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Research on the Impact of Financial Technology on the Total Factor Productivity of Manufacturing Enterprises

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Abstract. Driven by digital technologies including big data and artificial intelligence, financial technology (fintech) has emerged as a key engine for boosting the total factor productivity of manufacturing firms, and its underlying impact channels have been widely discussed in academic research. Based on a sample of Chinese A-share listed manufacturing enterprises covering the period 2015–2023, this study empirically confirms that fintech development can significantly enhance corporate total factor productivity primarily through the channels of supply chain finance and innovation effects. Meanwhile, government subsidies exert a negative moderating influence on this relationship. Further heterogeneity tests indicate that the productivity-enhancing effect of fintech is more pronounced in high-tech industries and regions with higher levels of economic development.

Keywords: financial technology, supply chain finance, innovation effect, government subsidies, total factor productivity

1. Introduction

Improving corporate total factor productivity via low-consumption and high-efficiency approaches is critical to building core competitiveness. As the mainstay of the real economy, manufacturing sector productivity growth supports corporate sustainability and drives China's growth driver transformation and new-quality productivity development. As a technology-enabled financial innovation, fintech injects new impetus into the real economy and powers financial services for the real sector. Examining its impact on manufacturing firms'total factor productivity carries great significance for advancing China's manufacturing industry.

Existing studies have found that financial technology can enhance the total factor productivity of enterprises through paths such as promoting digital transformation of enterprises [1], optimizing corporate governance [2], and reducing agency costs [3]. This paper further analyzes its mechanism from the perspectives of supply chain finance and innovation effects, examines the moderating influence of relevant factors, and conducts heterogeneity analysis from dimensions such as the technological attributes of enterprises and the regional economic development level.

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2. Theoretical analysis and research hypotheses

Using machine learning algorithms for credit rating and profit assessment, replacing traditional mortgages with data credit [4], this approach opens up a broader source of funds for enterprises that are difficult to obtain support through traditional financing methods, achieving "precise irrigation". From the perspective of enterprises, by utilizing core technologies including big data, effectively drives the generation and accumulation of enterprise digital resources [5]. This process not only helps enterprises connect the online and offline collaborative links, accelerate the value transformation of digital resources, and transform them from potential forms into practical production factors that can be directly applied.

Assumption 1: Financial technology has a positive impact on the total factor productivity of manufacturing enterprises.

The blockchain data has the characteristic of being unalterable. After the business data is uploaded, automatic payment, compliance checks and other operations can be realized through smart contracts, reducing human intervention and intermediate links. This helps to reduce costs while optimizing the process, enhancing the rationality of decision-making and the accuracy of resource allocation. Moreover, its data is transparent and traceable. By modeling the entire process of the enterprise supply chain and recording it on the blockchain, accounts receivable and other assets can be packaged into trusted digital assets for circulation (Bao Xinzhong et al.) [6], thereby activating funds, enhancing asset liquidity, and achieving the rational allocation of production factors to efficient links.

Assumption 2: Financial technology enhances the total factor productivity of manufacturing enterprises through supply chain finance.

Financial technology, breaks down data barriers and accelerates the flow of data elements. It can promote data sharing and interoperability among credit reporting agencies, thereby guiding financial capital to flow more precisely to innovative enterprises with high growth potential. This not only reduces credit risks but also provides more channels for financing and relief for enterprises' innovation activities [7], and offers continuous and stable financial support for enterprises' research and development innovation activities. With sufficient financial support, enterprises have the ability to increase R&D investment, attract technical talents, improve innovation mechanisms, promote technological, product and management innovation, and create an innovation effect.

Assumption 3: Financial technology enhances the total factor productivity of manufacturing enterprises by optimizing the innovative effect.

Government subsidies, if expanded, can easily lead to resource misallocation due to rent-seeking and moral hazard, failing to stimulate enterprise innovation and even hindering production efficiency. If the subsidies are not used for research and development but merely to cover losses or for extensive expansion, enterprises will become dependent on policies and lose their innovation drive, thus impeding high-quality development. Moreover, overly strict financial regulation and penalties can exacerbate the negative effects of fintech. Due to risk aversion, enterprises, even if they receive subsidies, are reluctant to engage in high-risk, long-term innovation. The greater the subsidy amount, regulatory pressure and the fear of failure, the lower the willingness of enterprises to conduct R&D and innovation related to total factor productivity.

Assumption 4: The greater the government subsidy, the stronger the negative regulatory effect of fintech on the total factor productivity of manufacturing enterprises.

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3. Research design

3.1. Variable definition

3.1.1. The dependent variable

In this study, the selection of indicators is based on the principle of data availability, and the input-output variables are chosen to comprehensively and scientifically reflect the enterprise's production and operation situation. After comparing the calculation methods of different industry samples in existing literature (Zhang Hu et al.) [8], the total factor productivity (TFP) calculated by the LP method is selected as the dependent variable of the empirical model.

Capital input K is represented by the original value of fixed assets, while labor input L is quantified by the total number of employees in the enterprise. M = (operating costs + sales expenses + management expenses + financial expenses - depreciation and amortization - employee payments and cash payments) / 10000. Operating income is used to measure the output variable Y.

Based on the production function, take the logarithmic form of this function and construct a specific model:

$$\ln Y_{i,t} = \alpha_0 + \alpha_k \ln K_{i,t} + \alpha_l \ln L_{i,t} + \alpha_m \ln M_{i,t} + \varepsilon_{i,t}$$

$$\ln TFP_{i,t} = \ln Y_{i,t} - \widehat{\alpha}_k \ln K_{i,t} - \widehat{\alpha}_l \ln L_{i,t} - \widehat{\alpha}_m \ln M_{i,t}$$

3.1.2. Explanatory variables

This study adopts the method of Li Chuntao et al. [9] to obtainthe metrics used to quantify the development level of regional fintech.

3.1.3. Mediating variable

Supply Chain Finance (Scf): According to the research by Pan Weihua [10],supply chain finance is calculated as the logarithm of the total amount of short-term loans and accounts payable plus 1.

Innovation effect (Patent): This study draws on the research method of Liu Huakuo et al. [11] and measures the variables by taking the logarithm of the number of patent applications of the sample enterprises plus 1.

3.1.4. Moderating variables

This paper selects the government support intensity (Gov) as the moderating variable, and measures it by the ratio of government funds to investment in scientific and technological innovation. Control Variables

3.1.5. Control variables

This study selects the following control variables. Enterprise age (Age) is measured as the natural logarithm of the number of years a firm has been listed. Independent director ratio (Indep) is calculated as the number of independent directors divided by the total number of directors on the board. Enterprise growth rate (Growth) is represented by the growth rate of operating revenue. Fixed asset ratio (Ppe) equals the total value of fixed assets divided by total assets at year-end. Return on

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assets (Roa) is computed as total profit divided by total assets. Equity concentration (Top1) refers to the proportion of shares held by the largest shareholder in the total share capital of the listed firm. Leverage level (Lev) is defined as total liabilities divided by total assets. Corporate liquidity (Cf) is measured by net cash flow from operating activities divided by total assets at the beginning of the year. Board size (Board) denotes the total number of directors on the board. Regional economic development (LnGDP) is measured as the natural logarithm of the city's gross domestic product, which is denominated in ten billion yuan.

3.2. Model

To examine the effect of fintech on the total factor productivity of manufacturing enterprises, the article conducts an empirical test by constructing the following model:

$$TFP_{i,t} = \beta_0 + \beta_1 Fintech_{i,t} + \sum \beta_n Controls_{i,t} + \varphi_i + \mu_t + \gamma_j + \varepsilon_{i,t}$$

We establish the econometric model as follows to verify H2 and H3:

$$M_{it} = \beta_0 + \beta_1 Fintech_{it} + \beta_n \sum Control_{it} + \lambda_t + \mu_i + \varepsilon_{it}$$

Among them, the explained variables are the mechanism variables, including supply chain finance (Scf) and innovation effect (Patent). The meanings of other symbols are the same as those mentioned earlier.

Introduce the interaction term between fintech and the intensity of government subsidies, and establish a regulatory effect model

$$\mathrm{TFP}_{i,t} = \omega_0 + \omega_1 \mathrm{Fintech}_{it} + \omega_2 \mathrm{Gov}_{it} + \omega_3 \mathrm{Gov}_{it} \times \mathrm{Fintech}_{it} + \sum \omega_4 \mathrm{Control}_{it} + \gamma_i + \varepsilon_{it}$$

4. Empirical analysis

4.1. Baseline regression analysis

As can be seen from Table 1,it can be seen that the estimation results in the first column without the inclusion of control variables, and the results in the second column after the inclusion of control variables. The coefficients of FI remain significant at the 1% level, which supports Hypothesis 1.

Table 1. Baseline regression results

	(1)	(2)
	TFP_LP	TFP_LP
FT	0.307***	0.271***
	(2.69)	(3.03)
Roa		2.105***
		(22.78)
Indep		0.000
		(0.18)
Top1		-0.001
		(-0.58)

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Table 1. (continued)

Ppe		-1.089***
		(-13.48)
Age		0.137***
		(8.33)
growth		-0.040***
		(-3.47)
LnGDP		0.264**
		(2.27)
Cf		0.372***
		(5.80)
Lev		0.753***
		(13.44)
Board		0.143***
		(3.56)
_cons	8.732***	4.600***
	(530.80)	(3.11)
Fixed effect of time	YES	YES
Individual fixed effect	YES	YES
N	12661	12661
adj. R^2	0.904	0.926

Note: ***, **, * indicate significance at the 10%, 5%, and 1% levels respectively. The numbers in parentheses represent the t-statistics.

4.2. Mediation effect analysis

Table 2 shows that fintech has effectively enhanced the total factor productivity of enterprises through supply chain finance and innovation effects. Both research hypotheses H2 and H3 have been verified.

Table 2. Mediation effect analysis

	(1)	(2)	(3)	(4)	(5)
	TFP_LP	lnScf	TFP_LP	Patent	TFP_LP
FT	0.271***	0.420*	0.223***	0.482**	0.241***
	(3.03)	(1.80)	(2.72)	(2.01)	(2.71)
lnScf			0.115***		
			(17.50)		
Patent					0.061***
					(12.47)
_cons	4.600***	13.933***	3.003**	6.517**	4.200***
	(3.11)	(4.32)	(2.29)	(2.00)	(2.74)

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Table 2. (continued)

Control	YES	YES	YES	YES	YES
Fixed effect of time	YES	YES	YES	YES	YES
Individual fixed	YES	YES	YES	YES	YES
N	12661	12661	12661	12658	12658
adj. R2	0.926	0.863	0.932	0.788	0.928

4.3. Analysis of moderating effects

Government subsidies may lead to information asymmetry, rent-seeking corruption and other problems, thereby triggering a crowding-out effect on R&D investment, causing enterprises to develop a policy dependence and making it difficult for them to effectively increase productivity. Empirical results show that government subsidies have a negative moderating effect regarding the effect of fintech on the total factor productivity of enterprises.

Table 3. Analysis of moderating effects

	(1)
	TFP_LP
FT	1.152***
	(2.59)
FT*Gov	-0.057**
	(-2.18)
Gov	0.096***
	(12.52)
_cons	3.008*
	(1.94)
Control	YES
Fixed effect of time	YES
Individual fixed effect	YES
N	12591
adj. R2	0.929

5. Research findings and recommendations

Research findings indicate that fintech can enhance the total factor productivity of manufacturing enterprises, mainly through the effects of supply chain finance and innovation. Moreover, government subsidies have a negative moderating effect. Further heterogeneity tests indicate that the improvement effect of fintech on manufacturing enterprises in high-tech industries and economically developed regions is more prominent.

First, strengthen policy guidance for the integration of fintech and the overall productivity of enterprises, improve the policy framework, and support financial institutions and manufacturing enterprises in jointly developing compatible fintech products and services through fiscal subsidies and tax incentives. Second, relying on artificial intelligence and big data technologies, promote the

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deep integration of fintech and the credit system, break data barriers, achieve information sharing, guide funds to flow to innovative enterprises, support enterprise research and development and talent introduction, and stimulate innovation investment. Third, establish a precise and transparent government subsidy allocation mechanism, introduce third-party supervision and digitalized full-process monitoring, optimize the regulatory system and establish a tolerance and error correction mechanism, prevent rent-seeking risks, ensure that subsidies promote enterprise innovation and the improvement of overall productivity, and facilitate high-quality development.

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