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Does Digital Finance Promote Business Performance of Manufacturing?

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Abstract. Manufacturing is the lifeblood of China's economy, and digital finance (DF), with its broad applicability, significantly aids in improving the business performance of manufacturing industry (BPMI). Utilizing panel data from China's 30 provinces over the decade from 2011 to 2021, this paper employs a fixed-effect model to analyze the influence of DF on the BPMI. Additionally, it introduces a mediation model and a threshold model to uncover the underlying mechanisms through which DF impacts the BPMI. This paper uncovers that DF significantly bolsters the business performance of the manufacturing industry, primarily by fostering innovation. Moreover, it reveals that industrialization's level exerts a non-linear threshold impact on the capacity of DF to enhance BMPI. These insights are instrumental for proactively shaping a novel framework for the convergence of digital finance and the manufacturing industry, thereby contributing to the enhancement of BMPI.

Keywords: Digital Finance; Manufacturing; Business Performance; Innovation; Industrialization.

1. Introduction

Long established as a key sector, China's manufacturing industry serves as the nation's cornerstone and a critical element in achieving national strength. The report from the 20th National Congress of the Communist Party of China outlined a strategic plan to prioritize the real economy within economic development strategies and to expedite the process of building a robust manufacturing powerhouse. With its manufacturing value constituting roughly 30% of the global total, China has secured the top position worldwide for an uninterrupted 14-year period, affirming its status as the leading manufacturing nation globally. The vigorous development of the manufacturing industry highlights the continuous improvement of China's comprehensive national power and core competitiveness, but at the same time, its survival and development still face many risks and challenges. China's manufacturing industry started late, the infrastructure is not perfect, and there is a lack of sufficient relevant technology and professional talents. This has led to many technical difficulties that are difficult to overcome, especially some high-precision, high-tech content of the core technology, often for a long time in a state of strict blockade by developed countries. Furthermore, the shortage of innovation capabilities within domestic manufacturing firms and research entities also impedes the overall transition of the manufacturing sector towards higher-value and more efficient operations. To develop on their own, they must rely on external financing to address their capital needs. Although in recent years, the financial sector continues to launch relevant policies and initiatives, but China's manufacturing enterprises "financing difficulties", "financing expensive" phenomenon has not been fundamentally resolved. Therefore, it is more and more urgent to solve the problem of time-consuming and high cost of enterprise financing, alleviate the financing constraints and improve the level of business performance of the manufacturing industry. This is the inherent requirements of the implementation of high-quality development strategy, but also the inevitable choice of building a modernised economic system.

Traditional finance faces issues like high costs and inefficiency, making it difficult to provide comprehensive, efficient services for capital supply and demand. However, the recent surge in digital technologies is driving the financial sector towards digitalization. The 2023 Central Financial Work Conference highlighted the importance of focusing on five key financial areas: science and technology finance, green finance, inclusive finance, pension finance, and digital finance. Digital

finance(DF), as a frontier area of financial innovation, uses the latest scientific and technological achievements to work together in financial services, enabling financial institutions to identify and meet customer needs with unprecedented precision and efficiency, greatly enhancing the coverage and relevance of financial services. This not only reduces the financing threshold, allowing the demand side of funds to obtain the required financial support at a lower cost; it also promotes the competitiveness of the supply side of funds, allowing them to evaluate investment projects and loan applications more flexibly, thus increasing returns while reducing investment and lending risks. Therefore, the emergence of digital finance has to a certain extent alleviated the problems existing in the traditional financial system and brought new opportunities for the modernisation of China's manufacturing industry(MI).

The advancement of DF has provided a strategic direction for the MI to overcome financing challenges and escape developmental dilemmas. The People's Bank of China's Financial Technology Development Plan (2022-2025) emphasizes that achieving strategic initiatives like innovation, the digital economy, rural revitalization, and carbon neutrality requires robust support from fintech. This plan underscores that the primary goal of industrial DF is to support major national strategies. The Guiding Opinions on Digital Transformation of the Banking and Insurance Industry issued by the former China Banking and Insurance Regulatory Commission (CBIRC) further pointed out that the banking and insurance industries should actively develop industrial digital finance, support the construction of advanced manufacturing industries and new infrastructures, etc., create a digital industrial financial service platform, as well as push forward the onlineization of business for corporate clients, and strengthen the construction of open banking interfaces and unified digital portals, etc. Thus, harnessing the benefits of DF to positively influence the business performance of MI is a subject that merits in-depth exploration. With this in mind, this paper examines the impact and mechanisms of DF on enhancing the BPMI. It specifically investigates the mediating role of innovation level on the relationship between iDF and BPMI, as well as the threshold effect of regional industrialization levels on this relationship.

Reviewing current research, the emphasis has been on how DF affects MI in areas such as total factor productivity, sustainability, and innovation levels. However, there is a lack of clarity on its direct effect on enhancing the businessl performance of MI and the underlying mechanisms at play. This paper introduces novelty in three key areas:(1)Systematic Examination: It conducts a systematic analysis of the impact of DF on the BPMI within a consistent theoretical framework, enhancing the quantitative research in this area through empirical testing.(2)Innovation as a Mediator: The paper posits innovation level as a critical intermediary mechanism through which DF influences the BPMI. It provides both theoretical and empirical interpretations and tests this relationship, offering a comparative analysis of the interaction's heterogeneity across different regional sub-dimensions (East, Central, and West) and aspects of DF. (3)Industrialization as a Threshold: This paper integrates the degree of industrialization into the analytical framework to explore the non-linear effects of DF on BPMI under varying levels of industrialization. This approach aims to offer insights to aid in the enhancement of BPMI, considering the role of industrialization within the "digital finance - manufacturing business performance" framework.

2. Theoretical Analysis and Research Hypotheses

2.1. Digital Finance and Business Performance of the Manufacturing Industry

Finance, as the nucleus of the modern economy, plays an indispensable role in directing capital flows and underpinning the manufacturing industry's growth. According to Guo & Sheng (2021), precise financial resource allocation and efficient financial services are instrumental in fostering high-quality development across various facets of the manufacturing sector, including research and development, procurement, production, and sales[1].The loss of credit funding for the manufacturing industry would have a significant adverse impact on the development of the manufacturing industry. However, if more funds are allocated to the manufacturing sector, especially development bank financing, it

can provide strong support for the transformation and upgrading of the manufacturing sector (Itaman & Oluwafemi, 2021), which will in turn contribute to the maximisation of the value of the manufacturing sector[2]. In recent years, the state has been promoting the upgrading of the manufacturing industry through the support of fiscal, tax and credit policies, and the scale of financing from commercial banks to the manufacturing industry has basically remained stable, meanwhile, financial institutions have been innovating the means of financing for the manufacturing industry (Xu, 2021)[3]. However, the research of Zhao et al. (2023) found that at present, there is a mismatch between the supply innovation and demand of financial services, and the short-term and long-term nature of financial service supply, and the resource allocation capacity of the financial market needs to be improved urgently to better serve the development of the manufacturing industry[4].

In the digital era, the development of DF based on big data and artificial intelligence can effectively make up for the shortcomings of traditional finance and bring new vitality to the manufacturing industry. Digital finance can make use of advanced financial technology to assess the development ability of enterprises, on the basis of which it can rank the qualifications of enterprises and guide the flow of innovative resources and capital resources to the advanced MI. Enhancing the quality of participants in the financial sector and the efficiency of financial resource allocation, DF is poised to cultivate a more conducive financial ecosystem. This development is anticipated to refine the corporate financing environment, exerting a substantial impact on the business performance of listed companies, notably those in the manufacturing sector (Cai et al., 2021)[5]. The benefits of this facilitation, however, are not uniformly distributed across regions. Hu et al. (2022) contend that the positive influence of DF on the real economy's development is particularly pronounced in underdeveloped areas[6]. Furthermore, Li's (2023) research emphasizes that the advent of DF presents manufacturing enterprises with the opportunity to expedite their digital transformation journey. It is crucial for these enterprises to understand how to leverage the support of DF to elevate their operational efficiency[6].Accordingly, hypothesis 1 is proposed as follows:

Hypothesis 1. Digital finance has a facilitating effect on the improvement of business performance in the manufacturing industry.

2.2. The intermediary Role of Technological Innovation

DF bolsters manufacturing innovation, as noted by Zhang Zhengping and Wang Long (2021)[7], by enhancing corporate operational efficiency through innovation. It also mitigates various mismatch issues in traditional finance, including attribute, domain, and stage discrepancies. DF corrects the "mismatch" phenomenon in traditional finance, such as "attribute mismatch", "field mismatch" and "stage mismatch", so that it can provide more targeted support for the enterprise's scientific and technological innovation activities, and has a "structural" driving effect on the enterprise's technological innovation (Tang et al., 2020)[8]. Moreover, DF can significantly improve the quantity and quality of innovation in the manufacturing industry through the positive cost-saving effect, human capital matching effect, technology spillover effect and negative industry competition effect (Zhu, 2024)[9]. By integrating and analysing a large amount of data, digital financial platforms can provide enterprises with more comprehensive and accurate information in terms of market demand, competitors and technological changes, which is conducive to the implementation of innovation strategies, product planning and clear market positioning. Therefore, in the process of innovation, enterprises can better understand the market demand through digital finance, anticipate market changes, and point out the direction for high-quality innovation (Wang et al., 2024)[10].

Kafetzopoulos et al. (2015)[11] explored the influence of innovation on Greek manufacturing firms, finding that innovation directly enhances product quality and operational performance, with indirect effects on financial performance. Younas et al. (2021)[12], in their examination of the Pakistani manufacturing sector, also determined that technological innovation positively influences firm performance. Chen & Zhang (2021)[13] suggest that the surge in digital finance bolsters the innovation capacity of the manufacturing industry, thereby facilitating its advancement. From these insights, hypothesis 2 is formulated as follows:

Hypothesis 2. Digital finance can elevate the business performance of the manufacturing industry through the enhancement of innovation levels.

2.3. Threshold Effect of Industrialisation Level

Digital finance and manufacturing business performance may also be affected by the degree of industrialisation and show a non-linear relationship. On the one hand, the smooth operation of the financial system and even digital change cannot be separated from specific infrastructure support. The new financial infrastructure will play an important role in guaranteeing the healthy operation of DF, promoting the development of market economy, improving the quality of digital financial services, and ensuring national financial security. And the strength, scope and scale of new infrastructure construction carried out by each province is deeply influenced by the local industrialisation foundation and its own industrialisation level (Li et al., 2024) [14]. On the other hand, regions with a good industrial base have a relatively higher starting point for manufacturing development, often with a higher level of technology, rich development experience and an open and inclusive vision, and there is a more fertile ground for the empowering role of digital finance in the MI. Given the potential for varying impacts under different levels of industrialization, the influence of digital finance (DF) on the BPMI is likely to exhibit non-linear traits. This consideration leads to the following hypothesis:

Hypothesis 3. The degree of industrialization serves as a threshold, beyond which the facilitative effect of DF on the BPMI becomes non-linear.

3. Model, Variables, and Data

3.1. Sample Selection and Variable Descriptions

The data analyzed in this study was collected from 30 provinces across China during the period of 2011 to 2021. The primary sources of the data include the EPS database and the official website of the China Statistics Bureau, excluding Hong Kong, Macao, Taiwan, and Tibet. Data on DF was obtained from the official website of the Institute of Digital Finance at Peking University, specifically referring to the comprehensive digital finance index computed by Guo et al. in 2020 [15].Due to the large differences in the data of the variables selected in this paper, in order to eliminate the effects of the magnitude and heteroskedasticity, the samples of the remaining indicators, except for indicators such as the marketisation index, are processed by taking the natural logarithm as much as possible.

3.1.1. Dependent Variable

The dependent variable of this paper is manufacturing business performance, and the total main business revenue (TR) of industrial enterprises above the scale is selected and logarithmically taken as the proxy variable for manufacturing business performance. In the robustness test part, the total profit (TP) of industrial enterprises above large scale is used to measure the business performance, which is divided by 100 in consideration of the fact that the total profit has a negative number. All data sources are EPS Global Statistical Data Analysis Platform.

3.1.2. Core Independent Variable

The core independent variable of this paper is digital finance (DF), which is measured by using the Peking University Digital Financial Inclusion Index to measure the level of digital finance, dividing it by 100 for the estimation of the econometric model. The index contains three sub-dimensions of breadth, depth and degree of digitisation in addition to the overall index, which can respond to the level of digital finance development in Chinese provinces in a more scientific, objective and comprehensive manner. The breadth of coverage (BC), depth of use (DU) and degree of digitalisation (DG) will be used in the sub-dimension heterogeneity analysis of digital finance, and they are all divided by 100.

3.1.3. Mediating Variable

In this paper, the innovation level (IL) will be used as a mediating variable to measure the level of manufacturing innovation in each province by the amount of science and technology financial expenditures in each province, region and city, and it is logarithmised.

3.1.4. Control Variables

In order to mitigate the impact of other omitted factors on the operating efficiency of manufacturing enterprises, this paper introduces the following control variables: the level of foreign investment (FI): using the logarithmic processing of the amount of foreign direct investment as a proxy; human capital structure (HR): selecting the number of students enrolled in the general undergraduate and specialist schools of higher education per 10,000 people in each region and taking the logarithmic measurement; the level of urbanisation (UB): measured using the ratio of urban population to total population; the level of foreign trade (FT): measured using the ratio of total regional imports and exports to regional GDP and taking the logarithm; the level of marketisation (ML): measured using the marketisation index to measure the level of local marketisation; and the investment in fixed assets (IN): proxied by the percentage of annual growth of investment in fixed assets in each region.

3.1.5. Threshold Variable

Considering that the impact of digital finance on the business performance of the manufacturing industry may have a non-linear relationship due to the different levels of regional industrialisation, this paper sets the degree of industrialisation (ID) as a threshold variable, measured by the proportion of regional industrial added value to regional GDP.

Table 1. Descriptive statistics of variables.

Variable category	Variables(Symbols)	Observations	Mean	Std.	Min	Max
Dependent variable	Business performance(TR)	330	10.02	1.050	7.379	12.06
Core independent variables	Digital finance(DF)	330	2.315	1.033	0.183	4.590
	Breadth of coverage(BC)	330	2.130	1.037	0.020	4.334
	Depth of use(DU)	330	2.268	1.058	0.068	5.107
	Degree of digitalisation(DP)	330	3.010	1.174	0.076	4.622
Mediating variable	Innovation level (IL)	330	4.348	1.059	1.324	7.064
Control variables	Foreign investment (FI)	330	2.945	0.624	1.452	4.656
	Human capital structure (HR)	330	5.286	0.272	4.388	6.052
	Level of urbanisation (UB)	330	59.59	12.14	35.03	89.60
	Foreign trade (FT)	330	2.815	0.956	-0.278	5.042
	Level of marketisation (ML)	330	8.039	1.914	3.359	12.39
	Investment in fixed assets (IN)	330	10.17	11.74	-62.65	41.18
Threshold variable	Degree of industrialisation (ID)	330	0.351	0.088	0.0969	0.530

3.2. Model Setting

3.2.1. Benchmark Regression Model

To test hypothesis 1 and investigate the direct influence of digital finance (DF) on the BPMI, this study employs a fixed-effect model utilizing panel data. The following benchmark regression model of DF on BPMI is constructed:

$$TR_{i,t} = \alpha_0 + \alpha_1 DF_{i,t} + \alpha_2 X_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (1)$$

Where TR denotes the business performance of manufacturing industry, DF denotes the digital finance index, $X_{i,t}$are the control variables that may affect the business performance of manufacturing industry. i, t represents the region and year in turn, α_0 is the constant term, α_1,α_2 denotes the coefficients of each variable.μ_i,$\delta_t$denotes the individual fixed effect, time fixed effect, $\varepsilon_{i,t}$ represents the random error term respectively.

The coefficient α1 of the core independent variable reflects the impact of DF on the business performance of the MI, and if it is significantly positive, it indicates that DF has a positive facilitating effect on the enhancement of the business performance of the MI. The larger the positive value, the greater the promotion effect.

3.2.2. Mediating Effect Model of Innovation Level

In order to verify hypothesis 2 and test whether DF can exert an influence on the business performance of the MI by improving the level of innovation, this paper constructs a transmission mechanism model with the level of innovation as a mediating variable:

$$Inn_{i,t} = \alpha_0 + \alpha_1 DF_{i,t} + \alpha_2 X_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (2)$$

$$TR_{i,t} = \alpha_0 + \alpha_1 DF_{i,t} + \alpha_2 IL_{i,t} + \alpha_3 X_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (3)$$

Where $IL_{i,t}$is the innovation level of region i in period t, i.e., the mediating variable, and the rest of the settings are the same as in Eq. (1).

3.2.3. Threshold Effect Model of the Degree of Industrialisation.

In order to verify hypothesis 3 and test the non-linear impact effect of DF on the business performance of MI under different levels of industrialisation, this paper takes the degree of industrialisation as a threshold variable, non-linearly fits digital finance and the degree of industrialisation, and constructs the following threshold model:

Single Threshold Model:

$$TR_{i,t} = \alpha_0 + \alpha_1 DF_{i,t} \times I(ID \le \lambda_1) + \alpha_2 DF_{i,t} \times I(ID > \lambda_1) + \alpha_3 X_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (4)$$

Dual Threshold Model:

$$TR_{i,t} = \alpha_0 + \alpha_1 DF_{i,t} \times I(ID \le \lambda_1) + \alpha_2 DF_{i,t} \times I(\lambda_1 < ID \le \lambda_2) + \alpha_3 DF_{i,t} \times I(ID > \lambda_2) + \alpha_4 X_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (5)$$

Where ID is the threshold variable, i.e. the degree of industrialisation, and λ_1,λ_2 are the two thresholds to be estimated, and the rest of the parameters have the same meaning as Eq. (1). The triple-threshold model follows suit.

4. Empirical Results and Analysis

4.1. Benchmark Regression Results and Analysis

The regression results, presented in Table 2, demonstrate a significant and positive correlation between DF and the performance of the MI. When no control variables are included, the coefficient for the impact of DF on BPMI is 0.387 (Column (1)), passing the 1% significance test. After incorporating control variables, the impact coefficient of DF on manufacturing business performance increases to 0.605 (Column (2)), and still passes the 1% significance test. This confirms the validity of hypothesis 1. In the current economic environment, digital finance not only simplifies the financing process and reduces costs, but also enhances the interaction between enterprises and the market, making decision-making more flexible and agile. Through more convenient and efficient financial services, digital finance provides more innovation and flexibility for the manufacturing industry, and therefore, can promote the significant improvement of the business performance of MI.

Table 2. Results of benchmark regression

Variable	(1)	(2)
	TR	TR
DF	0.387***	0.605***
	(0.129)	(0.129)
FI		0.137**
		(0.055)
HR		-0.135
		(0.159)
UB		0.040***
		(0.008)
FT		-0.094**
		(0.038)
ML		0.039*
		(0.020)
IN		0.003***
		(0.001)
Cons	9.606***	7.684***
	(0.060)	(0.709)
N	330	330
R^2	0.318	0.437

Note: () denote standard error; ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively. For consistency, the standard error retains three decimal places, and the same below.

4.2. Analysis of Impact Mechanism

Table 3 demonstrates the regression results with innovation level as the mediating variable. Among them, column (1) is the direct impact of digital finance on the business performance of manufacturing industry, and the results show that the impact is significantly positive.

Column (2) is the test result of the impact of digital finance on the innovation level of the manufacturing industry, and the coefficient of digital finance is significantly positive at the 1% level, which is 1.651. This suggests that the development of digital finance can provide more financial support for potential manufacturing enterprises by breaking down the information barriers and facilitating the circulation of innovative resources, thus effectively promoting the enhancement of manufacturing industry's innovation level.

Finally, the joint impact of digital finance and innovation level on the business performance of manufacturing industry is tested (Column (3)), and the results show that the coefficient of innovation level is 0.181, which passes the 1% significance test. Meanwhile, the coefficient of digital finance is 0.306, which passes the 5% significance test. This indicates that there is a partial mediating effect of innovation level in the mechanism of digital finance affecting the business performance of manufacturing industry, and hypothesis 2 is verified. By providing innovative financing solutions, digital finance stimulates technological innovation and management mode optimisation within the manufacturing industry, which in turn enhances the competitiveness of the whole industry. This financial support not only promotes the transformation of the traditional manufacturing industry to digitalisation and intelligence, but also provides strong support for the incubation of emerging industries, thus achieving an overall improvement in business performance. Through the integration

of data resources and advanced information technology, digital finance can help manufacturing enterprises analyse market trends and consumer demand more effectively and adjust production plans and product strategies accordingly, ultimately achieving double growth in profitability and market share. Therefore, digital finance can provide a boost to the improvement of manufacturing business performance by strengthening the level of manufacturing innovation.

Table 3. Regression results of intermediation effect: innovation level

Variable	(1)	(2)	(3)
	TR	IL	TR
DF	0.605***	1.651***	0.306**
	(0.129)	(0.175)	(0.144)
IL			0.181***
			(0.043)
FI	0.137**	0.293***	0.084
	(0.055)	(0.075)	(0.055)
HR	-0.135	-0.396*	-0.064
	(0.159)	(0.216)	(0.156)
UB	0.040***	0.078***	0.026***
	(0.008)	(0.010)	(0.008)
FT	-0.094**	0.049	-0.103***
	(0.038)	(0.051)	(0.037)
ML	0.039*	0.060**	0.028
	(0.020)	(0.028)	(0.020)
IN	0.003***	0.003**	0.003***
	(0.001)	(0.001)	(0.001)
Cons	7.684***	-0.491	7.773***
	(0.709)	(0.962)	(0.688)
N	330	330	330
R^2	0.437	0.777	0.470

4.3. Robustness and Endogeneity Tests

4.3.1. Replacement of Dependent Variable

In order to analyses whether the measurement of manufacturing business performance will have an impact on the robustness of the results, this paper refers to the research results of scholars such as Wang (2017) and uses the total profit (PR) of industrial enterprises above the size of the industry as an indicator to measure the business performance of the manufacturing industry [16]. The regression results after replacing the explanatory variables are shown in Table 4, regardless of whether the control variables are added or not, the coefficients of the digital finance index are still significantly positive and have passed the significance test at the 1% and 10% levels, respectively. This proves that the conclusion that digital finance promotes the improvement of manufacturing business performance is robust.

Table 4. Results of robustness test

Variable	(1)	(2)
	PR	PR
DF	17.026***	11.789*
	(5.662)	(6.097)
FI		-1.677
		(2.606)
HR		-16.985**
		(7.529)
UB		0.523
		(0.358)
FT		-2.216
		(1.786)
ML		0.997
		(0.968)
IN		0.146***
		(0.046)
Cons	13.515***	76.628**
	(2.644)	(33.484)
N	330	330
R^2	0.062	0.099

4.3.2. Core Independent Variable Lag One Period

The development of digital finance can indeed promote the improvement of manufacturing business performance, but in the process of promoting the improvement of manufacturing business performance may also in turn increase the local level of digital finance development, this independent variable and the dependent variable bidirectional causality may lead to errors in the regression estimation results. According to the concept of time series, the current development level of manufacturing business performance will not have an impact on the past digital finance, therefore, this paper selects the lagged one period of digital finance to solve the problem of reverse causality, and the regression results are shown in column (1) of Table 5. From the results, the coefficient of digital finance in the lagged period is significantly positive at the 5% level, 0.367. This indicates that after the lagged period, digital finance will still have a positive impact on the manufacturing business performance, and it also proves that the driving effect of digital finance on the manufacturing business performance has a high reliability.

4.3.3. Instrumental Variable Method

In order to further test the endogeneity problem, this paper refers to Huang(2019), adopts the Internet penetration rate as an instrumental variable for DF, and takes the logarithm of the number of Internet broadband access subscribers (in 10,000 households) in each province as a proxy variable for the Internet penetration rate[17]. From the perspective of correlation, the vigorous evolvement of DF cannot be separated from the strong promotion of Internet technologies and platforms; from the perspective of exogeneity, regional Internet penetration does not directly affect manufacturing business performance. Thus, this instrumental variable satisfies the conditions of relevance and exogeneity. The results of the two-stage least squares (2SLS) regression, presented in Table 5, columns (2) and (3), confirm this. The F-test value of the first-stage regression is 38.48, and the

Cragg-Donald Wald F-statistic value is 33.05, both surpassing 10 and exceeding the 10% critical value. This indicates the absence of weak instrumental variables. Additionally, the Kleibergen-Paap rk LM statistic p-value of 0.000 is significant at the 1% level, demonstrating the absence of under-identification issues. After incorporating instrumental variables, the coefficient for DF remains significant and positive at the 1% level, with a value of 1.542. This robust result further confirms that DF effectively enhances the business performance of the manufacturing industry.

Table 5. Results of endogeneity tests

Variable	(1)	(2)	(3)
	TR	DF	TR
IV		0.509***	
		(0.0820)	
DF			1.542***
			(0.356)
L.Dfi	0.367**		
	(0.144)		
FI	0.137**	0.293***	0.084
	(0.055)	(0.075)	(0.055)
HR	-0.135	-0.396*	-0.064
	(0.159)	(0.216)	(0.156)
UB	0.040***	0.078***	0.026***
	(0.008)	(0.010)	(0.008)
FT	-0.094**	0.049	-0.103***
	(0.038)	(0.051)	(0.037)
ML	0.039*	0.060**	0.028
	(0.020)	(0.028)	(0.020)
IN	0.003***	0.003**	0.003***
	(0.001)	(0.001)	(0.001)
Cons	7.684***	-0.491	7.773***
	(0.709)	(0.962)	(0.688)
Kleibergen-Paap rk LM		33.05	
		[0.000]	
Cragg-Donald Wald F		44.69	
		{16.38}	
Kleibergen-Paap Wald rk F		38.48	
		[0.000]	
N	300	300	
R^2	0.295	-0.559	

Note:For instrumental variable tests, the Kleibergen-Paap rk LM statistic is used for under-identification tests, [] denote the p-value of the corresponding statistic; the Cragg-DonaldWald F statistic is used for weak instrumental variable tests, {} denote the critical value at the 10% level of the StockYogo test ; and () denote the robust standard error.

4.4. Heterogeneity Analysis

4.4.1. Regional Heterogeneity

Given that the sample data involved covers 30 different provinces and cities across the country with a wide regional distribution, the significance of the geographical variability determines that the samples are bound to have diversity in their characteristics. In order to explore and compare the differences of these characteristics in terms of the influence of DF on the BPMI in a more detailed manner, this paper further subdivided these samples into different sub-samples, respectively, to explore the impact effect of DF on the BPMI under specific regions and dimensions.

Table 6. Regional heterogeneity analysis

Variable	(1)	(2)
	TR	TR
DF	0.564**	0.010
	(0.240)	(0.180)
FI	-0.001	0.107
	(0.072)	(0.085)
HR	-0.067	-0.263
	(0.434)	(0.170)
UB	0.036***	0.084***
	(0.010)	(0.014)
FT	-0.808***	0.016
	(0.123)	(0.039)
ML	-0.025	0.018
	(0.033)	(0.027)
IN	0.007***	0.002**
	(0.002)	(0.001)
Cons	11.447***	6.378***
	(2.133)	(0.842)
N	121	209
R^2	0.506	0.571

From the sub-regional results in Table 5, the positive effect of digital finance on manufacturing business performance has greater regional heterogeneity among different regions. For the eastern region, there is a significant promotion effect of digital finance on manufacturing business performance, while for the central and western regions, the effect is smaller and insignificant. The possible reason is that, on the one hand, due to the higher degree of openness in the eastern region, with strong capital accumulation and policy advantages, all kinds of digital financial institutions and facilities are more complete, and the overall economic and social environment is more conducive to the in-depth integration of DF and MI and the role of the role to play. On the other hand, the central and western regions are often faced with many unfavourable conditions such as backward infrastructure construction, difficulties in the introduction and cultivation of talents, and insufficient technological innovation capacity, which in turn limits the overall y development potential of the MI. At the same time, the western region in the allocation of factor resources there are obvious deficiencies, the lack of effective incentives to improve the efficiency of enterprises to the use of resources, so that the process of technological achievements into actual productivity is full of obstacles, the unique advantages of digital finance can not be given full play for the time being. Indeed, it is important to acknowledge that the current influence of DF on the business performance of MI in

central and western China remains positive. It is anticipated that as DF continues to develop and related services improve, its benefits, such as easing capital constraints and reducing financing costs, will become increasingly apparent. Consequently, the impact of DF on the BPMI in central and western China will become more prominent. This, in turn, will contribute to the balanced development of the inter-regional industry and economy, fostering overall growth and stability.

4.4.2. Sub-dimensional Heterogeneity

Table 7. The regression results of the three sub-dimensions

Variable	BC	DU	DP
	TR	TR	TR
BC	0.652***		
	(0.177)		
DU		0.344***	
		(0.081)	
DG			0.140***
			(0.051)
FI	0.104*	0.140**	0.140**
	(0.056)	(0.056)	(0.057)
HR	-0.268*	-0.117	-0.245
	(0.157)	(0.163)	(0.161)
UB	0.028***	0.046***	0.039***
	(0.008)	(0.008)	(0.008)
FT	-0.070*	-0.106***	-0.100**
	(0.039)	(0.038)	(0.039)
ML	0.041**	0.034	0.050**
	(0.021)	(0.021)	(0.021)
IN	0.004***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)
Cons	8.980***	7.384***	8.422***
	(0.654)	(0.761)	(0.702)
N	330	330	330
R^2	0.421	0.430	0.409

In order to further study the link between DF and BPMI, this paper examines the impact of different dimensions of DF, and the regression results of the three sub-dimensions are reported in the columns of Table 7: the coefficient of breadth of coverage is 0.652, the coefficient of depth of use is 0.344, and the coefficient of digitization degree is 0.140, all of which are significant at the 1% level. Analysing the above regression results, the main reason may be that DF is currently developing rapidly, and the expansion of coverage has attracted more investors to enter the financial market, expanded the financing channels of manufacturing enterprises, and played the most prominent role in the operating performance of the manufacturing industry; DF uses big data, artificial intelligence and other technologies to analyse and understand the operating conditions of manufacturing enterprises in a more in-depth manner, including non-financial information, so as to provide more accurate financial services and financial services, including non-financial information. Thus, it provides more accurate financial services and credit support, richer financial tools and products, which in turn meets the diversified financing needs of manufacturing enterprises; while China is

currently in the midst of an all-factor digital transformation, with many manufacturing enterprises still at a nascent stage of maturity in their digital transforming efforts. As a result, the true impact of digitization on business performance may not have been fully realized. Consequently, while the promotion of digitization has a noteworthy effect on the BPMI, its coefficient is comparatively smaller and plays a marginally inferior role when compared to the other two dimensions. This signifies that the influence of digitization on business performance is multifaceted, necessitating a comprehensive approach that considers all dimensions to achieve holistic digital transformation and optimize business outcomes.

4.5. Threshold Effect Analysis

To explore whether there is a threshold value for the degree of industrialisation that makes the relationship between digital finance and manufacturing business performance structurally change, this paper refers to the F statistic and LR statistic method proposed by Hansen (1999), and uses Bootstrap to repeat the sampling 300 times to test whether there is a threshold effect when the degree of industrialisation is the threshold variable[18]. The test yields the F statistic, P statistic and specific threshold estimates as shown in Table 8.

According to Table 8, when the degree of industrialisation is the threshold variable, the p-value of the single threshold effect and the double threshold effect is 0.00 and 0.01 respectively indicating the existence of a significant double threshold effect.

Table 8. Threshold estimation test

Threshold Variable	Threshold model	Threshold estimate	95% confidence interval
ID	Single threshold model	0.3485^{***}	[0.3391,0.3504]
	Dual threshold model	0.4107^{***}	[0.4049,0.4125]
	Triple threshold model	0.4543	[0.4458,0.4597]

Table 9 shows the regression results of the threshold model of digital finance on manufacturing business performance when the degree of industrialisation is the threshold variable. As can be seen from Table 9, under the restriction of the threshold variable of the degree of industrialisation, the impact of digital finance on the business performance of the manufacturing industry shows differences in different threshold intervals of the degree of industrialisation. When the degree of industrialisation reaches a certain level, the promotion effect of digital finance on the business performance of the manufacturing industry increases sharply, showing a non-linear characteristic of increasing "marginal effect". When the degree of local industrialisation is lower than the threshold value of 0.3485, the coefficient of digital finance is 0.0037, which is still positive even though the coefficient is small and insignificant. This indicates that when the degree of industrialisation is low, digital finance may need more support from other factors, such as government policy support and reasonable regulation, and tilting of resources such as capital data, in order to better help the manufacturing industry to achieve improved business performance. When the degree of industrialisation is located at 0.3485 to 0.4107, the impact of digital finance on the business performance of the manufacturing industry is significantly enhanced, and it can give full play to the advantages of digital finance in terms of efficiency and convenience, and have a positive effect on the business performance of the manufacturing industry. When the degree of industrialisation exceeds the threshold value of 0.4107, the promotion effect of digital finance on the business performance of the manufacturing industry is further enhanced, with a coefficient of 0.1556.This shows that as the development of local industrialisation matures, digital finance is deeply integrated with the traditional manufacturing industry, which improves the production efficiency and creates greater value for the manufacturing industry.

Table 9. Regression results of threshold effect

Variable	(1)
	TR
Dfi(Ind≤0.3485)	0.0037
	(0.0403)
Dfi(0.3485<Ind≤0.4107)	0.0384**
	(0.055)
Dfi(Ind>0.4107)	0.1556***
	(0.0351)
Controls	Yes
Cons	7.8327***
	(0.7152)
N	330
R^2	0.5725

Note: () denote robust standard error; ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

5. Conclusion and Policy Implications

This paper employs a fixed-effect model to analyze the relationship between DF and the business performance of the manufacturing industry (BPMI), using data from the Digital Financial Inclusion Index and BPMI across 30 provinces and cities during 2011 - 2021. The analysis reveals that DF positively influences regional BPMI, an effect that remains significant after controlling for variables such as foreign investment and marketization levels, and is further validated through robustness checks. The study also identifies innovation as a key intermediary in the positive impact of DF on manufacturing performance. It is observed that the broader and deeper aspects of DF have a more substantial effect on BPMI than mere digitization. While the positive effect of DF is present across all regions, it is particularly notable in the eastern region, indicating a need for greater integration of DF with the MI in central and western regions. Additionally, the research points to a threshold effect, where in highly industrialized areas, DF has a more significant role in enhancing BPMI. The study concludes that by increasing industrialization levels, the facilitative effect of DF on BPMI can be more effectively harnessed.

Based on the study's conclusions, here is a synthesized insight paragraph for strategic application:

(1) To harness the full potential of DF in enhancing the BPMI, China must actively develop its digital financial sector, recognizing the current nascent stage of integration between DF and the MI. A strategic focus on building robust financial infrastructure and advancing key digital technologies is imperative. This includes the Internet, big data, artificial intelligence, and cloud computing, which are foundational for the digital financial platforms that will elevate the quality of products and services.The expansion of DF should be a priority, particularly in the central and western regions where financial services are less prevalent. This involves increasing the accessibility and understanding of digital financial tools among the populace and developing personalized financial products that align with the specific requirements of manufacturing enterprises. Additionally, the application of digital technology in risk management should be emphasized to enhance financial institutions' risk assessment and management capabilities. Furthermore, the government should introduce supportive policies to encourage manufacturing enterprises to embrace digital transformation. This includes the adoption of digital technologies to innovate and upgrade their operations, thereby leveraging the benefits of digital finance for high-quality development and

improved business performance. By focusing on both the breadth and depth of digital finance usage, and by supporting the digitization of the manufacturing sector, the positive impact on business performance can be significantly amplified.

(2) Increase investment in research and development, enhance the level of innovation in the manufacturing industry, and smooth the intermediary role of the level of innovation. Manufacturing enterprises should increase their independent innovation capacity, explore diversified innovation paths and innovation activities according to the differences in the economic and political situation of each place, and improve the level of innovation as much as possible. In all aspects of procurement, production and sales, the manufacturing industry in all provinces and cities should increase R&D investment in technology and science, develop more personalised patents and produce more innovative products according to customers' needs, so as to promote the level of technological innovation of enterprises. At the same time, financial institutions should develop financial products in line with the characteristics of the manufacturing industry, such as intellectual property pledge financing, movable property pledge, accounts receivable pledge and equity pledge, etc., in order to support the innovative activities of enterprises. Thus, digital finance can be effectively used to promote the innovative activities of manufacturing enterprises, give full play to the intermediary role of the innovation level, and drive the growth of the business performance of the manufacturing industry through the improvement of the innovation level.

(3) Fully consider regional characteristics and strengthen the regional industrial base. For the eastern coastal region, it is possible to take advantage of openness to develop cross-border financial services, providing international settlement and foreign exchange management for manufacturing enterprises. Meanwhile, relying on the strong manufacturing base, supply chain finance should be developed to provide full-chain financial services from raw material procurement to finished product sales. For the central and western regions, the inclination of digital financial policies and resources should be increased, infrastructure construction should be strengthened, and the advantages of regional endowments should be utilised to accelerate the degree of integration between manufacturing and digital finance. Provinces and cities should build a firm industrial foundation to provide the prerequisites and safeguards for the construction of digital financial infrastructure, so as to ensure that the development of digital finance has a branch to rely on, and help digital finance to promote the steady improvement of the operating performance of the manufacturing industry.

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