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Does Financial Technology Stimulate Innovation in High-Tech Industries? A Study based on Provincial-level Empirical Evidence from China

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Abstract. Against the backdrop of the rapid development of financial technology, it provides diversified and flexible financing channels for high-tech industries and creates an ecosystem favorable for innovation. This paper explores the impact of financial technology on innovation in high-tech industries based on provincial-level panel data from 2011 to 2020. The results reveal that (1) Financial technology plays a crucial role in promoting innovation in high-tech industries, but its impact varies at the regional level. The influence of financial technology on innovation in high-tech industries is more significant in the eastern region than in the central and western areas. (2) Among different dimensions of financial technology, coverage breadth and usage depth have a positive impact on innovation in high-tech industries, while the digitization of inclusive finance services has a limited effect on promoting innovation. (3) The improvement of marketization level and increased financial regulatory spending further drive the innovation activities between financial technology and high-tech industries.

Keywords: Digital Finance; High-tech Industry; Innovation Output; Digitization.

1. Introduction

In the past, economic growth primarily relied on the input of resources and labor. However, with the increasing scarcity of resources and rising labor costs, this growth model has become unsustainable. As a pillar and driving force of the modern economy, high-tech industries are indispensable in optimizing and upgrading industrial structure, providing high-value-added products and services, and driving the development of related industries. The core driver of high-tech industry development is innovation. Firstly, only through technological innovation can high-tech companies continuously enhance the quality, performance, and added value of their products and services to meet the evolving market demands. Secondly, innovation can improve the competitiveness and risk resilience of high-tech enterprises, helping them continuously innovate and adapt to rapid changes in the market environment, thus maintaining a competitive advantage. Furthermore, innovation can also improve the ecological system and sustainable development capacity of high-tech industries by effectively utilizing resources and various green technologies, achieving harmonious development between economic growth and environmental protection. Therefore, an innovation-driven strategy, by focusing on the development and innovation of high-tech industries, can promote economic transformation and upgrading, enhance national competitiveness, and achieve the goals of economic growth and sustainable development.

Currently, financial technology is rapidly developing on a global scale. Many innovative financial technology companies and tech giants are driving the digital transformation of the financial industry by introducing cutting-edge technologies such as artificial intelligence, big data analytics, blockchain, and cloud computing. The development of financial technology, along with the funding, resources, and market support it brings, may become a solution to various challenges faced by innovation in high-tech industries. Firstly, financial technology provides more diversified and flexible financing channels for high-tech industries. Through crowdfunding platforms, venture capital networks, and digital currencies, businesses can directly access capital support, accelerating product research and development as well as commercialization processes. Secondly, financial technology has built an

ecosystem favorable for innovation in high-tech industries by utilizing technologies like cloud services, big data analytics, and blockchain. Through financial technology innovation, businesses can better collaborate and interact with financial institutions, investors, and other important stakeholders. Furthermore, high-tech industries face challenges such as technological risks, market risks, and intellectual property protection. Financial technology helps businesses manage risks more effectively by applying tools like smart contracts, big data analytics, and advanced risk assessment models.

In summary, fintech may accelerate the innovative development of high-tech industries through financing innovation, innovation ecosystem construction, risk management, and digital transformation. With the widespread application of 5G networks, new-generation information technologies such as blockchain, artificial intelligence, and the Internet of Things are gradually permeating various sectors of the financial industry. This is bound to have a significant impact on innovation in China's high-tech industries. Considering the current context of economic transformation towards high-quality development and the flourishing development of fintech, studying the impact of fintech on enterprise innovation holds important theoretical and practical significance.

The main contributions of this article are as follows: Firstly, based on provincial-level data, this article provides new evidence on the impact of fintech on innovation in high-tech industries from the perspectives of marketization and government financial regulation. Secondly, this article discovers the heterogeneity in the impact of fintech on innovation in high-tech industries. Overall, fintech is beneficial for innovation in high-tech industries. However, when considering different regions, the impact of fintech on innovation in high-tech industries is significant in the eastern region but not significant in the central and western regions.

2. Literature Review and Theoretical Analysis

Theoretically, finance plays a crucial role in providing funding (Levine, 1991), managing risks (Zhang et al., 2016), and promoting investments (Zhuang et al., 2020), which effectively facilitates various innovation activities of enterprises (Hsu et al., 2014; Gu and Zhu, 2021). Numerous empirical studies have also confirmed this conclusion. For example, Quan and Wang (2020) found that optimizing financial structure promotes corporate innovation positively. Zheng and Wang (2018) indicated that regional innovation levels are significantly influenced by the richness of local financial structure. Qu (2022) discovered that financial agglomeration positively contributes to the upgrading and innovation of high-tech industries. Further research has also revealed that different financing methods have varying degrees of impact on corporate innovation. Compared to internal financing, external financing significantly promotes R&D innovation in Chinese listed companies (Li et al., 2013). Additionally, equity financing is more suitable for providing financial support to technological innovation in enterprises compared to bank financing (Zhang et al., 2016).

In recent years, China has faced increasingly prominent issues in its traditional financial system, such as low efficiency and misallocation of resources (Gu and Gao, 2022). These problems have hindered economic growth. The development of fintech provides an effective solution to address these problems. Research on the impact of fintech can be broadly categorized into two parts: macro-level studies exploring the effects of digital finance on the overall economy and micro-level studies investigating how fintech influences the decision-making of firms. Regarding the former, most scholars believe that fintech can promote economic growth by driving industrial structural upgrading and transformation (Chen et al., 2018; Li and Zhang, 2022), stimulating long-tail consumer demand (Li and Cheng, 2018), and encouraging entrepreneurship (Xie et al., 2018). Moreover, the impact of financial development on promoting economic growth often exhibits diminishing marginal utility (Yang, 2014; Wang et al., 2017). In terms of the latter, existing research primarily focuses on the influence of fintech at the micro-level from perspectives such as credit allocation (Li et al., 2022), investment efficiency (Shao and Hu, 2022), and digital transformation (Li et al., 2022).

The innovation activities of high-tech enterprises are characterized by high risk, rapid iteration, continuous investment, and market orientation, resulting in a strong demand for funding (Cai and Dong, 2016). However, due to the high uncertainty in the returns of innovation activities, banks usually adopt a more cautious approach when facing large borrowing demands from such enterprises in order to avoid excessive risk (Yu and Dou, 2020). This often constrains the financing of enterprises engaged in innovation activities. The development of financial technology may improve this dilemma for high-tech enterprises. Firstly, the development of financial technology has overcome the limitations of traditional financial services in terms of time and space, reducing the cost and barriers of financial services. (Sheng et al., 2021) Secondly, financial technology can achieve enterprise deleveraging by improving the driving mechanisms of internal control and risk control (Zhang et al., 2020), thereby enhancing the investment efficiency of enterprises (Liang and Wu, 2021). Additionally, the development of financial technology can mitigate the degree of information asymmetry, reduce adverse selection and moral hazard problems, and provide more relevant information about high-quality enterprises to investors, which can increase the investment willingness of relevant investors and alleviate the financing constraint of high-tech enterprises.

In terms of the in-depth discussion on the impact of financial technology in China, the roles of the government and the market cannot be ignored. While some studies suggest that under strong government regulation, fintech increases compliance costs for businesses and suppresses their innovative behavior (Wang et al., 2019), most studies indicate that appropriate government regulation is beneficial for fintech to have a positive impact. For example, Wang et al. (2022) pointed out that macro-prudential regulation by the government is helpful in preventing systemic financial risks caused by fintech. Zhang et al. (2021) found that regulatory policies can reduce liquidity and credit risks in crowdfunding platforms, but the impact is not significant due to the lag in policy implementation. The empirical research of Feng et al. (2021) shows that the inclusive effects of fintech are stronger in regions with higher levels of financial regulation. The level of marketization also affects the effectiveness of fintech. Xin (2021) and He et al. (2022) believe that the process of marketization plays an important role in the positive impact of fintech. For example, in regions with higher levels of marketization, fintech can better restrain the process of local enterprises shifting away from the real economy.

3. Research Design

3.1. Model Specification

The measurement model constructed in this paper is shown in Equation (1):

$$INNO_{it} = \alpha_0 + \alpha_1 FT_{it} + \sum_j \varphi_j X_{jit} + \lambda_i + \mu_t + \varepsilon_{it} \quad (1)$$

Among them, i and t represent provinces and years respectively. INNO represents innovation in high-tech industries. FT represents financial technology, and X represents a series of control variables that affect the efficiency of innovation in high-tech industries. α_0 represents the constant term, α_1 and φ represent unknown regression coefficients. λ and μ represent province-fixed effects and year-fixed effects respectively. ε represents the random disturbance term.

3.2. Measurement of Variables

3.2.1. Explained Variable

This paper selects the sales revenue of new products in high-tech industries as the proxy for the output of innovation in high-tech industries. There are three reasons for this choice. Firstly, the core objective of high-tech industries is to introduce new products with higher added value and competitiveness through technological innovation and R&D. Therefore, the sales revenue of new products can directly reflect the achievements of innovation output. Secondly, the sales revenue of new products can reflect the innovation capability and market adaptability of high-tech industries. The R&D process of high-

tech products requires continuous technological breakthroughs and innovative practices, and the growth of sales revenue indicates that innovative products can meet market demands and gain recognition and acceptance from users. Lastly, the sales revenue of new products has a certain degree of comparability and quantifiability as a measurement indicator.

3.2.2. Explanatory Variable

Based on existing research findings, this paper selects the "Digital Financial Inclusion Index of China (PKU-DFIIC)" produced by a research team from the Institute of Digital Finance at Peking University and Ant Group as an indicator to measure the level of regional financial technology development. This index relies solely on data provided by Ant Group (now known as Ant Technology Group Co., Ltd.) (Zhang and Li, 2023), and in the process of index compilation, it takes into account the breadth of financial technology coverage, the depth of financial technology usage, and the level of digitalization in inclusive finance. As a result, this index can comprehensively and accurately assess the level of financial technology in a given region. (Guo et al., 2020)

3.2.3. Control Variable

Following the research conducted by Du and Wang (2022), this study selects population density, unemployment rate, industrial structure, investment intensity, and infrastructure development as control variables. A higher population density in a certain region indicates a relatively larger market size and more diversified consumer demand, thereby stimulating the local high-tech industry to introduce more innovative products. Meanwhile, a high unemployment rate in a region often accompanies increased economic instability and uncertainty, which poses greater risks and uncertainties for high-tech enterprises, discouraging them from engaging in large-scale technological innovation and research and development investment. The industrial structure is measured by the proportion of the secondary industry and the tertiary industry in the current year, reflecting the characteristics and development direction of the local economic structure. Investment intensity is measured by the ratio of the total fixed asset investment of the whole society to the gross domestic product in the current year, reflecting the importance and scale of investment activities in local economic development. The infrastructure development is measured by the per capita road area in the current year. The more comprehensive the infrastructure development in a region, the stronger its competitiveness, attractiveness, and sustainable development capacity, leading to higher innovation efficiency in the high-tech industry.

3.3. Data Resources

This paper conducts empirical analysis using panel data from 30 provinces, regions, and municipalities (hereinafter referred to as "provinces") in China from 2011 to 2020. Following the principles of data availability and completeness, this study excludes data from the Hong Kong, Macau, Taiwan, and Tibet regions. The empirical data are sourced from the "China High-Tech Industry Statistical Yearbook" (2011-2020), the "China Statistical Yearbook" (2011-2020), and the "Digital Financial Inclusion Index of China (PKU-DFIIC)" compiled by the Institute of Digital Finance at Peking University (2011-2020).

4. Results

4.1. Baseline Estimation Results

For the purpose of reducing the dimensional differences in the data, all the data in this study were subjected to logarithmic transformation. Table 1 presents the estimation results of the baseline regression model. In column (1) of Table 1, only the estimation results of the financial technology variable are included. In columns (2), (3), and (4) of Table 1, the effects of population density and unemployment rate, industrial structure and investment intensity, and infrastructure development on high-tech industry innovation are gradually controlled.

As shown in columns (1) to (4) of Table 1, the coefficients of financial technology are 1.496, 1.423, 1.490, and 1.174, respectively, and all are significant at the 1% level. After considering other factors, the impact of financial technology on high-tech industry innovation is somewhat weakened, indicating that the control variables indeed play a role and have an impact on high-tech industry innovation. Taking column (4) as an example, for every unit increase in financial technology level, the output of high-tech industry innovation increases by 1.174 units, which illustrates the facilitating effect of an improvement in financial technology level on high-tech industry innovation. This may be because the increase in financial technology level has positive influences on both investors and invested companies. For investors, a higher level of financial technology provides convenient information exchange and digital cooperation platforms, enabling investors to timely and accurately obtain relevant information about invested companies, thereby significantly reducing the occurrence of investment reluctance towards high-tech enterprises due to information asymmetry. For invested companies, financial technology not only provides more financing channels and opportunities, as well as more flexible and efficient financial tools for their innovation activities, but also enables them to gain deep insights through effective collection, storage, and analysis of massive data, facilitating market research, consumer behavior analysis, risk assessment, and precise decision-making in their innovation activities.

Table 1. Results for Baseline Regression

	INNO (1)	INNO (2)	INNO (3)	INNO (4)
LN(INDEX)	1.496***	1.423***	1.490***	1.174***
	(5.20)	(4.88)	(5.07)	(3.79)
LN(POP)		3.655***	5.014***	4.581***
		(2.94)	(3.63)	(3.34)
LN(UNE)		-1.203***	-1.292***	-1.132***
		(-3.82)	(-3.90)	(-3.42)
LN(IND)			-0.659**	-0.715**
			(-1.97)	(-2.16)
LN(INV)			-0.209	-0.104
			(-1.11)	(-0.55)
LN(ROAD)				0.982***
				(2.87)
Time Effect	YES	YES	YES	YES
Regional Effect	YES	YES	YES	YES
Intercept	8.746***	7.137	-16.901**	-16.043**
	(8.37)	(-1.32)	(-2.15)	(-2.07)
R2	0.555	0.594	0.602	0.614
Obs	300	300	300	300

Note: The value inside the parentheses represents the t-test result

* = Significant at 10% level

** = Significant at 5% level

*** = Significant at 1% level

4.2. Heterogeneous Regression

Given the significant disparities in economic and technological development across different regions in China, this study divides the entire sample into three sub-samples: the eastern region, the central region, and the western region for regression analysis. The regression results are shown in Table 2.

Table 2. Results for Heterogeneous Regression

	Eastern Region	Central Region	Western Region
LN(INDEX)	1.280***	1.370	1.223
	(3.52)	(1.05)	(1.61)
LN(POP)	5.818***	6.805***	3.649
	(3.87)	(3.24)	(0.87)
LN(UNE)	-0.486	0.305	-1.282*
	(-1.58)	(0.52)	(-1.66)
LN(IND)	0.006	0.699	-1.566**
	(0.01)	(1.34)	(-2.37)
LN(INV)	0.087	0.453	-0.751
	(0.56)	(-1.47)	(-1.40)
LN(ROAD)	0.622**	-0.201	0.568
	(2.03)	(-0.18)	(0.77)
Time Effect	YES	YES	YES
Regional Effect	YES	YES	YES
Intercept	-28.088***	-28.719**	-6.779
	(-2.72)	(-2.51)	(-0.36)
R2	0.675	0.784	0.670
Obs	300	300	300

Note: The value inside the parentheses represents the t-test result

* = Significant at 10% level

** = Significant at 5% level

*** = Significant at 1% level

It can be observed from the regression results that the impact of financial technology on innovation in high-tech industries is only significant in the eastern region, while it is not significant in the central and western regions. This suggests that financial technology can only play a significant promoting role in innovation in high-tech industries in the eastern region, whereas it does not have the same impact in the central and western regions. This disparity might be attributed to the fact that the eastern region is usually characterized by concentrated economic development and financial resources, with more abundant funding and investment channels flowing into high-tech industries. In contrast, the central and western regions may face challenges such as funding shortages and limited investment channels, which restrict the promoting effect of financial technology on innovation. Additionally, major cities in the eastern region tend to possess more advanced technological infrastructure and digital capabilities, providing better conditions for the development of financial technology. On the other hand, the technical infrastructure in the central and western regions may be relatively weaker, impeding the application and development of financial technology in these areas.

4.3. Dimensional Regression

Table 3 presents the regression results for the breadth of financial technology coverage, the depth of financial technology usage, and the level of inclusive financial digitization, denoted as columns (1) to (3) respectively. The results indicate that both the coefficients for the breadth and depth of financial technology coverage are significantly positive, while the coefficient for the level of inclusive financial digitization is significantly negative.

The result suggests that the promoting effect of financial technology on innovation in high-tech industries is mainly manifested in the breadth and depth of coverage. This could be attributed to the fact that as the breadth and depth of financial technology coverage increase, high-tech enterprises have the opportunity to reach a wider customer base and access more refined financial services. This, in turn, enables high-tech industries to proactively face challenges and continually pursue breakthroughs and innovative outcomes.

Table 3. Results for Dimensional Regression

	INNO (1)	INNO (2)	INNO (3)
BREADTH	0.470*** (3.91)		
DEPTH		0.873*** (4.08)	
DIGI			-0.512*** (-2.82)
LN(POP)	4.236*** (3.14)	3.969*** (2.98)	3.431** (2.55)
LN(UNE)	-1.144*** (-3.46)	-1.138*** (-3.46)	-1.263*** (-3.79)
LN(IND)	-0.760** (-2.30)	-0.528 (-1.59)	-0.604* (-1.79)
LN(INV)	-0.096 (-0.51)	0.007 (0.04)	0.014 (0.07)
LN(ROAD)	1.052*** (3.14)	1.152*** (3.53)	1.329*** (4.07)
Time Effect	YES	YES	YES
Regional Effect	YES	YES	YES
Intercept	-11.582 (-1.57)	-12.139 (-1.64)	-4.318 (-0.59)
R2	0.616	0.617	0.605
Obs	300	300	300

Note: The value inside the parentheses represents the t-test result

* = Significant at 10% level

** = Significant at 5% level

*** = Significant at 1% level

The insignificant effect of the level of inclusive financial digitization on innovation in high-tech industries may be due to the current lower level of development in China's financial technology in terms of inclusive financial digitization, which fails to meet the innovative requirements of high-tech industries. It could also be because inclusive financial services prioritize universality and standardization, paying relatively less attention to the specific demands and innovation requirements of high-tech industries. As a result, they are unable to meet the personalized and specialized financial solutions needed by high-tech industries.

4.4. Threshold Regression

Considering the roles played by the government and the market in the influence of financial technology on the innovation process of high-tech industries, this study employs the factor marketization index and financial regulatory expenditure as threshold variables. The regression results demonstrate that when the factor marketization index is greater than 2.398, the promoting effect of financial technology on innovation in high-tech industries becomes more significant. This may be attributed to the fact that with the improvement of marketization levels, high-tech enterprises can better utilize competitive and feedback mechanisms within the market-oriented environment, enabling rapid iteration and continuous improvement of innovation.

Table 4. Results for Threshold Regression

	D=MAR (1)	D=SUP (2)
L1.INNO	0.419***	0.421***
	(23.04)	(21.81)
Below_thres	0.525***	0.401***
	(10.57)	(4.20)
Above_thres	0.532***	0.445***
	(11.06)	(4.50)
LN(POP)	-0.923	-1.424
	(-0.98)	(-1.33)
LN(UNE)	0.429***	0.541***
	(6.76)	(3.53)
LN(IND)	0.002	0.027
	(0.02)	(0.17)
LN(INV)	0.617***	0.634***
	(8.63)	(5.18)
LN(ROAD)	0.521***	1.074***
	(2.74)	(6.60)
Intercept	9.706**	11.422**
	(2.18)	(2.08)
Threshold Value	2.398	-5.657
Obs	270	270

Note: The value inside the parentheses represents the t-test result

* = Significant at 10% level

** = Significant at 5% level

*** = Significant at 1% level

Table 4 also indicates that as financial regulatory expenditure increases, financial technology has a greater capacity to facilitate innovation in high-tech industries. This may stem from the fact that innovation in high-tech industries often involves challenges related to new business models, risk management, and data privacy. By strengthening financial regulation and providing relevant policies and rules, the legitimacy, compliance, and sustainability of financial technology in assisting high-tech industries can be ensured. This provides high-tech industry enterprises with a more stable innovation environment, allowing them to confidently invest in innovative practices.

4.5. Robustness Testing

To test the robustness of the empirical results and account for the possibility of a lagged effect of financial technology on innovation in high-tech industries, this study introduces a one-period lag for the high-tech industry innovation variable, as shown in column (1) of Table 5. Additionally, to address potential endogeneity issues arising from the two-way causality between higher levels of financial technology and higher levels of innovation in certain regions, this paper employs the number of internet access ports as an instrumental variable. The results demonstrate that financial technology continues to exhibit a significant positive impact on innovation in high-tech industries.

Table 5. Results for Robustness Testing

	(1)	(2)
L1.INNO	1.766***	
	(6.08)	
INNO		1.568**
		(2.13)
LN(POP)	7.445***	5.020**
	(4.88)	(2.40)
LN(UNE)	-0.805**	-1.089***
	(-2.15)	(-2.96)
LN(IND)	-1.219***	-0.714*
	(-3.70)	(-1.66)
LN(INV)	0.076	-0.157
	(0.41)	(-0.75)
LN(ROAD)	0.100***	0.828*
	(2.84)	(1.72)
Time Effect	YES	YES
Regional Effect	YES	YES
Intercept	-33.988***	-28.121*
	(-3.93)	(-1.68)
C-D F		34.782
R2	0.640	0.952
Obs	270	300

Note: The value inside the parentheses represents the t-test result

* = Significant at 10% level

** = Significant at 5% level

*** = Significant at 1% level

5. Conclusion and Recommendations

5.1. Principal Conclusion

Using provincial panel data from 2011 to 2020 in China, this study examines the impact and mechanism of financial technology on innovation in high-tech industries. The main conclusions are as follows: Firstly, financial technology has a significant promoting effect on innovation in high-tech industries. Secondly, the positive impact of financial technology on innovation in high-tech industries varies across regions, with a more significant effect in the eastern region compared to the central and western regions, which indicates heterogeneity. Thirdly, among the three dimensions of financial technology, the breadth of coverage and depth of usage have a more significant positive impact on innovation in high-tech industries, while no significant promoting effect of inclusive financial digitization on innovation in high-tech industries was found. Fourthly, as the level of marketization and financial regulatory expenditure increase, financial technology further promotes innovation activities in high-tech industries.

5.2. Policy Recommendations

First, continue to expand the coverage of financial technology and improve the quality of financial technology services to provide more personalized and professional financial solutions for high-tech industries. High-tech industries typically involve complex technologies and specialized knowledge, resulting in specific demands for financial services. For example, the biotechnology industry faces high technological and commercialization risks due to its innovative and high-risk nature. These risks include technological failures, market acceptance, and uncertainties in clinical trial results. Therefore, biotechnology companies have a stronger need for risk management in financial services, such as customized risk assessment and management tools, as well as adaptable insurance products. High-tech companies in other industries also have unique needs that align with their industry characteristics, necessitating more customized digital financial services to help address funding gaps and reduce capital costs, thereby driving innovation and development.

Second, strengthen innovation in financial technology regulation and establish a collaborative framework between the government and fintech companies. In the field of financial technology, regulation needs to keep pace with the times and adapt to the needs of technological advancements. Establish a flexible and open regulatory framework and allow and encourage innovation while maintaining risk control. Regulatory agencies can utilize advanced regulatory technologies and data analytics tools, such as artificial intelligence, big data analysis, and blockchain, to monitor risks and market changes and adjust policies and rules accordingly. At the same time, regulatory agencies need to engage in regular dialogue and communication with fintech companies to better understand their business models, technological characteristics, and risk management measures. Additionally, regulatory agencies can provide training and consulting services to assist fintech companies in complying with regulatory requirements and standards.

Third, focus on the balanced development of financial technology among regions. Firstly, the government can formulate relevant policies and regulations, including providing tax and financial incentives, to help attract financial technology companies to establish and develop in relatively underdeveloped areas. Secondly, it is necessary to enhance the construction of financial technology-related infrastructure in central and western regions, such as expanding coverage of high-speed internet and communication networks, constructing data centers, and improving digital payment and clearing systems. Thirdly, it is important to strengthen the exchange and cooperation of financial technology talents among regions, establish mechanisms for talent introduction and cross-regional cooperation, encourage the circulation and sharing of talents, and hence break down the regional barriers.

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