

Research on the impact mechanism of green finance on industrial digitalization

Yang Xiao

School of Henan University, Zhengzhou 450000, China

13774656261@163.com

Abstract. In January 2022, the "Notice of the State Council on Issuing the Digital Economy Development Plan for the '14th Five-Year Plan'" issued by the Central Committee of the Communist Party of China and the State Council clearly stated that data resources would be the key element during the '14th Five-Year Plan' period, and all-element digital transformation will become the vital driving force to promote the healthy development of the digital economy. Based on this, this article analyzes the influencing factors of industrial digitalization objectively with the usage of panel data from 30 Chinese provinces and cities from 2012 to 2021 to examine the impact of green finance on industrial digitalization. The results show that green finance is a favorable factor in promoting the development of industrial digitalization. The degree of advanced industrial structure is positively related to the degree of industrial digitalization. However, the proportion of greening in urban built-up areas hinders the development of industrial digitalization to a certain extent, and the Urban-rural income gap is negatively related to industrial digitalization.

Keywords: green finance; industrial digitalization; panel data; coefficient of variation method.

1. Introduction

In the late 20th century, the United Nations proposed the concept of 'sustainable development'. It called on all countries in the world to take the initiative to assume relevant responsibilities and jointly contribute to sustainable development. The Chinese government has actively responded by encouraging the acceleration of industrial digitalization and promoting the green and sustainable development of industries. At the end of 2015, 'green finance' was included in China's '13th Five-Year Plan' outline, pointing out "establishing a green financial system, developing green credit, green bonds, and establishing green development fund." The proposal of 'green finance' means the emergence of investment and financing projects specially set up for green enterprises and green industries. This has alleviated the problem of low and few investments in environmentally friendly enterprises and green industries, laying the foundation for the process of industrial digitalization. Industrial digitalization refers to the process of digital upgrading, transformation, and reinvention of all elements upstream and downstream of the industrial chain, with data as the key element, value release as the core, and data empowerment as the main line under the support and guidance of the new generation of digital technology. In 2020, 13 departments including the National Development and Reform Commission, the Central Cyberspace Administration of China, and the Ministry of Industry and Information Technology issued the "Opinions on Supporting the Healthy Development of New Business Forms and New Models to Activate the Consumer Market and Drive Expansion of Employment", requiring accelerating the development of industrial digitalization and promoting the digital transformation of the economy and society.

In recent years, China has adhered to sustainable development, which has already achieved good results in green finance and industrial digitalization, but there are still some related problems.

Firstly, all sectors of society, especially enterprises, do not have a sufficient understanding of green finance. Green finance aims to develop the economy and strengthen environmental protection to promote the realization of the 'dual carbon goals'. However, a considerable number of companies still lack understanding, knowledge, and attempts at 'green finance', making it difficult to promote green projects. Secondly, the identification standards of green finance need to be improved urgently. The problem with China's green finance norms and standards is that they are "not unified

domestically and not in line with international standards". Compared with internationally accepted standards, China's requirements are relatively low in terms of green project identification standards, product design, information disclosure, and risk management. Thirdly, the phenomenon of "greenwashing" appears one after another, affecting the order of the green financial market. In China, more than half of the funds obtained from green finance are used by financiers for non-green projects that cannot meet the expectations of environmental benefit, while industries that do need green financial investment support are facing financial problems such as fund shortages. Fourthly, there is a certain gap between the development of green finance and the actual needs. Insufficient funds in green finance and a small number of green financial instruments are not conducive to meeting the needs of economic life.

Based on this, this article will define green finance from four aspects: green credit, green investment, green insurance, and green patent application data, using panel data from 30 provinces and cities in China from 2012 to 2021 to examine the impact mechanism of green finance on industrial digitalization to improve related research in this field.

2. Literature review

Judging from the existing articles, research on industrial digitalization has shown a diversified trend with fruitful results in recent years. Research on industrial digitalization mainly includes two aspects, one is the influencing factors of industrial digitalization, and the other is the impact and changes it brought about.

Regarding the analysis of potential influencing factors of industrial digitalization, researchers now believe that digital management systems, cloud computing technology, big data technology, blockchain technology and the application of digital technology (Zhou Dasen et al., 2023) play an important role in the digitalization of the entire fruit and vegetable industry. Among them, Song Zhongyan (2013) studied the digital monitoring system of fruits and vegetables based on the Internet of Things. Dong Miaomiao (2022) studied the digitalization of the supply chain of fresh agricultural products in terms of the application model and digital management system of easing information technology in warehousing, circulation, and sales. Zhang Lewei (2021) studied a smart device for grading prickly pear fruits. Internet of Things technology, digital means such as the Internet and mobile Internet, and digital marketing means (Ma Liangliang, 2024) have directly affected the digitalization of the whole chain of livestock industry in Liaoning Province. Digital technology transformation, blockchain development, and supply chain finance rely on the two-wheel drive of modern information technology and modern finance (Shi Yu et al., 2024) to have a significant impact on the digitization of offshore fishery supply chain service platforms. Some researchers also believe that urban digital finance can promote corporate digitalization (Zhou Weihua et al., 2023). The formulation and implementation of relevant policies have a positive effect on the digital development of regional industries (Zeng Ying, 2022). The influencing factors of industrial digitalization are the focus of research in this field. Many literatures use empirical analysis, literature analysis, and other research methods to focus on the discussion of different influencing factors of industrial digitalization. The influencing factors of industrial digitalization cover a wide range of areas. In addition to the factors mentioned above, green finance may also become one of the influencing factors of industrial digitalization, and there has been research on the impact of green finance on industrial digitalization. Through the coupling mechanism at the industrial level, green finance and the apparel industry develop collaboratively (Liu Liang, 2022). Green finance promotes the digital transformation and upgrading of the clothing industry by strengthening the digital reform of clothing enterprise management work (Xu Jie, 2022). Green finance has a marginally increasing non-linear improvement effect on industrial digital transformation (Du Jiayan et al., 2023).

About the series of impacts and changes brought about by industrial digitalization. Kong Cui (2024) believes that the development of digital technology and resource misallocation are the intrinsic mechanisms for the digital collaboration of the industrial chain to drive the high-quality development

of the real economy. The digital collaboration of the industrial chain has a significant promoting effect on the high-quality development of the real economy. Based on the intermediary effect, Li Shengbo (2024) pointed out that industrial digitalization has adjusted the internal structure of the industry, and it has a greater impact on the industrial economy itself and can better promote the development of the industrial economy, thereby improving the high-quality development level of our country's economy. Yu Liping et al. (2024) studied the nonlinear effect of industrial digitalization on enterprise innovation from the perspectives of technological innovation and management innovation. The technological innovation effect of digital transformation decreases as the level of digitalization increases. Cheng Xinwei et al. (2024) pointed out that industrial digitalization improves the high-quality development level of regional manufacturing, having a significant positive impact on five aspects: innovation efficiency, technological structure, economic benefits, brand quality, and green development. Nevertheless, its impact on the improvement of economic efficiency and green development is still with obvious regional differences. Sun Xiaoxi et al. (2023) proposed that industrial digitalization provides transmission mechanisms for data elements to empower the low-carbon transformation of production methods, digital technology to empower resource allocation efficiency improvements, emerging industries to empower the optimization and upgrading of industrial structures, and consumption concepts to empower the green transformation of lifestyles path. Driven by digitalization, transforming the integrated development mode of rural industries, empowering with digital innovation and technology, and optimizing the integrated development path of rural industries are the inherent requirements for promoting rural industrial integration to enter the stage of high-quality development (Yu Huyue, 2022). These studies have carried out detailed discussions on some of the influencing factors of industrial digitalization and the changes brought about by industrial digitalization, having certain reference values for subsequent research on other influencing factors of industrial digitalization.

Existing literature mostly studies the field of industrial digitalization from the perspective of influencing factors such as digital management technology, information technology, digital technology, intelligent manufacturing, digital finance, and policy support. There are few studies on green finance as an influencing factor of industrial digitalization, and many focus on green finance research on a specific industry rather than the entire industry. To further enrich the research on the influencing factors of industrial digitalization and make up for the shortcomings in previous literature, this article is based on the panel data of 30 provinces and cities in China from 2012 to 2021 and empirically tests the impact of the green finance index synthesized from the green credit index, green investment index, green insurance index, and green patent application on industrial digitalization, to contribute to related fields.

3. Research design

3.1. Model setting

Based on the literature review, this paper sets up the following panel model to examine the impact of green finance on industrial digitalization, as shown in equation (1):

$$digin_{it} = \alpha_0 + \alpha_1 gfin_{it} + \alpha_2 green_{it} + \alpha_3 indu_{it} + \alpha_4 gap_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Among them, $digin_{it}$ is the industrial digitalization index, which reflects the comprehensive degree of national industrial digital development, that is, the degree of integration of digital technology and the real economy [1]. $gfin_{it}$ is the green finance index, which refers to the degree to which environmental factors are incorporated into the financial decision-making and investment process [2]. $green_{it}$ is the proportion of greening in urban built-up areas, which reflects the proportion of green space scale in urban built-up areas to the spatial scale of built-up areas to a certain extent [3]. $indu_{it}$ refers to the degree of advanced industrial structure, which is the process of progressive upgrading of an economy's leading industries from low-level to high-level [4]. gap_{it} is the urban-rural income gap, that is, the gap between the per capita disposable income of urban and

rural residents [5]. According to the synergy theory, green finance can promote the digital transformation of the energy industry by increasing the environmental costs of economic activities, forcing the industry to survive the fittest [6]. Green finance has a marginal incremental non-linear improvement effect on industrial digital transformation, and financial deepening helps green finance promote industrial digital transformation [7]. μ_i represents the regional effect, λ_t is the time effect, ε_{it} is the random disturbance term.

3.2. Variable selection

3.2.1 Explained variable

The explained variable in this article is the industrial digitalization index. The index is synthesized from the technology market turnover, the number of digital patent applications accepted, the number of employees in urban units in the scientific research and technical service industry, and the digital financial inclusion index through the coefficient of variation method. The index currently includes 30 provinces and cities in China, and the period is 2012-2021.

3.2.2 Explanatory variables

The explanatory variable in this article is the green finance index. The index is synthesized from the green credit index, green investment index, green insurance index, and green patent applications through the coefficient of variation method. There are many studies on the influencing factors of industrial digitalization, and most of the literature empirically tests the impact paths of green finance on the digitalization of each different industry [6,7].

3.2.3 Control variables

Considering other factors affecting industrial digitalization, this article selects the following variables for research:

(1) Greening proportion of urban built-up areas (green): The percentage of green space in urban built-up areas to the area of urban built-up areas.

(2) Degree of advanced industrial structure (indu): the ratio of the economic share of the tertiary industry and the secondary industry.

(3) Urban-rural income gap (gap): the ratio of per capita income levels between urban residents and rural residents.

The descriptive statistical results of the main variables are shown in Table 1.

3.3. Data source

This article selects 30 provinces and cities in China (excluding areas with missing data such as Tibet, Hong Kong, Macao, and Taiwan) as the research object, and uses panel data from 2012 to 2021 to test and analyze how green finance affects industrial digitalization. The main variable data comes from the ‘China Statistical Yearbook’, the National Bureau of Statistics website, etc. Some missing data are filled in by interpolation.

Table 1 Descriptive statistics of variables

Variables	Obs	Min	Max	Mean	Std. Dev.
gfin	300	0.0199708	0.929464	0.1778436	0.1418619
green	300	0.298	0.493	0.3993666667	0.034704835
indu	300	0.54926327	5.310126582	1.28302721	0.70980997
gap	300	1.842	3.646	2.55106	0.369340678

4. Empirical test

4.1. Baseline regression results

This article uses Stata software to perform fixed effects and random effects regression on the model. To eliminate possible multicollinearity between variables, this article adopts the method of adding explanatory variables one by one to perform regression. The Hausman test rejected the null hypothesis, which means that the regression results of the fixed effects model are more ideal. The results are shown in Table 2. The following conclusions can be drawn from Table 2:

First, the accuracy, breadth and depth of green finance applications play a significant role in promoting industrial digitalization. Green finance mainly affects the industrial digitalization process from four levels: investment orientation, capital accumulation, resource integration, and information transmission [8]. In terms of investment orientation, green finance investment orientation is clear and tends to invest in green industries. When financial resources are tilted towards environmentally friendly industries, heavily polluting industries will be excluded by financial institutions, and their behavior plays an important role in guiding the flow of social funds to green industries [9]. The digital transformation of the clothing industry has a good impact on the environment. The green finance plays a key role in the process of transformation and upgrading of the clothing industry [10]. Restrictions on financing conditions have increased the environmental costs of economic activities. This has forced industries with high pollution and high emissions to upgrade their core technologies, carry out green and digital transformation, and reduce pollution problems in the production and operation process of enterprises to obtain financial support. In terms of capital agglomeration, innovative financial instruments achieve capital aggregation and precise investment of green credit funds, broaden investment and financing channels for environmentally friendly industries [6], and promote industry green transformation and digital transformation. In terms of resource integration, differentiated credit interest rate management promotes industrial technological innovation and promotes the transfer of capital, human resources, and technical elements to green industries. In the context of high-quality development, corporate ESG information disclosure promotes green industries to have higher investment value in the market [6]. A green financial business assessment is required before green financial investment. A digital platform is similar to the green industry and a finance platform, which helps financial institutions conveniently, quickly, and obtain relevant information in detail on the management, operation, and production of relevant enterprises through the exchange and sharing of information. Digital platforms provide more reliable reference information for financial institutions' green finance business assessment, and green credit risk management and control. To obtain more support from green funds, related industries will continue to promote and strengthen their digital management levels. To attract more green investment, the apparel industry attaches great importance to strengthening the application of digital management models and building an enterprise digital management platform to enable financial institutions to obtain pollution and environmental protection information of enterprises more efficiently and comprehensively in production, sales, operation, and management, accelerating the digital transformation and upgrading process of the apparel industry.

Second, the proportion of greening in urban built-up areas is negatively correlated with the degree of industrial digitalization development. Green finance emphasizes the important role of finance in promoting green development and optimizing resource allocation, that is, guiding financial resources to the green economy [11]. Industrial digitalization is one of the ways for an extensive economy to move closer to a new economic form, and it is an important measure for the high-quality development of the green economy. The landscaping economy in urban built-up areas is also subordinate to the green economy and competes with industrial digitalization for green funds from green finance. When the proportion of greening in urban built-up areas increases, the amount and share of green funds invested in it also increases accordingly, which to a certain extent reduces the supply of funds for industrial digital transformation and upgrading, and that inhibits the digital development process of the industry.

Third, there is a positive correlation between the degree of advanced industrial structure and industrial digitalization. Industrial structure optimization can be divided into industrial structure rationalization and upgrading. The development of the digital economy relies more on the optimization of industrial structure, that is, industrial digitalization relies on the advancement of industrial structure [12]. It is possible to assist the digital transformation of the industry by promoting technological innovation and product upgrading,

Fourth, the urban-rural income gap is negatively related to industrial digitalization. The narrowing urban-rural income gap will promote the development of industrial digitalization to some extent. Digital reform has a significant regulatory effect on the balanced sharing of social resources and the fair distribution of social wealth. In addition, digital reform has a mitigating effect on the urban-rural gap, regional gap, and income gap [13], thus creating a virtuous cycle: industrial digitalization reduces the urban-rural income gap, and the narrowing of the urban-rural income gap further promotes the process of industrial digitalization, and the cycle repeats.

Table 2 Stepwise regression results of random effects model

VARIABLES	(1) hqd	(2) hqd	(3) hqd	(4) hqd
gfin	0.840*** (8.81)	0.702*** (6.92)	0.349*** (3.40)	0.339*** (3.32)
green		0.413*** (3.49)	0.075 (0.64)	-0.070 (-0.54)
indu			1.267*** (7.67)	1.081*** (5.94)
gap				-0.438** (-2.36)
Constant	0.0908486 (4.79)	-0.0993479 (-1.73)	-0.0558852 (-1.06)	0.2219874 (1.72)
Individual effect	YES	YES	YES	YES
Time effect	YES	YES	YES	YES
R square	0.4240	0.4745	0.5849	0.5074
Observations	300	300	300	300
Number of id	30	30	30	30

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.2. Robustness test

To verify the robustness of the benchmark regression results, this paper replaces one of the composite factors of the explained variable industrial digitalization index, that is, replacing the number of urban unit employees in the scientific research and technical service industry with the number of enterprises with e-commerce transaction activities. Then re-regress green finance and other control variables. The results are shown in Table 3. The coefficients of all influencing factors have not changed significantly in direction and value, indicating that the baseline regression results are relatively robust.

Table 3 Robustness test results

VARIABLES	(1) hqd	(2) hqd	(3) hqd	(4) coverage
gfin	0.902*** (8.95)	0.753*** (7.02)	0.384*** (3.53)	0.374*** (3.46)
green		0.446*** (3.57)	0.092 (0.75)	-0.061 (-0.44)
indu			1.325*** (7.57)	1.128*** (5.86)
gap				- 0.463** (-2.36)
Constant	0.0827931 (4.13)	-0.1226372 (-2.02)	-.0771946 (-1.39)	0.216596 (1.59)
Regional effect	YES	YES	YES	YES
Time effect	YES	YES	YES	YES
R square	0.4827	0.5246	0.5532	0.4977
Observations	300	300	300	300
Number of id	30	30	30	30

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5. Conclusions and suggestions

This paper uses panel data from 30 provinces and cities in China to empirically test the impact mechanism of the green financial index composed of the green credit index, green investment index, green insurance index, and green patent applications on industrial digitalization. The study found that green finance has a significant promotion effect on industrial digitalization, and the degree of advanced industrial structure among the control variables is significantly positively correlated with industrial digitalization. However, the proportion of greening in urban built-up areas among the control variables is negatively correlated with industrial digitalization, and the narrowing of the urban-rural income gap is conducive to the development of industrial digitalization.

Based on this, this article puts forward the following policy recommendations for the further development of industrial digitalization:

First, clarify the definition and service scope of green finance, improve the formulation of rules and indicators related to green finance, give full play to the role of green finance investment guidance, accurately allocate green credit, and provide green finance for green enterprises, green industries, and industrial green digitalization in need. Use green finance in related fields to reduce the possibility of "greenwashing" and avoid the outflow of green funds to the greatest extent.

Second, accelerate the creation and improvement of green industry and finance platforms, and develop digital technologies such as the Internet, Internet of Things, cloud computing, big data, 5G communications, and artificial intelligence. Strengthen the application of digital management models within the industry in terms of analyzing and predicting industrial market demand, digital production management, product marketing management and supply, business management, and customer management to improve technical support and assistance. At the same time, with the help of green industry and finance platforms and digital technologies, industry-related information is presented to financial institutions more comprehensively and completely, assisting financial institutions in their financial business assessment work, increasing the possibility of industries receiving green financial assistance, and promoting the process of industrial digitalization.

Third, pay attention to and strengthen the cultivation of compound talents. The promotion of industrial digitalization cannot be separated from the help of comprehensive talents who have both business management knowledge and data mining and analysis capabilities. Increase efforts in

cultivating innovative and management technology compound special talents, promote the innovative integration of the digital economy and cutting-edge digital technology, and urge the high performance of digital management. Comprehensive talents can strengthen the use of industry data in daily operation and management, rationally use the logistics, capital flow, and information flow brought by the digital economy, promote the integration of various production factors and the effective allocation of resources, and help build a digital economy with the current situation of economic development of modern digital industry.

Fourth, optimize the industrial structure and promote the upgrading of the industrial structure. Shift the focus of industries in turn, reduce the proportion of the primary industry, and increase the weight of the secondary and tertiary industries; shift the factor intensity in turn, reduce the proportion of primary product processing industries, and support the development of capital-intensive and technology-knowledge-intensive industries; Shift product forms, reduce primary product production lines, and increase the industrial proportion of intermediate products and final products. In addition, it deepens the reform of market-oriented allocation of factors, reduces barriers to the circulation of production factors, vigorously promotes the integrated development of capital factors, labor factors, and technological factors, and creates a good development environment for industrial digitalization.

Fifth, the government should strengthen the top-level design, accelerate the pace of narrowing the development gap between urban and rural areas, promote the transformation and upgrading of rural industries, increase the investment level and financial support of human resources, funds, and financial support for various rural industries, and promote the digitalization of industries process.

References

- [1] Wang Sanxing, Luo Juan. Research on the employment skill structure effect of industrial digitalization [J/OL]. Northwest Population: 1-13 [2024-01-26].
- [2] Shaymeldan Nyazi, Sun Yunyun, Zhao Tingting, etc. Research on the impact of green finance on environmental accounting in the context of "carbon neutrality" [J]. Business Exhibition Economics, 2024(02):168-172.
- [3] Cui Jiaqi; Liu Hongtao; Chen Yuanyuan. Analysis of changing characteristics and influencing factors of green coverage in China's urban built-up areas [J]. Journal of Ecology and Environment, 2021, (02): 331-339.
- [4] Yu Yongze, Sun Pengbo, Xuan Ye. Have local government environmental target constraints affected industrial transformation and upgrading? [J]. Economic Research, 2020(8):57-72.
- [5] Zhou Xiaogang; Wang Chaohua;. Research on the impact of digital economy and new urbanization on urban-rural income gap - Empirical analysis based on spatial Durbin model [J]. Journal of Agricultural and Forestry Economics and Management, 2023, (06): 780-791.
- [6] Li Wenxiang, Lu Yu, Wang Jing. Green finance supports the digital transformation of the energy industry from the perspective of synergy theory: theoretical implications, practical dilemmas and implementation paths [J]. Gansu Finance, 2023, No.548(11):9- 14+8.
- [7] Du Jiating; Yuan Yixin; Gu Qiannong; Shi Xi. Financial deepening, green financial development and industrial digital transformation [J]. Financial Supervision Research, 2023, (03): 1-16.
- [8] Li Zehui. Research on the impact of green finance on industrial structure optimization [D]. Shanxi University of Finance and Economics, 2023.
- [9] Zhang Qian, Yu Ying. Research on the role of green finance in high-quality urban development - Evidence from data from 277 prefecture-level cities [J]. Financial Development Research, 2023(03):52-58.
- [10] Liu Liang, Ni Wufan, Lu Peifeng. Research on the path of green finance supporting the digital transformation of the apparel industry [J]. Textile Report, 2021, 40(09): 29-31.
- [11] Wu Tong. my country's green finance and economic development path [J]. Shanghai Enterprise, 2024, (02): 45-47.

- [12] Su Ying; Luo Jiayi. Research on the dynamic relationship between the digital economy, technological innovation and industrial structure upgrading - based on PVAR model [J]. Productivity Research, 2024, (01): 108-114.
- [13] Tang Linjia; Zhou Xiaoyan. Research on the impact of digital reform policies on the construction of common prosperity [J]. Journal of Zhejiang University of Technology (Social Science Edition), 2022, (02): 159-166.