's growing needs for a better life. With its unique geographical penetration, digital finance breaks the dimension of time and space, reduces the cost of financial services to a large extent, improves the efficiency of financial inclusion, and promotes the rational allocation of social resources and technological progress. The development of digital finance can help reduce carbon intensity, facilitate the energy transition, and make a positive contribution to the achievement of the Sustainable Development Goals.

Digital finance refers to the application of digital technology to provide users with new forms of financial services through the Internet and mobile communication channels. In recent years, digital

finance has developed rapidly around the world and has had an important impact on the economy and society. Digital finance not only plays an important role in improving the efficiency of financial services, expanding the scope of financial services, and reducing the cost of financial services, but also enhances the efficiency of production technology, which is of great significance for the green transformation of the economy. In view of this, it is of great significance to explore whether digital finance can help promote technological progress, release the momentum of green innovation and transformation of the economy and entities, and activate the enthusiasm of economic entities for green and low-carbon development, which is of great significance for achieving the "dual carbon" goal and realizing the transformation of green and sustainable development.^[1]

2. Research on digital finance at home and abroad

2.1. Definition of relevant concepts of digital finance

Digital finance is a revolutionary product of the deep integration of finance and technology, and the combination of finance and technology has a long history, and has successively produced concepts such as "financial technology", "electronic finance", "online finance", "Internet finance" and "digital finance". In 1972, Bettinger first proposed the concept of "financial technology", pointing out that financial technology is a combination of computer technology with banking expertise and modern management science. In the late 20th century, the most prominent manifestation of the combination of finance and technology was the use of information technology to promote the electronic business processes of traditional finance,^[2] thus giving rise to the concept of "e-finance". Subsequently, as Internet technology was gradually widely used in the financial field, the concept of "Internet finance" was born. Internet finance is a new financial model that integrates mobile payment, information processing and resource allocation, which is fundamentally different from indirect financing by banks and direct financing by the capital market.^[3] The further integration of finance and technology has not only promoted financial innovation, but also subverted the traditional financial service methods^[4] and developed a digital financial format. The first to emerge is the concept of "digital financial inclusion", and the 2016 G20 summit emphasized the use of digital technology to promote financial inclusion. However, due to the late emergence of the concept of digital finance, there is no unified definition, and there are some differences in the definition angle and emphasis: based on the dual attributes of "finance and technology", digital finance refers to a new financial model in which traditional financial institutions and Internet enterprises use digital technology to realize financial services such as financing, payment, and lending.^[5] Based on the transformation of traditional financial services, digital finance is a new type of financial service formed by the deep integration and development of digital technologies such as big data, cloud computing, block chain, and artificial intelligence with traditional financial services.^[6] Based on the carrier of digital finance, digital finance is defined as a series of financial services provided through mobile terminals, personal computers, the Internet, etc. ^[7] In the realm of digital finance, there is a growing integration of various digital technologies, such as artificial intelligence, enhanced perception, the Internet of Things, software-defined approaches, computational networks, and privacy computing, with traditional financial practices. This convergence is reflected in diverse forms, including mobile payments, smartphone banking, electronic wallets, online banking services, and internet-based lending. The evolution is based on the digital performance in the financial domain, representing a fusion of these technologies with established financial processes.^[8]

It can be seen that digital finance is fundamentally different from these related concepts. First of all, the participants in digital finance are not simply limited to traditional financial institutions, nor are they limited to Internet companies and fintech companies, but a combination of the three. Secondly, the fields covered by digital finance have gradually expanded from the electronic and informatization of business management of financial institutions, the mobility and online of financial service transactions, to the digitization of the whole process of financial services, and even subverted the form of money, forming a digital currency.^[9] With the development and popularization of digital currency, digital currency will also become a fundamental element of digital finance.^[10] Finally, the underlying technology that needs to be relied on for the development of digital currency has been significantly upgraded, from traditional technologies such as computer information technology and mobile Internet to very cutting-edge digital technologies such as big data, cloud computing, block chain and artificial intelligence.

2.2. The development of traditional finance and digital finance

As a technology-driven financial innovation, fintech can effectively serve the real economy by

promoting the quality and efficiency of financial development.^[4] In August 2019, the People's Bank of China issued the FinTech Development Plan (2019-2021). The document points out that the main goal of financial technology is to use modern scientific and technological achievements to transform or innovate financial products, business models, business processes, etc, and promote the quality and efficiency of financial development. The implementation of this leading document has strongly promoted the healthy development of financial technology. On December 31, 2021, the People's Bank of China issued the Fintech Development Plan (2022-2025), which clearly sets out the vision, principles and key tasks of fintech development from 2022 to 2025. Generally speaking, in the absence of hardware facilities such as bank branches, financial institutions can rely on terminal devices such as mobile phones to penetrate financial services into the economically backward central and western regions, third- and fourth-tier cities, and even rural and remote areas. The development of financial technology makes up for the lack of coverage of financial institutions' business outlets, and contributes to the coordinated development of financial resources in various regions.^[3]

Regarding the relationship between traditional finance and digital finance, there are two main views in the academic circles: "substitution theory" and "complementarity theory". The "substitution theory" believes that digital finance can directly open up the financing pattern composed of direct financing and indirect financing, forming a new financing model, which basically replaces the traditional financial model.^[31] The "complementarity theory" believes that digital finance, as a new form of finance, will not change the essence of finance, but is only a supplement to the traditional financial industry.

3. Research on carbon emission intensity at home and abroad

3.1. Foreign research on carbon emission intensity

The definition of carbon emission intensity by foreign scholars is mainly characterized by the ratio of total carbon emissions to total economic output (or the scale of other indicators). For example, carbon intensity is measured by the amount of CO₂ produced by the wine industry during production and transportation as a proportion of the overall economic benefits generated by the industry;^[11] In the study using the UK electric shovel as a sample, the ratio of the total CO₂ produced by electricity generation to the total amount of electricity generated was used as the carbon emission intensity.^[12]

A large number of relevant studies have been carried out on the influencing factors of carbon emission intensity, especially the analysis of economic growth, energy structure and technological innovation. In the focus on the impact of resource endowment on carbon intensity, empirical results based on data from various states in the United States show that carbon intensity is higher where fossil energy production is high.^[13] In the United Kingdom, Russia, Canada, China and other major economies in the world, the impact of tariffs on carbon emission intensity was empirically tested, and it was concluded that the increase in tariffs had no significant impact on carbon dioxide emissions, but reduced the overall efficiency of the market, thus increasing carbon emission intensity.^[14] By comparing and analyzing the differences between China and India in carbon emission intensity, and discussing the reasons for the decrease in China's carbon emission intensity and India's increase, scholars believe that the gap between the two countries in their economic structure is the main reason, in which China's economic structure has changed from crude industry to high-end manufacturing, while India's economic structure has always been dominated by heavy industry and higher energy consumption industries. An empirical test of China's heavy industry samples shows that technological innovation, environmental regulation, and energy consumption structure all have negative impacts on carbon emission intensity.^[15]

3.2. Domestic research on carbon emission intensity

In November 2009, the State Council proposed to reduce carbon dioxide emissions per unit of GDP to 40%-45% by 2020, which was the first time that the concept of "carbon intensity" was explicitly proposed in China, and most domestic studies have followed this idea in the definition of "carbon emission intensity". At present, the definition of "carbon emission intensity" in China is the proportion of carbon emissions and economic scale, and different measurement methods will evolve for different samples or research topics. For example, the intensity of industrial CO₂ can be defined as the proportion of total CO₂ emissions in the industrial sector to the increase in industry;^[16] Agricultural carbon emission intensity can be defined as the proportion of carbon emissions in the agricultural production process to the total agricultural output value;^[17] The proportion of total provincial carbon emissions to regional production is defined as regional carbon emission intensity.^[18] In short, the research on carbon emissions

in China in the past ten years has mainly focused on "carbon emissions/economic scale".

The influencing factors of carbon emission intensity have also been studied in China, and the existing research focuses on the impact of economic development, industrial structure, technological innovation, and technological innovation on carbon emission intensity. By establishing the IO-SDA model to discuss the impact of the change of economic growth model, scholars have concluded that the most important path to reduce carbon emission intensity is the reduction of energy intensity, and the optimization of energy structure and industrial structure can also significantly promote sustainable growth.^[19] In addition, the impact of technological innovation on carbon emission intensity is also worthy of our attention, and the current domestic research mainly supports the conclusion that "technological innovation contributes to the reduction of carbon emission intensity" in the relationship between the two. Through the study of various economic factors, the impact of technological progress on carbon emission efficiency is highlighted.^[20] When discussing the impact of two-way FDI on carbon emission intensity, it is found that FDI can promote carbon neutrality through technological innovation, and emphasizes the role of the government in regulation.^[21]

When discussing the importance of carbon emission intensity in sustainable development, many scholars believe that carbon emission intensity is an important indicator of green development and sustainable development. As an important indicator of low-carbon economy, carbon emission intensity is the efficient use of energy resources, which requires efforts in technological innovation, overall planning, and organization and management.^[22] The spatial Durbin model is used to study the spatial effect of carbon emission intensity on high-quality economic development, and it is found that both high-quality economic development and carbon emission intensity have significant spatial heterogeneity characteristics, and the two show a negative impact relationship, and the reduction of carbon emission intensity has a significant promotion effect on the high-quality economic development of the region.^[23]

4. Research on the relationship between digital finance and sustainable development

In recent years, Chinese scholars have conducted rich discussions on how digital finance affects economic growth, people's lives, the gap between the rich and the poor, and sustainable development. In the research on the relationship between digital finance and residents, empirical studies based on the Digital Financial Inclusion Index show that for every 1% increase in the Digital Euro Financial Index, the probability of relative poverty decreases by about 3.2%.^[24] In the empirical study of the data of listed companies and the digital inclusive finance index, it is concluded that digital finance can significantly alleviate the financing constraints of enterprises, and the alleviating effect on enterprises excluded from traditional finance is more obvious.^[25] The research topics on digital finance abroad are roughly the same as those in China. Specifically, the impact of digital finance on household consumption is discussed, and the conclusion is concluded that digital finance does significantly promote household consumption.^[26] At the same time, there are also studies that prove the positive impact of digital finance on green innovation technologies and energy and environmental performance.^[27]

Among the existing studies on the relationship between financial development and sustainable growth, most of the foreign studies support that financial development is beneficial to sustainable aspects such as pollution control, environmental protection and industrial upgrading. There are scholars using the four aspects of green credit, green securities, green investment and green insurance to construct the green finance index, and examining the panel data of China from 2000 to 2018, it can be concluded that although green finance is conducive to the reduction of carbon emission intensity, high carbon emission intensity also hinders green investment to a certain extent. Based on the panel data of the OECD countries, the environmental Kuznets curve is constructed with indicators such as e-finance and energy consumption, and it can be seen that e-finance can promote the reduction of carbon dioxide emissions and pollution rates.^[28] Financial development can promote technological innovation of enterprises, especially in cities with stricter environmental regulations, and this innovation effect is more significant, especially from the perspective of industry, the positive impact of financial development on sustainable development is more significant in light industry.^[29] Using the model to measure the economic development index GTFP, it is found that the development of digital inclusive finance will significantly promote the improvement of GTFP, and the promotion effect is stronger in regions with better economic foundation.^[30]

5. Conclusions

The impact of digital finance on the environment is mainly manifested in changes in carbon emission intensity. On the one hand, the technological innovation and application of digital finance can improve the efficiency of financial institutions and reduce the carbon emission intensity of financial services. On the other hand, the development of digital finance has also brought some new sources of carbon emissions, such as energy consumption in data centers and the manufacturing and transportation of electronic equipment, resulting in an increase in carbon emission intensity. As a result, the environmental impact of digital finance is complex and two-way. Secondly, relevant studies show that the impact of digital finance on carbon emission intensity is mainly affected by the following factors: technology, products and markets. The innovation and application of digital financial technology can improve the efficiency of financial services and reduce carbon emission intensity. The design and positioning of digital financial products and services will also affect their environmental effects; The development of the digital financial market and the policy environment will also affect the impact of digital finance on the environment. In addition, the impact of digital finance on the environment also involves aspects such as carbon emission trading and carbon pricing. Digital finance can provide support for the construction of a low-carbon economy through carbon emission trading and other means; Carbon pricing can also lead digital financial companies to actively reduce carbon emissions.

At present, the impact of digital finance on the environment has become the focus of social attention, and related research is increasing. On this basis, future research can deeply explore the environmental effect mechanism of digital finance, study the impact of different fields of digital finance on the environment, and explore the environmental governance path of digital finance. It is worth noting that the impact of digital finance on the environment is not only limited to carbon emission intensity, but also includes other environmental issues, such as resource consumption and waste generation. Digital financial companies should comprehensively consider these environmental issues and actively promote sustainable development.

The impact of digital finance on carbon intensity is a complex issue that requires multifaceted research and collaboration to solve. With the development of digital finance, digital financial enterprises need to take their environmental responsibilities seriously and take proactive measures to reduce carbon emission intensity and achieve sustainable development. At the same time, the government, enterprises and the public also need to strengthen cooperation to jointly promote the environmental governance of digital finance and create a cleaner and better future for mankind. Future research can also deeply explore the environmental effect mechanism of digital finance, study the impact of different fields of digital finance on the environment, and explore the environmental governance path of digital finance. At the same time, research can be carried out on green finance, carbon emission trading, carbon pricing and other aspects of digital finance to explore the potential of digital finance in the field of environmental governance.

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