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LINGJUAN XU
Nanjing University of Aeronautics and Astronautics, China

YIJIANG LIU
Nanjing University of Aeronautics and Astronautics, China

BEIBEI XIANG
Nanjing University of Aeronautics and Astronautics, China

QUNWEI WANG
Nanjing University of Aeronautics and Astronautics, China

THE IMPACT OF DIGITAL FINANCE ON THE HIGH-QUALITY DEVELOPMENT OF MANUFACTURING INDUSTRY: EVIDENCE FROM CHINA

Abstract:

In order to explore the impact of digital finance on the high-quality development of manufacturing industry, this paper uses data from 30 provinces in China from 2012 to 2021, and uses a multiple intermediary effect model to empirically study the mechanism and path of digital finance promoting the high-quality development of manufacturing industry. The research reveals that the eastern provinces of China are leading in the high-quality development index of the manufacturing industry from a spatial dimension. Looking at the temporal dimension, the overall level of high-quality development in the manufacturing industry in each province is showing an increasing trend, with the eastern region demonstrating the most significant upward trend. Empirical research has found that digital finance plays a significant catalytic role in the high-quality development of the manufacturing industry, with an impact coefficient of 0.032. Furthermore, digital finance can enhance the level of high-quality development in the Chinese manufacturing industry through three pathways: industrial upgrading, optimization of resource allocation, and environmental regulation.

Keywords:

High-quality sustainable development, Manufacturing industry, Digital finance, Multiple mediation effects model, Empirical testing

JEL Classification: O23

1 Introduction and Literature Review*

At the 19th CPC National Congress, green, low-carbon, and sustainable development were identified as the primary means for China to achieve carbon peak and carbon neutrality, as well as the inherent requirement for the high-quality development of the manufacturing industry. Accelerating the High-quality development of the manufacturing industry is not only crucial for ensuring the stability and security of China's industrial and supply chains but also serves as an effective support for achieving high-quality economic development. The 14th Five Year Plan period is a crucial and important period for China to maximize its efforts to achieve the dual goals of "carbon peaking" and "carbon neutrality". It is also a transformative period for comprehensively promoting the development of a low-carbon economy. This underscores the central importance that the Party places on a green development strategy (Pan and Dong, 2023). As China's economy enters a new normal and faces rigid constraints associated with the "dual carbon" goals, driving the high-quality and sustainable development of China's traditional manufacturing industry, accelerate the sustainable development of China's real economy, building a modern industrial system and economic structure, and achieving high-quality economic development have become the focal points of society. Therefore, comprehending the current status of high-quality sustainable development in China's manufacturing industry and delving into the pathways to promote such development is of practical significance for the comprehensive and systematic advancement of high-quality sustainable development in China's manufacturing industry.

The High-quality development necessitates substantial financial support, and digitalization of finance has emerged as a response to this demand. Digital finance (DIF), developed based on digital technology, integrates digital and financial concepts, thereby digitally expanding the breadth and depth of financial services. The 14th Five-Year Plan of the nation advocates the prudent development of financial technology and the acceleration of the digital transformation of financial institutions. The digitalization of finance model can effectively advocate for public participation in environmental protection initiatives, contributing to the reduction of environmental pollution (Hao et al.,2023). As a core element of modern economic operations and a crucial regulatory tool for government departments to implement emission reduction measures from energy conservation, digitalization of finance presents an epochal opportunity for the High-quality development in China. A thorough exploration of the impact of digital finance on the low-carbon and high-quality sustainable development of manufacturing industry not only effectively expands the research scope of relevant academic fields but also provides decision-making foundations for government departments to layout digital finance infrastructure and formulate high-quality sustainable development policies in practice.

Research on digital finance has predominantly focused on exploring its impact on urban-rural income disparity, corporate financing constraints, and industrial transformation and upgrading (Li and Liu, 2023; Razza et al., 2023). Some studies have delved into a detailed analysis of the intermediary mechanisms driving regional innovation development through digital finance. The

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Corresponding author: nuaaxulj@163.com

findings indicate that the primary channels through which digital finance promotes regional innovation include the improvement of credit resource allocation, optimization of banking industry competition(Qiong et al., 2023), growth in household consumption, and the elevation of marketization levels. Digital finance has the capacity to facilitate the low-carbon transformation of agriculture. By fostering traditional financial development, enhancing regional innovation capabilities, and elevating resident consumption levels, digital finance influences agricultural entrepreneurial activities, thus promoting the low-carbon transformation of agriculture (Razzaq and Yang, 2023). Yin et al. posit that owing to the technological impetus and efficiency enhancement capabilities inherent in digital finance, it can exert a restraining effect on carbon intensity, theoretically contributing to achieving carbon peak goals (Yin, 2023). Financial projects implemented with government involvement will prioritize supporting emerging enterprises aligned with national development strategies. This approach aims to reduce financing barriers for relevant small and medium-sized enterprises, enhance innovation dynamics within enterprises, and thereby encourage small and medium-sized enterprises to engage in the research and application of green technologies (Lyu et al., 2023). The development of digital finance significantly promotes corporate carbon performance through technological innovation. Furthermore, when compared to large-scale and non-manufacturing enterprises, the impact of digital finance on the carbon performance of small and medium-sized, manufacturing enterprises is more pronounced (Hou et al., 2023).Against the backdrop of rapid development in the digital economy and widespread application of digital technologies, the emergent business model of digital finance, reliant on digital technology, holds substantial influence on the High-quality development of China's manufacturing industry. It is likely to emerge as a crucial driving force for the High-quality development of the manufacturing industry. Therefore, careful attention should be paid to the research on the impact of digital finance on the High-quality development of manufacturing industry, as existing literature in this field has left numerous unanswered questions, underscoring the value of this study.

High-quality sustainable development is proposed based on the considerations of the “Five concepts for development”and the primary contradictions in contemporary society. In the implementation of the new development concept, the Chinese Academy of Social Sciences defines high-quality sustainable development as embodying the continuous optimization of economic structure and efficiency, achieving full balance in economic development, extending the benefits of development to the entire population, and realizing social fairness and justice. As a key pillar of China's economic development, the High-quality development of the manufacturing industry holds paramount significance (Xu et al., 2023). Currently, research on high-quality sustainable development primarily focuses on the elucidation and measurement of its connotations. The first category of research transforms the connotations of high-quality sustainable development into the quality or performance of economic growth, utilizing indicators such as (green) total factor productivity, innovation performance, and optimization of industrial structure for evaluation (Li et al., 2023；Guo et al., 2023). Total factor productivity not only reflects the quality of production factors but also mirrors the efficiency of factor allocation. Therefore, the 19th National Congress of the Communist Party of China report suggests advancing high-quality sustainable development by elevating total factor productivity. Deputy Minister Xin Guobin of the Ministry of Industry and Information Technology points out that promoting the High-quality development of the manufacturing industry can be approached from four aspects: advancing supply-side structural reform, enhancing innovation capabilities and levels, accelerating the development of advanced manufacturing modes, and optimizing the market environment for fair competition. On the basis of research in this area, some scholars have proposed a feasible path for the High-quality development of the manufacturing industry, including the active development of the digital economy, the promotion of the integrated development of the manufacturing industry, and the upgrading of the manufacturing industry to the high-end of the global value chain through industrial chain integration (Du and Ren, 2023). Some scholars also suggest that improving the quality of products and transforming China's manufacturing industry into a powerhouse of high-quality sustainable development and world-class manufacturing can be achieved through targeted optimization of industrial structure, strengthening technological innovation, and promoting low-carbon circular production (Bai et al., 2023).

The above literature review reveals distinct patterns: research on the extent of financial digitization in foreign countries is relatively early and has already established a comprehensive theoretical and methodological framework. However, research on the impact of digital finance on the High-quality development of the manufacturing industry in foreign countries emerged relatively late. Chinese scholars' research on the extent of financial digitization started slightly later than that of developed countries, and domestic scholars' research on Chinese finance and the impact of digital finance on the High-quality development of the manufacturing industry predates that of developed countries abroad. Chinese scholars' studies on the impact of digital finance on the High-quality development of the manufacturing industry exhibit distinct Chinese characteristics. These studies are conducted in accordance with the requirements of the Chinese government and consider the actual situation in China. In recent years, as Chinese scholars have delved deeper into the impact of digital finance on the High-quality development of the manufacturing industry, these studies have gradually acquired Chinese characteristics. This has significantly influenced some foreign scholars to join related research endeavors and commence investigations into this important issue. Given the existing limitations in the empirical testing models, relatively short-term data, and the simplicity of the discussions in current research on this topic, this study attempts to address these evident shortcomings in the existing literature.

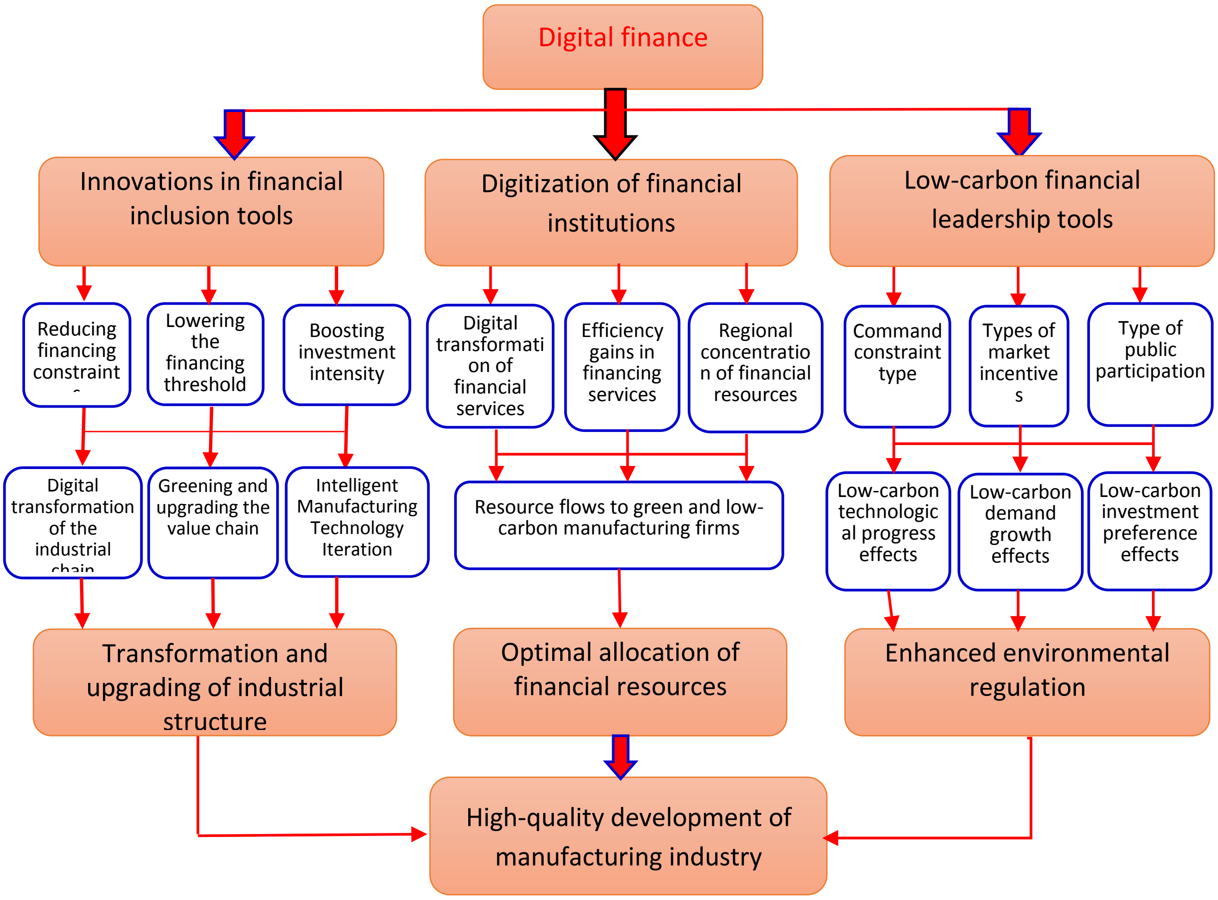
2 Materials and Methods

2.1 Research Framework and Hypotheses

2.1.1 Research Framework

The purpose of this study is to empirically test the impact of digital finance on high-quality development indicators of China's manufacturing industry. In order to achieve effective testing, the "entropy weight method" was used to scientifically measure the High-quality development indicators of 30 provinces in China. Subsequently, a mediation variable model is utilized to empirically test the influence of digital finance and auxiliary variables on the High-quality development indicator of the manufacturing industry in various Chinese regions. The specific mechanisms and research framework are detailed in Figure 1.

Figure 1 Mechanism of the impact of digital finance on high-quality sustainable development in the manufacturing industry



2.1.2 Research Hypotheses

(1) Digital finance and the High-quality development of the manufacturing industry. As a modern financial service, digital finance relies on digital technology, offering advantages such as security, sharing, low cost, and convenience. It has the potential to expand and enhance the scope and efficiency of financial services, refine financial service networks, improve resource allocation efficiency, thus providing innovative perspectives for the High-quality development of the manufacturing industry (Xiong and Li, 2023). Leveraging big data, cloud computing, and artificial intelligence technologies, digital finance constructs data-driven risk control systems, comprehensively enhancing the security of financial services, lowering financing thresholds and costs, facilitating the flow of credit funds toward high-tech and environmentally friendly industries, and optimizing the efficiency of financial resource allocation. Through the transmission pathway of green technological innovation, digital finance significantly improves China's energy and environmental performance. This promotion effect is primarily attributed to alleviating corporate financing constraints, driving industrial structural upgrades, and promoting the development of the manufacturing industry (Wan et al., 2023). Simultaneously, based on data analysis, digital finance effectively meets the financing needs of the long-tail population while promoting industrial structural optimization and upgrading through mechanisms such as income distribution optimization, capital accumulation, consumption demand expansion, and technological innovation

(Tang et al., 2023). Therefore, the following hypothesis is proposed:

H1：Digital finance exerts a positive impact on the High-quality development of the manufacturing industry.

(2) Digital finance, industrial upgrading, and high-quality sustainable development in the manufacturing industry. Digital inclusive finance can efficiently provide services to enterprises through the innovation of inclusive financial tools, offering better financing channels for environmentally friendly, innovative, and growing enterprises. The primary avenues through which digital inclusive finance promotes industrial upgrading are outlined as follows: Firstly, digital inclusive finance, as an amalgamation of digitization and inclusive finance, effectively addresses the shortcomings of traditional financial services. It has a broader coverage, alleviating long-standing issues in financial markets such as "ownership discrimination" and "scale discrimination." Leveraging advantages in data, scenarios, and services, digital inclusive finance, through algorithmic iteration optimization and the rapid advancement of computer technology, can swiftly and accurately match various demand points in the industrial chain. This reduces information asymmetry problems, mitigates financing constraints, and lowers financing barriers for enterprises. With ample financing funds in place, manufacturing enterprises, based on a virtual network aggregation centered on data and information sharing, enable businesses in different locations and times to simultaneously assume multiple specialized roles in the industrial chain. The industrial chain expands into a complex topological network structure. Simultaneously, for the closely coordinated associated enterprises in manufacturing production, including raw material supply, manufacturing, and market sales, digital technology empowers the entire process of industrial chain-associated enterprises. This not only reduces external transaction costs between enterprises but also enhances collaborative efficiency (Wang and Wei, 2023). It extends the industrial value chain, diversifies manufacturing business, thereby obtaining additional value multiplication effects, and achieves digital upgrading of the manufacturing industry's industrial chain. Secondly, digital inclusive finance expands the scope of financial services, leading to increased household incomes. With environmental conservation concepts gaining widespread acceptance, consumer preferences shift toward low-carbon products and services. This prompts the allocation of funds and social resources to be more inclined toward low-pollution enterprises and green innovation projects, driving pollution and energy-intensive manufacturing enterprises to increase investments in high-tech and environmentally friendly directions. Companies optimize production processes, engage in innovative activities under the principles of low-carbon high-quality sustainable development, facilitating the greening and upgrading of the value chain and the iterative advancement of intelligent manufacturing technology, thereby achieving the transformation and upgrading of the industry (Fang et al., 2023). Therefore, the following hypothesis is proposed:

H2a: Digital finance can promote high-quality manufacturing through industrial upgrading

(3) Digital finance, resource allocation, and high-quality sustainable development in the manufacturing industry. With the rapid advancement of technology and the continuous progression of digitization, financial institutions are encountering new opportunities for transformation. Technological empowerment provides financial institutions with rich technical tools and platforms, and digital transformation has become a crucial means for driving efficient operations and innovative development within the financial sector. The digitization of financial institutions can propel the digital transformation and upgrade of financial services, assisting in enhancing operational efficiency, reducing labor costs, and accelerating business processing

speed. For instance, through automated processing workflows and the application of intelligent algorithms, technology can significantly boost the operational efficiency of financial institutions. The extent of financial digitization, as the integration of traditional finance and internet technology, infuses distinctive characteristics into the development process of digitized financial institutions. While lowering the financing costs and constraints of traditional financial services, it enhances the efficiency of financing services (Ozturk and Ullah, 2022). Financial institutions, utilizing big data technology, acquire relevant information about the environmental processes and equipment of green enterprises, thereby reducing the financial risk associated with providing credit. Consequently, financial institutions are more willing to provide credit funds for the development of enterprises. The extent of financial digitization guides the allocation of financial resources to environmentally friendly and resource-saving enterprises, promotes the regional concentration of financial resources and in a risk-diversifying and cost-reducing manner, stimulates technological progress or organizational changes within enterprises. This facilitates the transformation of industrial and energy structures, reduces unit output energy consumption, and subsequently lowers carbon emissions (Muvumbu-Mukalayi, 2023).

In the context of digital finance, financial institutions, through the digitization of financial services, the improvement of financing service efficiency, and the regional concentration of financial resources, provide financing support to enterprises addressing environmental pollution issues. This effectively promotes the green development of enterprises, making the effects of financial resource service to the green economy more robust. Furthermore, digitalization of finance utilizes digital technology to promptly convey enterprise information to environmental governance departments, establishing a green financial closed loop and promoting the optimization of green production methods. Therefore, it is evident that digitalization of finance not only plays a role in financial resource allocation but also drives the synchronous development of ecological environmental protection. It guides financial resources to tilt more towards green and low-carbon manufacturing enterprises (Jin et al., 2023). Green enterprises dedicated to pollution prevention, energy conservation, and environmental improvement will gradually dominate economic development. Therefore, the following hypothesis is proposed:

H2b: Digital finance can promote high-quality manufacturing through resource allocation

(4) Digital finance, environmental regulation, and high-quality sustainable development in the manufacturing industry. Environmental regulation is a constraining force with the purpose of environmental protection and ecological governance, targeting individuals or organizations and manifesting as tangible systems or intangible awareness. In recent years, with scholars' multiple revisions, the connotation of environmental regulation has gradually enriched. The definition has evolved into control-oriented, incentive-oriented, and voluntary environmental directives involving the joint participation of government departments, social organizations, and entities such as nations, enterprises, and associations (Yan et al., 2023). Among these, command-and-control regulatory tools (including the formulation and implementation of environmental resource laws and regulations, with the establishment of the United States Environmental Protection Agency (EPA) as a significant milestone) employ a "command-and-control" approach to restrict pollution emissions or reduce energy consumption by managing specific production processes, material usage, or other activities related to the environment within certain times or areas (Wang et al., 2023). Command-and-control regulatory tools compel enterprises to adopt environmentally friendly technologies to replace previous high-pollution, high-energy consumption production methods. This, in turn, propels sustainable development in the manufacturing industry through the

efficiency gains of low-carbon technological advancements (Hao et al, 2023). Market incentive-based control tools (such as pollution taxes and environmental subsidies) utilize price mechanisms to coordinate various environmental behaviors of enterprises. This ensures that environmental costs are factored into company decisions, simultaneously enhancing resource usage and allocation efficiency. Through the transmission of market incentive-based control tools, manufacturing enterprises recognize the strong market support for low-carbon technologies. Leveraging the growth effects of market demand for low-carbon products, enterprises increase the adoption of low-carbon innovative technologies to obtain environmental cost benefits. Public-participation-based regulatory tools (such as environmental disclosure and voluntary environmental management) significantly influence corporate reputations through public opinion, conveying social value signals and affecting market behavior (Assem et al., 2023). Simultaneously, public-participation-based regulatory tools guide investors to participate in green and low-carbon projects through securities investment, aligning with the preference for low-carbon investments. Therefore, through the dominance of low-carbon finance, environmental regulation utilizes mechanisms of resource reallocation and market competition to induce internal restructuring within the manufacturing industry. This is particularly evident in accelerating the transformation or exit of polluting industries, increasing the concentration of polluting industries, and incentivizing enterprises to shift towards clean production or low-carbon industries, fostering the development of the green environmental protection industry (Chen et al.,2023). Therefore, the following hypothesis is proposed:

H2c: Digital finance can promote high-quality manufacturing through environmental regulation.

2.2 Variable Design and Data Description

(1) Dependent variable: The Manufacturing High-quality sustainable development Indicator (LCQD). Guided by principles of data accessibility, foresight, and sustainability, this study employs a comprehensive analysis method to refine the existing indicator system into an evaluative framework for the High-quality development level of the manufacturing industry. The indicator system comprises three hierarchical levels: the goal level, the criterion level, and the indicator level. The first-level goal is the economic development level of high-quality manufacturing under the framework of sustainable development. The second-level criterion includes five aspects: innovation-driven, quality-first, low-carbon development, structural optimization, and talent-based, as shown in Table 1 below.

Table 1 Indicator system for high-quality development of the manufacturing industry

Level 1 Indicators	Level 2 indicators	Description of indicators	Indicator attributes	weights
innovation drive (0.170)	R&D inputs	R&D expenditure	positive	0.120
	New product development inputs	Expenditure on new product development	positive	0.116
	Number of R&D organizations	Number of R&D organizations	positive	0.101
	Inputs from research and DI	Expenditure on running research and DI	positive	0.108
	R&D outputs	Number of R&D projects	positive	0.119
	New product project outputs	Number of new product development projects	positive	0.117
	Income from new products	Revenue from sales of new products	positive	0.118
	Patent output	Number of active patents	positive	0.101
	technical contribution	Technology market contract turnover	positive	0.100
Quality first (0.212)	Total labor productivity	Value added of industry/number of persons employed	positive	0.190
	Level of product quality	Superiority rate	positive	0.193
	Product sales	Product sales rate	positive	0.197
	Level of brand value	Brand value/industrial value added	positive	0.091
	Technology introduction	Expenditure for the introduction of technology	positive	0.152

Level 1 Indicators	Level 2 indicators	Description of indicators	Indicator attributes	weights
Low carbon development (0.210)	Equipment modification	Expenditure on technological transformation	positive	0.177
	Comprehensive ISW utilization rate	Solid waste consolidated use/solid waste generation	positive	0.258
	Pollution treatment investment intensity	Completed investment in IPT /industrial added value	positive	0.241
	Wastewater management	Treatment capacity of IWT facilities	positive	0.236
	EC per unit of industrial added value	Total energy consumption/industrial value added	negative	0.265
Structural optimization (0.204)	smart manufacturing	Number of Internet broadband access ports	positive	0.243
	information level	Number of mobile phone subscribers	positive	0.256
	Efforts to develop new products for HEI	NPDN/NNPD	positive	0.264
	Technical transformation intensity in HEI	ETTHTI/ETT	positive	0.237
Talent-based (0.204)	Intensity of talent investment	R&D staff full-time equivalent/number of employees	positive	0.355
	treatment of talent	Average wage of employed persons in MI	positive	0.355
	Intellectual level of talent	Number of PhDs and Masters in ERDI	positive	0.290

DI: development institutes; ISW: industrial solid waste; IPT: industrial pollution treatment; IWT: industrial wastewater treatment; NC: Energy consumption; NPDN: Number of new product development projects in high-tech industries; NNPD: Number of new product development projects in industry; HEI: high-end industries; ETTHTI: Expenditure on technological transformation of high-tech industries; ETT: expenditure on technological transformation; MI: the manufacturing industry；ERDI: Enterprise R&D institutions.

The subjective weighting method involves human judgment to determine the relative importance of indicators and assign corresponding weights. In contrast, the objective weighting method relies on the original information of indicators for the weighting process. Given that the subjective weighting method is prone to inaccuracies in weight assignment due to subjective influences, it may not effectively reflect the comprehensive indicator of indicators. Therefore, in constructing the indicator system for the High-quality development level of regional manufacturing, this study employs the entropy weighting method from the objective weighting approach.

Due to significant differences in dimensional units and magnitudes among the 26 basic indicators, standardization is necessary before they can be compared, ensuring the accuracy of the composite indicator. Therefore, the standardization formulas for positive and negative indicators are provided:

$$x_{ij}^* = \begin{cases} \dfrac{x_{ij} - \min\{x_j\}}{\max\{x_j\} - \min\{x_j\}} & \text{forward indicator} \\ \dfrac{\max\{x_j\} - x_{ij}}{\max\{x_j\} - \min\{x_j\}} & \text{Contrary Indicators} \end{cases} \tag{1}$$

In the expressions: $i = 1,2, \dots, n; j = 1,2, \dots, m$, where x_{ij}^* denotes the value of the jth evaluation indicator in the ith province after the calculation, x_{ij} denotes the original data of the indicator, and n denotes the number of provinces in the study. And $min\{x_j\}$ represents the minimum value of the jth evaluation indicator in the provinces,$max\{x_j\}$ is the maximum value of the jth evaluation indicator in the provinces, x_{ij}^* denotes the dimensionless result after standardizing the data. To calculate the weights, it is necessary to calculate the proportion of indicator j in year i, denoted by f_{ij}:

$$f_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} \tag{2}$$

To calculate the information entropy of the indicator f_{ij}, denoted by e_j:

$$e_j = -\frac{1}{In\ n}\sum_{i=1}^{n} f_{ij} \times In\ f_{ij}, 0 \leq e_j \leq 1 \tag{3}$$

To calculate the redundancy of information entropy for indicator e_j, denoted as d_j:

$$d_i = 1 - e_i \tag{4}$$

Calculate the weight for indicator d_j, denoted by w_j:

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}(1 \leq j \leq m) \tag{5}$$

Finally, calculate the comprehensive score for each sample:

$$RLCE_i = \sum_{j=1}^{m} w_j x_{ij}^{*} (i = 1,2, \dots, n) \tag{6}$$

(2) Core explanatory variable:

Digital Finance (DIF): Regarding the indicator of the level of digital financial development, most scholars choose the Digital Inclusive Finance Index released by the Digital Finance Research Center of Peking University to reflect this variable. A small number of scholars have selected different indicators, such as the internet finance heat indicator and the financial technology index, to measure the level of digital financial development. However, upon comparing the above indicators, it is found that the internet finance heat indicator uses keyword search and text mining methods, making it unable to objectively reflect the actual application level of digital finance. While the financial technology indicator has a broader coverage compared to digitalization of finance, the scale of third-party online payments only reflects a partial feature of digital financial development. Considering that the internet finance heat indicator and financial technology index have certain shortcomings in measuring the development level of digital finance, while the Peking University Digital Inclusive Finance Index, based on a large amount of data estimation, can relatively comprehensively measure the development level of regional digital finance. Therefore, this article ultimately chooses the logarithmic value based on the Peking University Digital Inclusive Finance Index to comprehensively reflect the level of regional digital finance development.

（3）Mediating variables. Industrial Structure Upgrade Indicator (ISU): Industrial structure upgrading implies the transition of industries and the enhancement of efficiency. In order to comprehensively and accurately reflect the purpose of the study and the connotation of industrial structure upgrading, this paper constructs the industrial structure upgrading indicator to characterize the level of industrial structure upgrading, and the specific measurement formula is as follows:$ISU = \sum_{i=1}^{3} I_I \times i = I_1 + 2 \times I_2 + 3 \times I_3$,where I_I represents the ratio of the output value of the i-th industry to the total output value, calculated as the added value of the i-th industry in the region divided by the regional GDP for that year. Generally, this indicator mainly reflects the upgrading relationship among three types of industries. The larger the ISU value, the higher the level of industrial structure development, indicating a more advanced industrial structure in the region.

Financial Efficiency (FE): The loan-to-deposit ratio is chosen as a measure of financial resource allocation efficiency, serving as the explanatory variable in this study and denoted as FE. The loan-to-deposit ratio is the ratio of a region's commercial bank loan balance to deposit balance during a certain period, reflecting the ability to convert deposits into loans and, consequently, indicating the ability to transform savings into investments. It can reflect the efficiency of financial resource allocation.

Environmental Regulation (ER): The intensity of environmental regulation is measured using the proportion of investment completed in industrial governance to the added value of the secondary industry, represented as ER.

（4）Control Variables: Degree of Openness (OPEN): The proportion of the value of goods imports and exports to GDP is selected as the measure for the degree of openness; Human Capital Level (HR): The proportion of the number of individuals with a bachelor's degree or higher in the employed population in the manufacturing sector is chosen as the measure for the level of human capital; Marketization Indicator (EMI): EMI is a linearly weighted composite indicator encompassing six aspects: the relationship between government and the market, the development of non-state-owned economy, the maturity of product markets, the maturity of factor markets, the development of market intermediaries, and the legal institutional environment; Foreign Direct Investment (FDI): The proportion of foreign direct investment to GDP is selected as the measure for the level of foreign direct investment; Degree of Government Intervention (GI): The proportion of fiscal expenditure to GDP is chosen as the measure for the degree of government intervention.

This paper investigates the intersection of digital finance and the High-quality development of the manufacturing industry. Given that the Digital Finance Indicator calculated by Beijing University commences from the year 2012, this study adopts 2012 as the base year and selects the period from 2012 to 2021 as the research timeframe. Due to substantial data gaps in the regions of Hong Kong, Macao, Taiwan, and the Tibet Autonomous Region, the research focuses exclusively on the mainland of China, encompassing 30 provinces, as the sample for analysis. Regional data for each year, excluding the mentioned regions, are sourced from publications such as the "China Statistical Yearbook," the "China Energy Statistical Yearbook," and the "China Environmental Statistical Yearbook."

2.3 Research Model Construction

The main content of this paper is divided into two parts: pairwise examination of variables and testing of mediating effects. Following the research paradigm of "digitalization of finance - causal pathways - realized outcomes," this study employs individual and time fixed-effects models for analytical testing. Building upon the theoretical analysis presented earlier, the paper formulates a research model to systematically validate the research hypotheses.

Model 1: Incorporating Digital Finance (DIF) as an explanatory variable and the High-quality development Indicator of the Manufacturing Industry (LCQD) as the dependent variable, with $OPEN_{it}$, HR_{it}, EMI_{it}, FDI_{it}, GI_{it} serve as control variables, representing the degree of openness, human capital level, marketization indicator, foreign direct investment, and government intervention degree, respectively.

$$LCQD_{it} = \alpha_0 + \alpha_1 DIF_{it} + \alpha_2 OPEN_{it} + \alpha_3 HR_{it} + \alpha_4 EMI_{it} + \alpha_5 FDI_{it} + \alpha_6 GI_{it} + \varepsilon_{it} \tag{7}$$

To examine the impact of digitalization of finance on industrial upgrading, digital finance (DIF) is employed as the explanatory variable, while the Industrial Structure Upgrade Indicator (ISU) serves as the dependent variable. Control variables are introduced, and Model 2 is formulated as follows:

$$ISU_{it} = \alpha_0 + \alpha_1 DIF_{it} + \alpha_2 OPEN_{it} + \alpha_3 HR_{it} + \alpha_4 EMI_{it} + \alpha_5 FDI_{it} + \alpha_6 GI_{it} + \varepsilon_{it} \tag{8}$$

To examine the influence of digitalization of finance on resource allocation, digital finance (DIF) is designated as the explanatory variable, with resource allocation (FE) as the dependent variable. Control variables are incorporated, and Model 3 is constructed as follows:

$$FE_{it} = \alpha_0 + \alpha_1 DIF_{it} + \alpha_2 OPEN_{it} + \alpha_3 HR_{it} + \alpha_4 EMI_{it} + \alpha_5 FDI_{it} + \alpha_6 GI_{it} + \varepsilon_{it} \tag{9}$$

To examine the impact of digitalization of finance on resource allocation, digital finance (DIF) is employed as the explanatory variable, while environmental regulation (ER) serves as the dependent variable. Control variables are introduced, and Model 4 is formulated as follows:

$$ER_{it} = \alpha_0 + \alpha_1 DIF_{it} + \alpha_2 OPEN_{it} + \alpha_3 HR_{it} + \alpha_4 EMI_{it} + \alpha_5 FDI_{it} + \alpha_6 GI_{it} + \varepsilon_{it} \tag{10}$$

Lastly, to account for the mediating roles of industrial upgrading, resource allocation, and environmental regulation in the process through which digitalization of finance facilitates the High-quality development of the manufacturing industry, Model 5 is constructed:

$$\begin{aligned} LCQD_{it} = {} & \alpha_0 + \alpha_1 DIF_{it} + \alpha_2 ISU_{it} + \alpha_3 FE_{it} + \alpha_4 ER_{it} + \alpha_5 OPEN_{it} + \\ & \alpha_6 HR_{it} + \alpha_7 EMI_{it} + \alpha_8 FDI_{it} + \alpha_9 GI_{it} + \varepsilon_{it} \end{aligned} \tag{11}$$

3. Results and Discussion

3.1 Calculation Results of the High-quality development Level

According to the "Entropy Weight Method," the values of the High-quality development indicator of the manufacturing industry for 30 provinces (excluding Tibet) from 2012 to 2021 were calculated. The comprehensive calculation results of the provincial-level high-quality sustainable development of the manufacturing industry are presented in Table 2. From the perspective of the mean values of the High-quality development of the manufacturing industry across provinces from 2012 to 2021, Guangdong, Jiangsu, Zhejiang, Shanghai, and Shandong rank in the top five, while the bottom five provinces are Xinjiang, Ningxia, Shanxi, Gansu, and Qinghai. Spatially, the level of high-quality sustainable development in the manufacturing industry exhibits a regional characteristic of "high in the east and low in the west." Provinces in the eastern regions, such as Guangdong, Jiangsu, and Zhejiang, top the indicator rankings, while western regions like Ningxia, Gansu, and Qinghai have comparatively lower dynamic total indices. Guangdong province holds the first position in the ranking of the High-quality development indicator of the manufacturing industry, with a value of 0.969 in 2021 and a mean value of 0.730 from 2012 to 2021. In contrast, Qinghai province ranks 30th, with a value of 0.236 in 2021 and a mean value of 0.184 from 2012 to 2021. The eastern regions encompass the top seven positions in the High-quality development indicator of the manufacturing industry. Beyond national strategies and geographical considerations, this phenomenon is more closely associated with factors such as innovation drivers, quality and efficiency levels, green development, structural optimization efforts, and human capital intensity. New growth dynamics propel provinces in the eastern regions to lead the development of the manufacturing industry nationwide. Over the temporal dimension, the overall trend of the High-quality development level of the manufacturing industry at the provincial level shows an increasing pattern, with the eastern regions exhibiting the most noticeable upward trend. Surprisingly, although the western regions are still in the category of "followers," during 2018–2019, they demonstrated strong development momentum, with a growth rate significantly higher than that of the economically stronger eastern and central regions. The annual average growth rate of the manufacturing industry development indicator in the western regions is 6.26%, which is 1.14, 1.31, and 1.27 percentage points higher than that of the eastern, central, and northeastern regions, respectively.

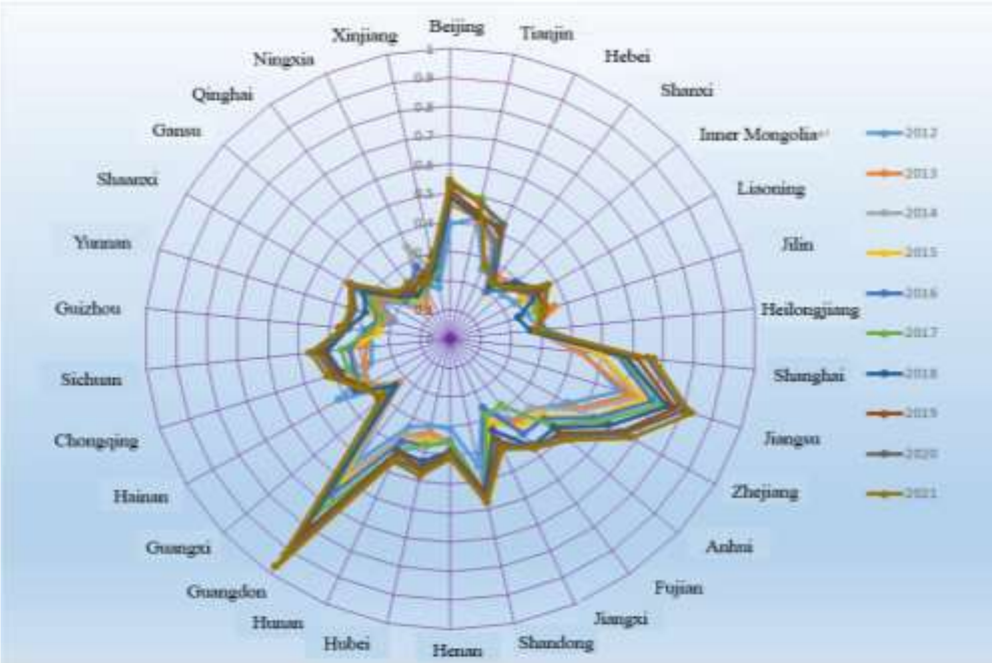
Table 2 High-quality development Indicator of the Manufacturing Industry

Province	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Mean value	Rank
Beijing	0.398	0.465	0.481	0.477	0.484	0.522	0.488	0.508	0.533	0.545	0.490	6
Tianjin	0.425	0.423	0.441	0.436	0.442	0.492	0.428	0.445	0.476	0.479	0.449	7
Hebei	0.259	0.342	0.353	0.373	0.363	0.398	0.421	0.402	0.429	0.277	0.362	13
Shanxi	0.249	0.262	0.233	0.194	0.199	0.236	0.227	0.243	0.239	0.236	0.232	28
Inner Mongolia	0.227	0.292	0.299	0.287	0.26	0.26	0.288	0.255	0.259	0.259	0.269	23
Liaoning	0.247	0.268	0.29	0.277	0.305	0.332	0.339	0.332	0.356	0.369	0.312	19
Jilin	0.267	0.36	0.315	0.294	0.302	0.299	0.234	0.319	0.328	0.321	0.304	20
Heilongjiang	0.296	0.268	0.265	0.3	0.309	0.295	0.265	0.282	0.289	0.289	0.286	22
Shanghai	0.434	0.424	0.486	0.493	0.548	0.56	0.577	0.614	0.648	0.67	0.545	4
Jiangsu	0.582	0.621	0.646	0.667	0.695	0.733	0.749	0.773	0.803	0.83	0.710	2
Zhejiang	0.444	0.477	0.496	0.539	0.545	0.565	0.596	0.643	0.653	0.68	0.564	3
Anhui	0.356	0.359	0.354	0.394	0.411	0.44	0.456	0.481	0.499	0.519	0.427	8
Fujian	0.349	0.356	0.38	0.377	0.406	0.283	0.456	0.468	0.451	0.463	0.399	10
Jiangxi	0.262	0.319	0.305	0.309	0.26	0.289	0.345	0.383	0.401	0.417	0.329	18
Shandong	0.449	0.542	0.529	0.54	0.55	0.557	0.542	0.556	0.567	0.577	0.541	5
Henan	0.31	0.354	0.353	0.354	0.352	0.359	0.388	0.395	0.402	0.411	0.368	12
Hubei	0.307	0.328	0.345	0.358	0.377	0.373	0.431	0.453	0.463	0.482	0.392	11
Hunan	0.332	0.364	0.367	0.383	0.386	0.422	0.423	0.43	0.449	0.462	0.402	9
Guangdong	0.527	0.578	0.571	0.623	0.67	0.74	0.835	0.867	0.919	0.969	0.730	1
Guangxi	0.229	0.225	0.238	0.278	0.256	0.237	0.241	0.312	0.289	0.297	0.260	25
Hainan	0.422	0.318	0.358	0.342	0.33	0.325	0.357	0.328	0.346	0.339	0.347	16
Chongqing	0.272	0.297	0.318	0.338	0.334	0.352	0.375	0.391	0.405	0.421	0.350	15
Sichuan	0.258	0.278	0.329	0.326	0.331	0.358	0.407	0.423	0.438	0.461	0.361	14
Guizhou	0.262	0.269	0.286	0.233	0.274	0.258	0.336	0.362	0.345	0.356	0.298	21
Yunnan	0.193	0.213	0.23	0.261	0.247	0.238	0.292	0.338	0.328	0.345	0.269	24
Shanxi	0.264	0.293	0.378	0.343	0.351	0.321	0.326	0.375	0.371	0.38	0.340	17
Gansu	0.174	0.186	0.178	0.192	0.194	0.209	0.219	0.228	0.233	0.24	0.205	29
Qinghai	0.128	0.118	0.16	0.174	0.225	0.182	0.184	0.208	0.224	0.236	0.184	30

Province	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Mean value	Rank
Ningxia	0.197	0.246	0.345	0.229	0.27	0.188	0.209	0.228	0.213	0.209	0.233	27
Xinjiang	0.179	0.214	0.221	0.218	0.213	0.231	0.25	0.286	0.275	0.286	0.237	26

To depict the calculated results of the High-quality development indicator of the manufacturing industry for the 30 provinces, municipalities, and autonomous regions in China, a radar chart is employed within a Cartesian coordinate system. The radar chart provides a visual representation of the High-quality development status of the manufacturing industry across the aforementioned regions. Detailed results can be found in Figure 2.

Figure 2 High-quality development Levels of the Manufacturing Industry in Various Regions



3.2 Empirical Test Results

3.2.1 Foundational Test Results

(1) Descriptive statistical results. Effectively capturing the comprehensive characteristics of the research variables, a central description of variable features and their trends is primarily achieved through descriptive statistical analysis. This chapter's descriptive statistical analysis focuses on computing four key indicators to explore some fundamental aspects of the sample data. The significance of descriptive statistical analysis lies in its ability to lay the groundwork for subsequent in-depth analysis. The descriptive statistical results are presented in Table 3.

Table 3 Descriptive Statistical Analysis

Variable	Obs	Mean	SD	Min	Median	Max
DFI	300	2.397	0.038	1.789	2.407	2.662
LCQD	300	0.373	0.056	0.118	0.512	0.969
ISU	300	2.406	0.120	2.132	2.393	2.834
FE	300	0.792	0.152	0.312	0.782	1.160
ER	300	0.003	0.003	0.001	0.002	0.025
OPEN	300	0.254	0.275	0.008	0.140	1.441
HR	300	0.020	0.006	0.009	0.020	0.042

EMI	300	0.479	0.023	0.198	0.598	0.981
FDI	300	0.018	0.015	0.001	0.016	0.080
GI	300	0.280	0.192	0.107	0.229	1.333

In the table, the mean of the explanatory variable, Digital Finance Indicator (DFI), is 2.397, with a maximum of 2.662 and a minimum of 1.789, indicating variations. For the dependent variable, the maximum value of the High-quality development Level Indicator of the manufacturing industry (LCQD) is 0.969, and the minimum is 0.118, showing a significant disparity. This suggests substantial differences in the manufacturing industry development levels among the 30 provinces and municipalities in China from 2012 to 2021. Further examination of specific numerical values reveals a continuous increase in the High-quality development Indicator of the manufacturing industry with the growth of the years. The mediating variable, Industrial Development Indicator (ISU), exhibits an overall high numerical value, with a relatively small difference between the maximum and minimum values. For resource allocation (FE) and environmental regulation (ER), numerical differences remain.

(2) Correlation Test Results. The primary objective of conducting a correlation analysis on variables is to ensure the smooth progression of regression analysis. This analysis serves as a preliminary statistical method to assess the interdependence between variables. In this section, using STATA as the statistical analysis tool, a Pearson correlation test was performed on all variable data of the sample enterprises to validate the degree and direction of interdependence among variables. Based on this, a preliminary analysis of the results was conducted. The Pearson correlation coefficient matrix is presented in Table 4.

Table 4 Results of Variable Correlation Analysis

Variable	LCQD	DIF	ISU	FE	ER	OPEN	HR	EMI	FDI	GI
LCQD	1									
DIF	0.636	1								
	0.000									
ISU	0.219	0.165	1							
	0.000	0.000								
FE	0.198	0.092	0.004	1						
	0.000	0.000	0.231							
ER	0.121	0.101	0.201	0.198	1					
	0.000	0.000	0.187	0.291						
OPEN	0.143	0.008	0.013	0.232	0.416	1				
	0.000	0.002	0.078	0.000	0.000					
HR	0.089	0.221	0.231	0.323	0.087	0.192	1			
	0.000	0.000	0.003	0.000	0.006	0.032				
EMI	0.066	0.132	0.281	0.012	0.102	0.186	0.141	1		
	0.000	0.000	0.721	0.000	0.728	0.000	0.003			
FDI	0.189	0.651	0.451	0.293	0.671	0.006	0.271	0.213	1	
	0.000	0.017	0.711	0.002	0.198	0.000	0.000	0.837		
GI	0.008	0.219	0.087	0.822	0.195	0.006	0.393	0.275	0.192	1
	0.001	0.789	0.198	0.781	0.000	0.918	0.000	0.000	0.819	

The results of the tests in Table 4 clearly indicate the following: the Pearson correlation coefficient between the Digital Finance Indicator (DIF) and the High-quality development of the Manufacturing Industry (LCQD) is 0.636***, suggesting a positive impact of the extent of financial digitization on the High-quality development of the manufacturing industry. This preliminary validation supports Hypothesis H1. The Pearson correlation coefficients of 0.165***, 0.092***, and 0.101*** represent the correlations between Industrial Upgrading, Resource Allocation, Environmental Regulation, and the Digital Finance Indicator. These coefficients have passed the 1% significance test, indicating a positive correlation between the values of industrial upgrading, resource allocation, environmental regulation, and the Digital Finance Indicator. Similarly, the Pearson correlation coefficients of 0.219***, 0.198***, and 0.121*** represent the correlations between Industrial Upgrading, Resource Allocation, Environmental Regulation, and the High-quality development of the Manufacturing Industry. These coefficients also passed the 1% significance test, indicating a positive correlation between industrial upgrading, resource allocation, environmental regulation, and the High-quality development of the manufacturing industry. Combining results from (2) and (3), a preliminary judgment can be made that Hypotheses H2a, H2b, and H2c are supported. Regarding the relationships with control variables, the High-quality development Indicator of the manufacturing industry exhibits positive correlations with the levels of openness, human capital, marketization indicator, foreign direct investment, and government intervention. The corresponding Pearson correlation coefficients pass the 1% significance level test, suggesting that higher levels of openness, a higher proportion of individuals with a bachelor's degree or higher in the manufacturing industry employment, a higher marketization indicator, greater foreign direct investment, and a higher proportion of fiscal expenditure to GDP are associated with a better High-quality sustainable development Indicator of the manufacturing industry.

(3) Hausman Test Results. Establishing regression models through panel data to validate the research hypotheses in this study requires the use of the Hausman statistic to assess the effects present in the research model. Ultimately, this test determines whether to employ a fixed-effects model or a random-effects model. A precise and effective econometric model enhances the reliability of the study results. The Hausman test was conducted using Eviews 6.0 statistical analysis software, and the results are presented in the table. The p-values of the Hausman test statistics are all <0.05, passing the significance test. Therefore, the rejection of the random-effects model is justified, and a fixed-effects model is adopted to validate the hypotheses in this study. The specific test results are outlined in Table 5.

Table 5 Results of Hausman Test

Name	X^2	P
Verification model 1	47.556	0.000
Verification model 2	35.481	0.000
Verification model 3	55.918	0.000
Verification model 4	23.091	0.000
Verification model 5	53.012	0.000

(4) Variance Inflation Factor (VIF) Test Results. To further examine multicollinearity and assess the variance inflation factors of each variable, a statistical testing method was employed, statistical testing methods were used to empirically test the variance Inflation Factor of variables. The results of the variable VIF test are presented in Table 6.

Table 6 Results of Variable Inflation Factor Test

Variable	VIF	1/VIF
DIF	1.43	0.699
LCQD	1.28	0.781
ISU	1.79	0.559
FE	2.35	0.426
ER	1.05	0.952
OPEN	1.66	0.602
HR	1.22	0.820

Variable	VIF	1/VIF
EMI	1.28	0.781
FDI	1.43	0.699
GI	2.98	0.336
Mean VIF	1.674	

From the data in the table, it is evident that the variance inflation factors for each variable are significantly below 10. Therefore, there is no need to be concerned about multicollinearity issues, and subsequent mediation effect analysis can be conducted.

3.2.2 Mediation Effect Test Results and Analysis

In this paper, a mediation effect model is constructed to empirically test the proposed hypotheses. The specific results of the mediation effect test are shown in Table 7.

Table 7 Intermediary effect results

Variable	LCQD	ISU	FE	ER	LCQD
DFI	0.085***(3.994)	0.053***(3.829)	0.042***(3.847)	0.049***(3.964)	0.009***(4.017)
ISU					0.067***(4.012)
FE					0.027***(3.899)
ER					0.023***(4.298)
OPEN	0.506***(4.209)	0.601***(6.289)	0.429***(5.921)	0.298***(4.890)	0.128***(3.956)
EMI	1.193***(6.745)	1.932***(10.876)	0.963***(12.276)	3.193***(4.285)	3.028***(3.098)
HR	5.023***(4.012)	9.092***(6.912)	0.123***(6.033)	3.012***(5.024)	1.019***(3.120)
FDI	0.290**(2.776)	0.003*(1.879)	0.129**(2.456)	0.198*(2.091)	0.002*(1.987)
GI	0.009*(1.789)	0.123**(2.897)	0.230*(2.173)	1.209**(2.382)	0.005**(2.097)
c	-0.493**(2.374)	7.120*(2.193)	11.023**(2.938)	8.012*(1.678)	1.981(0.355)
A-R2	0.864	0.908	0.871	0.723	0.837
Individual fixation	be	be	be	be	be
fixed time	be	be	be	be	be

Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. T-values are provided in parentheses.

Firstly, Model 1 represents the impact of digital finance on the High-quality development of the manufacturing industry. The coefficient of the effect of digital finance on the High-quality development of the manufacturing industry in Model 1 is significantly positive, with a coefficient of 0.032 (T-value of 3.994). This implies that the extent of financial digitization has a positive impact on the High-quality development of the manufacturing industry, confirming the validity of Hypothesis H1.

Secondly, combining Models 2 and 5 reveals that the coefficient of the effect of digital finance on industrial upgrading in Model 2 is significantly positive, indicating a positive impact of digital finance on domestic industrial upgrading. The regression coefficient of industrial upgrading on the High-quality development of the manufacturing industry in Model 5 is also significantly positive, indicating that the extent of financial digitization can indirectly promote the improvement of the High-quality development level of the manufacturing industry through its positive impact on industrial upgrading. This validates Hypothesis H2a. Specifically, holding other factors constant, for each unit increase in the level of digital finance, the High-quality development level of the manufacturing industry will directly increase by 0.009 units. Simultaneously, it will also raise the level of domestic industrial upgrading by 0.053 units, leading to an indirect increase of 0.004 units

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(0.053 × 0.067 = 0.004) in the High-quality development level of the manufacturing industry. The total effect is the sum of the direct and indirect effects, amounting to 0.013. It is noteworthy that the indirect effect constitutes 30.77% of the total effect, with a ratio of 2:1 between the direct and indirect effects.

Thirdly, combining Models 3 and 5 shows that the extent of financial digitization significantly promotes the High-quality development level of the manufacturing industry, and resource allocation also has a positive effect on the High-quality development of the manufacturing industry. Specifically, while controlling for other factors, the coefficient of the impact of digital finance on resource allocation is 0.042, and the impact coefficient of resource allocation on the High-quality development level of the manufacturing industry is 0.027. This indicates that the extent of financial digitization, through the positive mediating effect of improving resource allocation efficiency, promotes the High-quality development level of the manufacturing industry, confirming the validity of Hypothesis H2b. In concrete terms, the indirect effect of digital finance in promoting the High-quality development of the manufacturing industry through improving resource allocation efficiency is 0.001, accounting for 14.3% of the total effect.

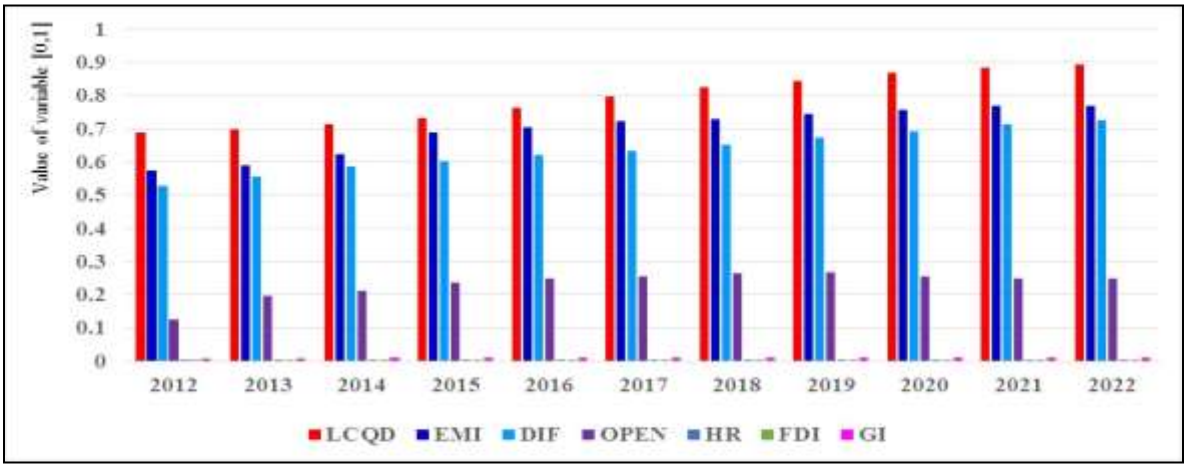
Fourthly, combining Models 4 and 5 reveal that the impact coefficient of digital finance on environmental regulation is 0.049 and significant, while the impact coefficient of environmental regulation on the High-quality development level of the manufacturing industry is 0.023 and significant. This suggests that the extent of financial digitization can indirectly drive the High-quality development level of the manufacturing industry through environmental regulation, validating Hypothesis H2c. Specifically, the indirect effect is 0.001, constituting 25% of the total effect, and the ratio of the indirect effect to the direct effect is 1:3.

In summary, the extent of financial digitization can indirectly drive the High-quality development of the manufacturing industry by accelerating industrial upgrading, improving resource allocation efficiency, and enhancing environmental regulation. A comparison reveals that the direct effect of digital finance on the High-quality development of the manufacturing industry is greater than the indirect effect. However, the indirect spillover mechanism of digital finance in the process of high-quality sustainable development in the manufacturing industry should not be ignored.

3.3 Discussion of Test Results

This study employs a multiple mediation effects model, utilizing data from 2012 to 2021. The Industrial Structure Upgrade Indicator (ISU), Resource Allocation Efficiency (FE), and Environmental Regulation Intensity (ER) are selected as intermediary variables for the Digital Finance's impact on the Indicator of High-quality sustainable development in China's manufacturing industry. Using the entropy weight method to measure the Indicator of High-quality sustainable development in the manufacturing industry across various provinces in China (LCQD), a correlation test is conducted involving Digital Finance Indicator (DIF), Industrial Upgrade (ISU), Resource Allocation (FE), Environmental Regulation (ER), and High-quality sustainable development in Manufacturing (LCQD). In order to discuss the impact of explanatory variables and control variables on LCQD, as the dependent and independent variables fall within the interval [0, 1], a histogram is employed to illustrate the relationship between the dependent variable and the independent variables in the same Cartesian coordinate system, as depicted in Figure 3.

Figure 3 Histogram of the Relationship between Dependent and Independent Variables



From the above figure, it is evident that the dependent variable LCQD exhibits a rapid growth trend from 2012 to 2022 under the combined influence of the independent variables EMI, DFI, OPEN, HR, FDI, and GI. The values of the explanatory variable DFI, as well as the control variables EMI and OPEN, are relatively large, with minimal difference compared to the values of the dependent variable. On the other hand, the values of the control variables HR, FDI, and GI are relatively small. Almost all indicators show an upward trend.

4. Conclusion and Recommendations

4.1 Fundamental Research Conclusions

This study, through the systematic examination of the mechanistic role of digital finance in facilitating the High-quality development of the manufacturing industry, posits four hypotheses. Grounded in provincial panel data spanning the years 2012 to 2021, the research employs the entropy method to assess the indicator of high-quality sustainable development in the manufacturing sector. It constructs a multi-intermediary effect model encompassing industrial upgrading, resource allocation, and environmental regulation to comprehensively analyze the impact of digital finance on the High-quality development of the manufacturing industry. The principal findings are outlined as follows:

(1) The development of digital finance can enhance the level of high-quality sustainable development in the manufacturing industry through industrial upgrading. The industrial upgrading effect is one of the intermediary effects through which the development of digital finance influences the High-quality development of the manufacturing industry. With the progress of urban digitalization of finance, resource allocation is optimized, and the increased sources of corporate funding provide financial support for technological research and development. Simultaneously, incentivized by rising household income, there is an increased demand for low-carbon products. The allocation of funds and social resources tends to favor low-pollution enterprises and green innovation projects, thereby stimulating the development of green manufacturing enterprises from the demand side.

(2) The development of digital finance can improve the level of high-quality sustainable development in the manufacturing industry through resource allocation. Digitalization of finance enhances the efficiency of financial resource allocation, significantly improving the accessibility of financial services and credit support for different groups. This, in turn, increases individual consumption expenditures and augments productive investment expenditures by small and

medium-sized enterprises, contributing to the improvement of economic behaviors among low-income populations and small and micro-enterprises. The precision of digital finance can balance the efficiency and fairness of economic activities. It can alleviate corporate financing constraints and restrain the shift of real entities towards virtual entities. Green enterprises also gain increased financial resource support through digitalization of finance, promoting high-quality sustainable development in the manufacturing industry.

(3) The development of digital finance can elevate the level of high-quality sustainable development in the manufacturing industry through environmental regulation. Environmental regulation, employing mechanisms of resource reallocation and market competition to drive industry restructuring, particularly accelerates the transformation or market exit of polluting industries, enhancing the concentration of the pollution industry. Moreover, by raising the green threshold of existing industries, it encourages enterprises to shift towards clean production or low-carbon industries, fostering the development of the green environmental protection industry.

4.2 Key Policy Recommendations

In light of the research findings presented above and considering the current status of high-quality sustainable development in the manufacturing industry in China's regional context, this paper puts forth the following policy recommendations:

(1) Promoting the decarbonization of digital finance investment. The development of digital finance, through industrial upgrading, provides a pathway to reduce carbon emissions by decreasing energy consumption. To achieve the goal of "peak carbon," it is imperative to optimize financial investments and expedite the substitution of clean energy for traditional energy sources in both production and consumption processes. Accordingly, local governments can incentivize financial institutions to increase their financial allocation to low-carbon industries through subsidies or government guarantees. For instance, the introduction of credit products supportive of "peak carbon" initiatives can be facilitated, offering specialized assistance to emerging enterprises and small and micro-enterprises within the manufacturing sector. This not only encourages manufacturing enterprises to adopt low-carbon energy, actively engage in research and development of low-carbon technologies but also sends a positive market signal, attracting clean energy and low-carbon manufacturing enterprises, eliminating outdated production capacity, and fostering a virtuous drive towards optimizing and upgrading industrial structures.

(2) The current stage calls for a moderate increase in the intensity of environmental regulations by the government. On one hand, the system of environmental protection, regulation, and accountability needs further refinement, especially in intensifying supervision following the formulation of environmental policies. This ensures the effective implementation of policies, providing legal support for achieving environmental protection goals and facilitating green development in industries. On the other hand, simultaneous strengthening of environmental regulations should be accompanied by the development of differentiated environmental regulatory tools based on industry characteristics and policy effectiveness. For instance, rewarding green environmental enterprises in the manufacturing industry is more likely to drive their engagement in green innovation activities, while the mandatory implementation of policies on heavily polluting enterprises in the manufacturing industry is expected to yield relatively better results.

(3) Coordinate various aspects of high-quality sustainable development in the manufacturing industry and narrow the development gap between regions. Leverage the exemplary role of regions with relatively better high-quality sustainable development in manufacturing, emphasizing the establishment of a scientific management system and institutional framework to enhance the

coordination of high-quality sustainable development in the manufacturing industry across the country. Simultaneously, further develop interregional connectivity systems, delineate and clarify mechanisms for regional collaborative cooperation, fully harness their spillover effects, optimize the allocation of factor resources, and mitigate development disparities arising from uneven distribution of resources among provinces.

(4) To enhance the central region's radiative effects on surrounding areas and reduce the "siphoning" effect, it is recommended to refine top-level institutional designs. Encourage provinces with well-developed digitalization of finance to provide support, particularly in terms of financial and production factors, to entrepreneurial enterprises in less developed surrounding regions through targeted policies. Strengthen economic and financial cooperation across regions to optimize the spatial distribution of financial resources, channeling more financial resources to underdeveloped economic regions, optimizing the allocation of financial resources in these areas, and leveraging the regional radiation effects of digital finance businesses to promote the coordinated and low-carbon high-quality sustainable development of the manufacturing industry.

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