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Digital Economy, Fintech and Carbon Intensity

-- An Empirical Test based on the PVAR Model of Prefecture-Level Cities

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Abstract

Low-carbon development is an important issue that needs to be addressed urgently in China's economic development. The improvement of the level of financial technology and digital economy development can not only promote economic development, but also have an impact on carbon emissions. Based on this, 260 prefecture-level cities from 2011 to 2021 were used as the research objects of this paper, and the relationship between digital economy, financial technology and carbon emission intensity was explored through the autoregressive model of the panel vector. The following results were obtained: (1)The GMM estimation of the PVAR model shows that fintech and digital economy have a significant inhibitory effect on the carbon emission intensity of prefecture-level cities, and the digital economy has a significant role in promoting the development of fintech; (2)Carbon emission intensity is greatly affected by the previous period, and there is a long-term relationship between digital economy, financial technology and carbon emission intensity. Therefore, the government should accelerate the pace of development of the integration of fintech, digital economy and low-carbon economy, so as to provide support for fintech and digital economy to exert carbon reduction effects.

Keywords

Carbon Emission Intensity; Digital Economy; Fintech; PVAR Model.

1. Introduction

Since the reform and opening up, China's national economy has made great progress, and the current economic development of China is based on manufacturing and industry with high energy consumption, accompanied by serious environmental pollution problems. An important manifestation of China's environmental pollution is the increase in carbon dioxide emissions. In 2022, China's carbon dioxide emissions were about 11.49 billion tons, accounting for more than 27% of the world's total emissions, making it the country with the highest greenhouse gas emissions. Among them, industrial carbon emissions decreased by 161 million tons compared with last year, but emissions from coal power generation increased by about 3%. At present, China is facing industrial transformation and upgrading, the rapid development of the tertiary industry, the intensification of power consumption and other development problems, and is in a period of economic structural transformation and upgrading. Therefore, how to accelerate the low-carbon transformation of various industries has become a major challenge and opportunity for China's economic development. In the face of the grim situation, China proposed at the 75th session of the United Nations General Assembly the goals of carbon peak before 2030 and carbon neutrality before 2060. Therefore, under the dual carbon goal, it is of

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constructive significance for China to achieve green and low-carbon development and help reduce carbon emissions based on the background of high-quality development (Xu X.,et al., 2020).

Fintech is the use of artificial intelligence, blockchain, big data analysis and other advanced technologies to combine with traditional financial services to improve the efficiency, convenience and innovation of financial services. Fintech aims to reduce costs, strengthen risk management capabilities, promote financial inclusion, and promote healthy competition and innovation in financial markets through the introduction of innovative technologies and digital solutions.

The digital economy plays an important role in promoting a low-carbon economy. On the one hand, the digital economy will promote the development of the tertiary industry, promote the development of electronic technology, and the transformation of enterprise production facilities, which will lead to an increase in energy consumption and carbon emissions. The rapid development of the digital economy and the need for a large amount of power supply to maintain the operation of digital infrastructure have led to an increase in electricity consumption and aggravated carbon dioxide emissions. On the other hand, the development of the digital economy continues to promote technological innovation and progress, which provides new opportunities to reduce carbon intensity by improving energy efficiency, promoting the use of renewable energy, enabling smart urban planning, and facilitating remote work. On this basis, the impact of the digital economy on carbon emission intensity is uncertain, so this paper focuses on how to promote the development of the digital economy in the context of financial technology development to achieve the development of China's low-carbon economy.

2. Literature Review

Based on the reading and combing of relevant literature, this paper will comprehensively expound the literature from the perspective of carbon emissions, the relationship between financial technology and carbon emissions, the relationship between digital economy and carbon emissions, and the carbon emission issues based on the PVAR model.

A review of the literature on carbon emissions. The issue of carbon emissions has become an urgent issue for economic development, and the Chinese government attaches great importance to the issue of carbon dioxide emissions.Chen X.,et al. (2021),Liu L.,et al. (2015)and Zhang Y.J.,et al. (2017)Many scholars are also actively exploring the path of carbon emission reduction in China. Carbon emissions from provinces and prefecture-level cities are difficult to measure, Ma X. J.,et al. (2019)From the perspective of China's energy consumption, seven major industrial fossil energy sources such as coal and oil are selected to measure China's carbon emissions over the years. At the enterprise level, green and low-carbon development has more costs, so Dhaliwal, et al. (2011) argues that voluntary disclosure of carbon information by enterprises is often closely related to carbon performance and capital costs.Chen H., et al.(2013) By determining the content and calculation method of carbon disclosure, it is found that there are characteristics such as structural confusion and asymmetry between the quantity and quality of corporate carbon disclosure. At the government level, carbon emission reduction policy formulation and industry supervision play an important role in carbon emissions, and although the asymmetric information between states will reduce the differences in environmental policies between governments, it lacks the rationality of environmental policies(Alistair Ulph,2000). Controlling the pace and progress of urbanization is seen as an opportunity for low-carbon development (Song Q. J.,et al.,2018).

With the attention to carbon dioxide emissions at home and abroad, many scholars have analyzed the main influencing factors of carbon emissions from different perspectives. Among

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them, Li Z. G., et al. (2022) and Zhao M., et al. (2022) explored the spillover effect of carbon emissions from the perspective of spatial measurement. Lin B. Q., et al. (2018) and Liu J. G., et al. (2021) explored the regional differences affecting carbon emissions, and concluded that population factors have a higher impact on carbon emissions in municipalities than other factors. According to the decomposition of factors affecting carbon emissions by Hao J. H., et al. (2022) and Liu M. Z.et al. (2021), China's energy consumption structure is still dominated by coal. Gao Y. N., et al. (2022), Ma Q., et al. (2020) and others believe that the development of the digital economy, technological progress, and carbon emission trading rights policies are important factors influencing the reduction of carbon emissions (Figueroa and Fout 2008).

A literature review on the relationship between fintech and carbon emissions. Fintech-empowered green development has become an important theme of economic development, with Saba Fazal Firdousi (2023) and others arguing that fintech can integrate renewable energy to reduce carbon consumption, thereby reducing carbon emissions. In terms of total carbon emissions, some scholars believe that fintech can help the economy develop smoothly and transition to a lower level of greenhouse gas emissions (Tao R.. et al., 2022), and the main mechanisms by which fintech affects carbon emissions are industrial structure, financing constraints, and green technology innovation (Cheng X.Q., et al., 2023); At the industry level, Li H.J., et al. (2023) empirically examines a significant negative correlation between fintech and coal consumption by industrial enterprises, and confirms that fintech can reduce coal consumption by improving export and innovation performance. Jiang S., et al. (2019) used the weighted least squares method and threshold regression model to prove that the development of financial technology has an inverted "U" shaped impact on agricultural non-point source pollution.

The literature on the relationship between the digital economy and carbon emissions shows that most scholars believe that there is an inverted "U" shaped trend in the impact of the digital economy on carbon emissions (LI Z.G., et al., 2022), that is, the development of digital infrastructure needs to consume electricity in the early stage, which leads to the increase of carbon emissions, and with the continuous development of the digital economy, the increase of total carbon emissions will be inhibited. Some scholars believe that the digital economy indirectly affects carbon emissions through intermediary variables such as technological innovation, industrial structure, and environmental governance (Zhang J.N., et al., 2022), and empirical evidence shows that industrial structure upgrading is the variable with the greatest intermediary utility of the digital economy affecting carbon emissions. In addition, Zhu Z.C., et al. (2022) argues that the digital economy has a significant spatial spillover effect in inhibiting carbon emissions, and the spatial spillover effect is regionally heterogeneous.

Exploring the influencing factors of carbon emissions based on the Panel Vector Autoregressive Model (PVAR) can capture the interaction between multiple variables and avoid the problem of heteroskedasticity in the VAR model. Among them, Acheampong A. O. (2018) found that carbon dioxide emissions have a positive impact on economic development, while economic growth does not lead to energy consumption at the global level. Charfeddine L., et al. (2019) analyzed the impact of renewable energy and financial development on carbon dioxide through variance decomposition, and the results showed that financial development and the renewable energy sector in MENA countries made a small contribution to environmental protection and economic growth. Tzeremes P., et al. (2023) solved the endogeneity problem in panel data analysis by using the GMM-PVAR method, and the study showed that economic growth and carbon dioxide emissions can both contribute to the transition of energy consumption, and in addition to technical factors, it is particularly important for the development of renewable energy.

In summary, in a series of studies on digital economy, financial technology and carbon emissions, the impact of digital economy and financial technology on carbon emissions is only

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included, but the three are not considered in the same model, and carbon emission intensity, digital economy and financial technology are long-term development processes, and the interaction between the three may be dynamic. Therefore, this paper uses the PVAR model at the prefecture-level city level to study the dynamic relationship between China's digital economy, financial technology and carbon emission intensity by using the Granger causality test, impulse response function and variance decomposition, so as to make up for the shortcomings of existing research

3. Data and Methodology

3.1. Data Source

Due to the problem of missing values in the sample data, linear imputation, time series supplementation and other methods were used to supplement the missing values of the sample, and the cities with more missing data were deleted. This paper selects the sample data of 260 cities in China from 2011 to 2021 and constructs panel data for empirical research. Urban carbon emissions, digital economy, and other control variables are derived from the China Urban Statistical Yearbook, the prefecture-level city statistical yearbook, and the China Urban Construction Statistical Yearbook.

3.2. Description of the Variable

3.2.1. Carbon Emission Intensity

Carbon Intensity (cei). Authorities such as the International Energy Agency (IEA) have well-established estimates of China's CO2 emissions, but there is still no unified method for estimating China's CO2 emissions at the prefecture-level city level. Therefore, the total carbon emissions of each city are obtained by adding the carbon emissions from transport and buildings, industrial production processes, agroforestry and land use change, waste disposal, purchased electricity, heating and cooling, using the practices of L E Glaeser, et al. (2010) and Li H., et al. (2013). The ratio of each city's total carbon emissions to GDP is used as an indicator of urban carbon emission intensity.

3.2.2. Digital Economy

Digital Economy (dig). Drawing on the practice of Zhao T, et al. (2020), the comprehensive development index of the digital economy was calculated by using the principal component analysis method (PCA) by using the number of mobile phone users per 100 people, the proportion of employees in computer services and software industry in urban units, the total number of telecommunication services per capita, the number of Internet users per 100 people, and the China Digital Financial Inclusion Index (Guo F,.et al., 2020). The digital economy is an important part of economic development as it drives economic growth and innovation, while catalyzing new business and consumption patterns.

3.2.3. Financial Technology

Financial Technology(fintech). Referring to Li, C.T., et al. (2016), 48 keywords related to financial technology in the 13th Five-Year Plan for National Science and Technology Innovation were extracted, matched with prefecture-level cities, and the number of matching results was logarithmically processed as an indicator to measure the development level of financial technology in prefecture-level cities. Fintech is the use of advanced digital technologies and innovative business models to reimagine and deliver financial services and products. Fintech aims to improve financial efficiency, facilitate data-driven decision-making, and collaborative innovation in the financial ecosystem.

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3.2.4. Control Variables

Government intervention(gov). It is expressed as the ratio of local environmental protection expenditure to local budget expenditure in each region. A large number of relevant literature points out that the government's support and control of policies will greatly affect high-carbon emission industries and limit their carbon emissions. Optimize urban planning and transportation systems, and guide cities to adopt low-carbon solutions to reduce urban carbon intensity.

Upgrading of industrial structure(ois). It is expressed by the ratio of the added value of the tertiary industry to the added value of the secondary industry in each region. The secondary industry mainly includes high-carbon emission industries such as manufacturing and industry. Therefore, the smaller the share of GDP in the secondary sector, the lower the region's carbon emissions(Zheng J. J.,et al.,2021).

Population size(pop). The population size is represented by the year-end permanent resident population of each region as logarithmic. The larger the number of permanent residents in a region, the faster urbanization, the greater the energy consumption and industrial demand, the more carbon emissions, and the smaller the permanent population, the smaller the industrial demand, the lower the transportation and electricity consumption, and the smaller the carbon emission intensity.

Educational attainment(edu). It is expressed using the ratio of education expenditure to local budget expenditure by region. Educated people are more likely to focus on environmental protection and adopt low-carbon lifestyles. In addition, highly educated populations tend to work in knowledge-intensive industries, which tend to be more sensitive to urban carbon intensity. As a result, the more educated the region, the less carbon intensity.

Table 1. Statistical description of related variables

Regions	Variables	Number of samples	Mean	Standard deviation	Minimum	Maximum
Eastern region	cei	1056	5.085	9.74	0.212	172.305
	dig	1056	1.471	0.862	0.534	6.529
	fintech	1056	3.441	1.512	0.001	7.491
Central Region	cei	1067	8.309	13.09	0.200	147.015
	dig	1067	1.172	0.661	0.095	10.498
	fintech	1067	3.254	1.544	0.001	6.945
Western region	cei	737	7.121	7.337	0.131	44.498
	dig	737	1.216	0.522	0.455	4.586
	fintech	737	3.411	1.422	0.001	6.721
Nationwide region	cei	2860	6.812	10.711	0.131	172.305
	dig	2860	1.294	0.725	0.095	10.498
	fintech	2860	3.363	1.504	0.001	7.491
	gov	2860	4.785	1.056	0.100	9.040
	ois	2860	1.044	0.580	0.100	5.348
	pop	2860	5.949	0.662	0.100	8.136
	edu	2860	0.168	0.062	0.007	1.778
	pgdp	2860	1.570	0.549	0.009	3.845

Level of economic development(pgdp). GDP per capita is expressed as logarithmic. According to Li Y., et al. (2021), the carbon emissions of industrial pollution are affected by per capita disposable income, and areas with high economic development levels will pay more attention

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to environmental pollution, and supervision will force industrial enterprises to reform, resulting in more diversified economic structures and more advanced production technologies, resulting in low carbon emission intensity in cities with high economic development levels.

The statistical descriptions of each variable are shown in Table 1, and the results show that the mean, maximum, minimum and standard deviation of carbon emission intensity (cei) in each region are 6.812, 0.131, 172.305 and 10.711, respectively, indicating that there are large differences in carbon emission intensity among cities at different levels. As can be seen from Table 1, the carbon emission intensity of the eastern region is higher than that of the central and western regions, which is consistent with the actual situation. As an industrial power, China's eastern region is a concentrated industrial development area, so its carbon emissions are also higher than other regions. With the Chinese government's increasing emphasis on carbon emissions and in order to promote sustainable economic development, green finance was formally proposed and valued in 2016 by the State Council of the People's Republic of China in the "Guiding Opinions on Building a Green Financial System". Due to the developed economy and rapid financial development in the eastern region, financial technology has been more widely developed and applied in the eastern region. This trend is consistent with the data in Table 1.

3.3. Model Building

3.3.1. Panel Vector Autoregressive Model(PVAR)

Based on the above theoretical analysis, this paper uses the Panel Vector Autoregressive Model (PVAR) to empirically analyze the dynamic relationship and long-term impact trend between digital economy (dig), financial technology (fintech) and carbon emission intensity (cei). Holtz Eakin and Newey Rosen first introduced the panel vector autoregressive model in 1988. The model was further refined by Pesaran, Smith and others. The Panel Vector Autoregressive (PVAR) model can be applied when the duration is greater than the lag order plus 3. The general form of the model is as follows:

$$\lambda_j \Phi_{it} = \eta_i + \mu_i + O_{it} + \varepsilon_{it} \tag{1}$$

where Φ_{it} represents the matrix of endogenous variables, and $\Phi_{i(t-j)}$ represents the matrix of explanatory variables composed of the lagged terms of endogenous variables. λ_j represents the estimation matrix of the j-order lag; O_{it} represents the impact term set on the cross-sectional effect in the panel data; η_i and μ_i represent individual fixed effects and time fixed effects, and ε_{it} represent possible random error terms.

4. Analysis of Empirical Results

4.1. Empirical Testing

Since non-stationary panel data will lead to spurious regression, this paper first performs a panel unit root test for the variable carbon emission intensity (cei), financial technology (fintech) and digital economy (dig) before establishing the PVAR model. In order to ensure the robustness of the results, four methods were used to verify the stationarity of the panel data: LLC test, Breitung test, Fisher test and IPS test. The test results are shown in Table 2, and each variable passed the significance test with a significance level of 1% in the LLC test, Fisher test and IPS test. In the Breitung test, only the carbon emission intensity failed the stationarity test. The results of the four unit root tests show that the three variables are stationary series. On the

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basis of the unit root test, the Kao test, Westerlu test and Pedroni test are used to perform cointegration tests for each variable. According to the test results in Table 3, all variables passed the significance test with a significance level of 1%. Therefore, it is shown that there is a cointegration relationship between the variables cei, dig, and fintech.

The cointegration relationship only reflects the long-term stable relationship between the variables, and cannot depict the direction of the specific causal relationship between the three. Therefore, this paper uses the panel vector autoregressive model to conduct the Granger causality test for the three variables of carbon emission intensity, financial technology and digital economy.

Table 2. Stationarity test results

Variables	LLC Test	Breitung Test	Fisher Test	IPS Test
cei	-90.343***	2.892	-23.115***	-55.940***
dig	-87.999***	-17.174***	-26.427***	-55.664***
fintech	-81.228***	-19.751***	-26.850***	-51.039***

Note: ***, **, and * indicate that they are significant at the significance level of 1%, 5%, and 10%, respectively, and the same below.

Table 3. Results of cointegration test

Kao Test	Westerlu Test	Pedroni Test
-53.001(0.000)	-4.950(0.000)	-58.237(0.000)

According to Table 4, the digital economy and fintech are the Granger reasons for carbon intensity at the 1% significance level, and the fintech is the Granger reason for the digital economy at the 5% significance level. Therefore, it shows that carbon emission intensity is affected by the digital economy and financial technology, and the development of digital economy is related to financial technology, and the specific short-term and long-term causal relationships need to be obtained using GMM estimation, impulse response function and variance decomposition.

Table 4. Results of Granger causality test

Dependent variable	Independent variable	Chi-square statistic	P-value	Result
cei	dig is not the reason	27.873	0.000	Refuse
	fintech is not the reason	41.754	0.000	Refuse
dig	cei is not the reason	1.374	0.241	Accept
	fintech is not the reason	4.683	0.030	Refuse
fintech	cei is not the reason	1.958	0.162	Accept
	dig is not the reason	0.343	0.558	Accept

4.2. Analysis of GMM Estimation Results

After determining the stationarity and cointegration relationship of the sample data, the lag order needs to be determined to establish the PVAR model. Too long and too short lag order can lead to inaccuracy and loss of degrees of freedom, so it is important to choose the lag order appropriately. In order to comprehensively evaluate the lag order, this study used the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) and HQIC Information Criterion. The statistical test results in Table 5 show that the AIC, BIC, and HQIC statistics all clearly support the first-order hysteresis as the best choice. Therefore, the first-order lag order is used to construct the PVAR model.

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Table 5. Selection of the optimal lag order of the model

Lag order	AIC	BIC	HQIC
1	13.045*	13.133*	13.077*
2	13.691	13.799	13.730
3	14.620	14.746	14.666
4	15.737	15.883	15.789
5	19.164	19.330	19.224

According to the results in Table 6, as the explanatory variable, the carbon emission intensity is inhibited by the digital economy and financial technology, with coefficients of -4.559 and -3.776, respectively, and the significance level is 1%. There are three possible reasons for the digital economy to reduce carbon emission intensity: first, the development of the digital economy has promoted the virtualization of information, services and transactions, reducing the physical resources and energy consumption required for traditional real economic activities, thereby reducing carbon emission intensity; Third, the digital technologies needed for the development of the digital economy can make the calculation and monitoring of carbon emissions more accurate and real-time, and play an important role in managing and reducing carbon footprint. Therefore, the development of the digital economy has a significant inhibitory effect on carbon emission intensity. The possible reasons for fintech to curb carbon emission intensity are: Fintech provides multi-dimensional solutions for reducing carbon emission intensity through sustainable financial support, energy innovation financing, carbon data management, carbon trading market and other means, promotes the flow of funds to clean energy, optimizes carbon footprint management, and innovates carbon markets, thus creating synergistic effects in the fields of finance and environmental protection in curbing carbon emission intensity.

As the explanatory variable, the first-order lagging carbon emission intensity and financial technology have a positive impact on the digital economy. The possible reason why carbon emission intensity promotes the development of the digital economy is that the growth of energy-intensive industries may stimulate the development of related technologies and infrastructure, thereby driving the expansion of the digital economy. Energy-intensive industries require massive amounts of computing and storage power, attracting investment and innovation to further drive digital technologies. However, in fact, carbon emissions do not directly affect the development of the digital economy and will exacerbate the negative impact on the environment, so while promoting the digital economy, we should pay attention to environmental protection measures and sustainable development to reduce carbon emissions and reduce their potential adverse impacts. At present, China has put forward the ,'dual carbon' goal and is committed to promoting energy transition with low carbon emissions, which brings opportunities and challenges to the sustainable development of the digital economy.

It should be noted that the development of the digital economy is an inevitable process in the process of modern economic development, and the digital economy will incorporate the Internet and big data into the process of economic development, bringing new business opportunities and markets to the traditional industrial industry, so the traditional industry should adapt to the development and change of the modern economy and promote the coordinated and sustainable development between the secondary industry and the modern economy.

It is worth noting that when fintech is used as the explanatory variable, carbon emission intensity and digital economy both have a promoting effect on fintech, but the positive impact on it is not significant. Fintech is greatly affected by its own development, which is due to the

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competitive pressure caused by fintech in the market, encouraging traditional financial institutions to cooperate with technology companies to develop and accelerate technological upgrades and meet innovation needs, thereby promoting the further development of fintech.

Table 6. GMM estimation results of PVAR model

variable	cei		dig		fintech	
	α	t	α	t	α	t
L1.cei	-0.213***	-3.730	0.002	1.170	0.005	1.400
L1.dig	-4.559***	-5.280	0.012	0.440	0.040	0.590
L1.fintech	-3.776***	-6.460	0.068**	2.160	0.185***	3.180

4.3. Impulse Response Function Analysis

After the Granger causality test and GMM estimation analysis, the next step is to use the impulse response function to analyze the dynamic relationship between the three variables. The middle line of the impulse response function plot represents the actual degree of response. Figure 1 shows the impulse response diagram of carbon emission intensity, fintech, and digital economy. After the carbon emission intensity and the digital economy are affected by themselves, they reach the maximum response value in the current period, and then gradually decrease and tend to flatten. The impact of fintech on itself was negative in the first period, and fell to zero in the second period. It can be seen that carbon emission intensity, digital economy, and financial technology have responded quickly to their own impacts.

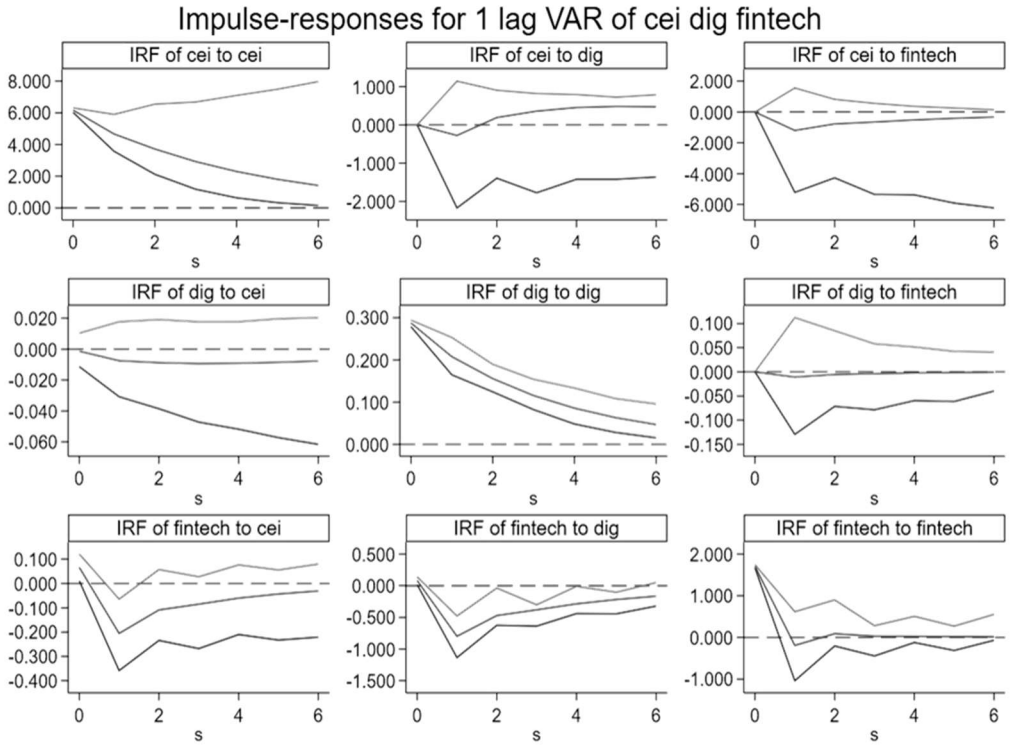


Figure 1. Diagram of the impulse response function of financial development and green finance to carbon emissions in all regions of the country

When the carbon emission intensity is impacted by the digital economy, the carbon emission intensity is negative in the first period and then positive, indicating that the inhibition effect of the digital economy on carbon emission intensity lasts for a short period. The impact of fintech on carbon emission intensity is negative, and the inhibition effect on carbon emission intensity

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reaches the maximum in the first period; when the digital economy is affected by carbon emission intensity and financial technology, it shows a negative impact on the digital economy, and the impulse response curve is relatively stable; when financial technology is affected by carbon emission intensity, it decreases from the current period, and in the first period The negative impact of the digital economy on fintech showed a certain fluctuating trend and tended to be stable in the fourth period. Looking at the whole impulse response function graph, the relationship between carbon emission intensity, financial technology and digital economy gradually plateaus with the increase of lag order, so the variance decomposition method (Table 7) is further used to investigate the impact of each shock on the fluctuation of endogenous variables.

4.4. Variance Decomposition

From the variance decomposition results in Table 7, it can be seen that the variance decomposition results are similar around 15 periods, so it can be judged that the variance decomposition results are relatively stable at this time. Carbon emission intensity (cei) is greatly affected by financial technology (fintech)and digital economy (dig), with fintech contributing 25.5% to carbon emissions and digital economy contributing 17.5% to carbon emissions. The long-term trend of the impact of the digital economy on carbon emission intensity is small, which may be due to the fact that the digital economy improves energy efficiency to a certain extent, promoting the intelligent, transformation and upgrading of traditional industries, but the operation of digital technology will consume a lot of electricity, so the digital economy will not only suppress carbon emission intensity, but also bring new challenges to the environment.

From the perspective of the long-term trend of growth, carbon emissions in the past are also one of the important factors leading to the change of carbon emissions, and the change of carbon emissions is not only affected by the economic and industrial structure of the current year, but also by the historical cumulative carbon emissions and the level of carbon emissions over the years, which is because carbon emissions are a continuous process, and the carbon dioxide emitted will not disappear in the short term but accumulate in the atmosphere. Therefore, the carbon emissions of regions with high economic activity intensity and high energy consumption will increase this year, and the level of carbon emissions last year will also affect energy use and policy formulation, causing changes in investment and consumption, and these changes will further affect the changes in carbon emissions this year.

Table 7. Variance decomposition results

Dependent variable	Lag periods	cei	dig	fintech
cei	1	1	0	0
dig	1	0.392	0.608	0
fintech	1	0.619	0.037	0.344
cei	5	0.575	0.169	0.256
dig	5	0.254	0.622	0.125
fintech	5	0.369	0.332	0.298
cei	10	0.57	0.175	0.255
dig	10	0.248	0.623	0.129
fintech	10	0.359	0.348	0.293
cei	15	0.57	0.175	0.255
dig	15	0.247	0.623	0.129
fintech	15	0.359	0.349	0.292

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Through the trend of mutual influence between financial technology and digital economy, financial technology has less impact on the digital economy, while the digital economy has a greater contribution rate to financial technology. The development of the digital economy drives technological innovation, and financial technology is usually applied to the financial field on the basis of technological innovation, so financial technology is greatly affected by the digital economy.

5. Conclusion and Policy Recommendations

Based on the panel data from 2011 to 2021, this paper uses the panel vector autoregressive model to explore the dynamic relationship between carbon emission intensity and financial technology and digital economy in 260 prefecture-level cities. The empirical analysis shows that, firstly, the development of fintech and the digital economy has significantly reduced carbon emission intensity. In the short term, fintech has a faster impact on urban carbon intensity, and in the long run, fintech has a more durable effect on carbon emission intensity than the digital economy. Fintech plays a significant role in promoting the development of the digital economy, which shows that the development of fintech improves the efficiency and convenience of financial services and lays the foundation for the sustainable development of the digital economy. Secondly, the role of carbon emission intensity in promoting the development of the digital economy and financial technology is not significant, which shows that the establishment of a carbon market, the promotion of carbon financial innovation to encourage the digital reform of enterprises, and the promotion of financial technology development have not achieved significant results. Finally, the development of the digital economy has not been able to effectively play a role in promoting financial technology, and at present, the development of financial technology has been improved by the innovation and efficiency of the financial industry, and the development stage of the digital economy has not fully penetrated the traditional financial system, thus failing to significantly promote the development of financial technology.

Based on the above empirical tests, the policy recommendations of the paper are as follows: (1) guide the role of fintech in the development of low-carbon economy through government policy supervision and control. To this end, banks and other financial institutions should increase their efforts to develop financial technology to promote the inhibitory effect of the digital economy on carbon emission intensity; local governments should improve the screening of industry types and select green and low-carbon industries and foreign enterprises with high technology content when introducing foreign investment for development; (2) accelerate the development of the digital economy and encourage technological innovation. To improve China's overall technological level, the development of financial technology and digital economy can promote the research of energy-saving and emission reduction technologies, reduce energy consumption per unit of GDP, and reduce the proportion of coal, crude oil and other environmentally polluting energy sources in China's energy consumption; Through economic incentives, guide traditional industries to introduce digital technology into production and processing, and promote cooperation between financial institutions and technology companies; (4) accelerate the construction of digital financial services. Promote the development of digital finance, including digital payments, online banking services, electronic money, etc., to promote the penetration of the digital economy in the field of financial technology.

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