Regional Fintech Development and Enterprise Digital Transformation: Theoretical and Mechanism Analysis

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Abstract. In the context of the new round of technological revolution and industrial revolution, fintech has increasingly become the core driving force of economic development. The development of regional fintech is profoundly affecting the policy arrangements of relevant enterprises. Digital transformation is what enterprises must strive to achieve after entering the current data era, which will help enterprises to enhance their core competitiveness and brave the wind and waves in the digital era. Therefore, in this paper, the panel data of A-share listed companies in Shanghai and Shenzhen stock markets from 2011 to 2018 were used as the original samples, word frequency statistics related to enterprise digital transformation in the annual reports of listed companies were used to measure the degree of enterprise digital transformation, and the influence of regional fintech development on enterprise digital transformation and its mechanism were analyzed by measuring the level of regional fintech development. The study found that the development level of local fintech significantly has promoted the digital transformation of enterprises in their jurisdictions. Heterogeneity analysis shows that development of fintech has significant regional heterogeneity on the investment efficiency of enterprises. Its influence is concentrated in the eastern and central regions, but has no significant impact on enterprises in the western region. Mechanism analysis shows that the development of regional fintech alleviates the degree of information asymmetry of enterprises, increases the innovation input of enterprises, affects the strategic decision of sustainable innovation of enterprises, and thus promotes the digital transformation of enterprises. This paper discusses the influence of regional fintech development on the digital transformation of enterprises, analyzes the reasons from multiple perspectives, and provides important enlightenment for promoting the development of regional fintech and promoting the digital transformation of enterprises.

Keywords: Fintech development; Digital transformation; Regional differences; Information asymmetry; Innovation input; Innovation strategy decision.

1. Introduction

At present, a new round of technological revolution and industrial transformation is in-depth development, and digital transformation has become the general trend. On December 12, 2021, General Office of the State Council of the People's Republic of China issued “the 14th Five-Year Plan for the Development of Digital Economy”, which clearly pointed out that digital economy is the main economic form after agricultural economy and industrial economy. It takes data resources as the key element, modern information network as the main carrier, integrated application of information and communication technology and all-factor digital transformation as the important driving force, which will promote a new economic pattern that integrates fairness and efficiency. The digital economy is developing at a fast speed, with a wide range of radiation and an unprecedented degree of influence. It is promoting profound changes in in modes of production, lifestyles and governance methods, and has become a key force for reorganizing global factor resources, reshaping the global economic structure, and changing the global competitive landscape At the same time, the People's Bank of China also issued the "Fintech Development Plan (2022-2025)", which puts forward the guidance on fintech development in the new era, affirming the positive significance of fintech,

indicating that the steady development of fintech can effectively promote the process of digital transformation and cope with new opportunities and challenges in the era of digital economy.

The existing literature on the development of fintech and digital transformation mostly discusses the impact of the development of financial technology on the financial field and other related fields of financial services. For example, fintech changes the traditional loan technology and is an important tool to solve the credit supply problem of small and micro enterprises in the whole banking system (Sheng and Fan, 2019) Fintech can also reduce poverty levels in China by promoting economic growth (Appiah-Otoo and Song, 2021). Other studies consider how to promote the digital transformation of enterprises. For example, government subsidies can promote the digital transformation of enterprises (Wen and Huang, 2023). Big data and machine learning are also affecting the process of digital transformation of enterprises (Miklosik and Evans, 2020). Only a few articles have found that the development of financial technology has promoted the digital transformation of enterprises and made relevant recommendations (Cai et al., 2021). However, these studies did not directly focus on the relationship between the development of financial technology and the digital transformation of enterprises, and lacked exploration of the relationship between the two. To this end, this study analyzes the relationship between regional fintech development and enterprise digital transformation, the impact of regional fintech development on enterprise digital transformation, and why regional fintech development has an impact on enterprise digital transformation.

This paper uses the panel data of A-share listed companies in Shanghai and Shenzhen stock markets from 2011 to 2018, and obtains the following conclusions through theoretical and mechanism analysis. First, the level of local fintech development has promoted the digital transformation of enterprises in their jurisdictions. This result is obtained by analyzing the regression results of the benchmark model. At the same time, three kinds of robustness tests are carried out to consider the influence of various errors, and the same conclusion is still obtained. Second, the development of financial technology has significant regional heterogeneity in the investment efficiency of enterprises. Although the development of financial technology in the region can promote the digital transformation process of enterprises in the region, due to the different locations of enterprises, the development of financial technology will also cause differences in promoting the digital transformation of enterprises. For example, for enterprises located in the eastern and central regions, the development of financial technology has a significant role in promoting the digital transformation of enterprises. However, there was no significant effect in the western region. Third, there are three main reasons why regional fintech can promote the digital transformation of enterprises. First of all, the development of regional financial technology alleviates the information asymmetry of enterprises, thus promoting the digital transformation of enterprises; secondly, the development of financial technology expands the R&D investment of enterprises, and the more innovation investment will accelerate the digital transformation of enterprises; finally, the development of regional financial technology affects the strategic decision-making of enterprises' sustainable innovation, so as to improve the digital transformation of enterprises.

Compared with previous studies, the contribution of this paper is mainly reflected in the following three aspects. First, most of the existing studies focus on the banking industry such as commercial banks and analyze the relevant impact of the development of financial technology on their digital transformation, but lack the promotion effect of the development of financial technology on other industries. This paper does not distinguish between industries and selects original samples from listed companies to explore whether the development of financial technology can promote the digital transformation of enterprises. Second, this paper selects samples according to different regions for research to explore whether the development of fintech in different regions will have different effects on the digital transformation of enterprises. By studying the impact of financial technology development on enterprises from different regions, the implications are revealed in a more comprehensive and diversified way. Third, this paper makes an in-depth study of why the development of financial technology promotes the digital transformation of enterprises, and explores

the reasons in detail from multiple perspectives. Through research, this paper finds that the development of regional fintech can slow down the information asymmetry of enterprises, thereby promoting the digital transformation of enterprises. Moreover, the development of financial technology for enterprises requires a large amount of innovation investment, which also plays a role in promoting the digital transformation of enterprises. At the same time, the strategic decision-making of enterprise innovation is also driven by the development of financial technology, thus enhancing the digital transformation of enterprises.

The rest of paper is arranged as follows. Section 2 is the review and discussion of related literature and the proposal of theoretical hypotheses. Section 3 introduces the data structure and research design of this paper. Section 4 is the basic empirical results. Section 5 further discusses the mechanism; Section 6 presents the concluding comments and policy implications.

2. Literature review and theoretical hypothesis

2.1 Related research on financial technology

The Financial Stability Board defines fintech as technological innovations in the financial services sector that are capable of generating new business models, applications, processes or products and have a relevant and significant impact on financial markets and institutions and the provision of financial services. Thakor (2020) also believes that the core of fintech is the use of technology to provide new and improved financial services. In summary, fintech innovations are affecting many different areas of financial services. Song et al. (2020) found that the development of fintech can reduce the information asymmetry between financial institutions and enterprises, alleviate the financing constraints of enterprises in quantity, improve the efficiency of credit allocation among departments in quality, and then significantly improve the total factor productivity of enterprises. Li et al. (2019) found that the development of regional fintech significantly promoted the innovation output of enterprises; Moreover, the development level of financial technology alleviates the inhibitory effect of financing constraints on enterprise innovation. Appiah-Otoo and Song (2021) found that fintech can promote economic growth and financial development to reduce poverty in China. Zhou et al. (2022) analyzed that fintech innovation promotes the development of green finance by improving green credit and green investment, thus significantly promoting the growth of green economy. Qiu et al. (2018) found that the development of financial technology would affect the debt structure of banks. The more developed financial technology is, the lower the proportion of household deposits and the larger the proportion of interbank liabilities. It can be seen that fintech is having a significant positive effect in many different areas.

In addition, fintech has also had a significant impact on the financial sector. Safiullah and Paramati (2022) first investigated the impact of fintech companies on the financial stability of banks, using a sample of 26 banks in Malaysia, and found that the development of fintech companies increased the financial stability of banks. Daud et al. (2022) studied the impact of fintech on financial sector stability in 63 countries and found that there is a significant positive correlation between fintech and financial stability; at the same time, greater market concentration can improve the relationship between fintech and financial stability. Demir et al. (2022) found that fintech indirectly reduces income inequality through its impact on financial inclusion, and that financial inclusion reduces inequality across all quantiles of the inequality distribution, with the effect being greater in the upper quantile.

2.2 Related research on digital transformation

At present, the research on the impact of digital transformation is mainly discussed from the policy environment, government subsidies, the impact of the COVID-19 pandemic, financial factors and other aspects. Yang et al. (2022) found that policy uncertainty will strengthen the dual innovation orientation of enterprises and then strengthen the digitalization of enterprise innovation. The study by Yu et al. (2022) confirms that the government promotes the digitalization of enterprises by increasing

the service supply of the digital industry and increasing the investment cost of digital manpower. Wen and Huang (2023) also found that government subsidies can alleviate financing constraints, improve risk taking, and strengthen the "certification effect" to promote the digital transformation of enterprises. Yang et al. (2021) found that the higher the local economic growth target, from the macro perspective, it will aggravate the degree of fiscal imbalance, reduce the special fiscal expenditure on science and technology, and from the micro perspective, it will lead to the reduction of the "R&D input - innovation output" of enterprises, so as to inhibit the digital transformation of enterprises. Wu et al. (2021) analyzed that fiscal science and technology expenditure can alleviate the financing constraints of enterprises, stabilize their financial situation, and further optimize the innovation behavior of enterprises from the "input - output" level, thereby promoting the digital transformation of enterprises. By analyzing the opportunities in the COVID-19 crisis, Wang and Ke (2020) found that the COVID-19 pandemic is accelerating the digital transformation of China's economy and society to a certain extent. Zhang et al. (2021) found that supply chain finance promotes the digital transformation of enterprises by reducing information asymmetry and transmitting positive market signals, alleviating financing constraints and strengthening financial stability, and improving total factor productivity and innovation output. Ma and Wang (2022) found that big data resources can help enterprises improve digital dynamic capabilities and update organizational routines, so as to realize enterprise digital transformation. Miklosik and Evans (2020) found that big data and machine learning are affecting multiple aspects of the digital transformation of the sales industry. Tang et al. (2022) found that interest rate liberalization can alleviate the problem of difficult financing and expensive financing for enterprises, and can effectively drive enterprises to deleverage, increase investment in innovation and research and development, and help enterprises' digital transformation. Wang (2022) found that the myopic behavior of managers inhibits the digital transformation of enterprises by reducing the level of corporate governance.

2.3 Fintech promotes the digital transformation of enterprises

There are few literatures on how fintech promotes the digital transformation of enterprises, and several studies have been discussed from some individual perspectives. Luo et al. (2022) considered information cost and resource allocation and found that fintech innovation can effectively improve the total factor productivity of real enterprises and promote the transformation and upgrading of China's real economy. Tang et al. (2022) researched based on the perspective of enterprise life cycle and found that fintech plays a significant role in promoting the digital transformation of enterprises. Although the effect varies in different life cycles, the direction of the effect remains unchanged. Li et al. (2022), based on the intermediary transmission between the easing of financing constraints and the promotion of innovation, concluded that the development of fintech can promote the process of digital transformation of enterprises through the main path of easing the financing constraints of enterprises, stabilizing the financial level, reducing the leverage level and increasing the R&D investment.

At present, the research on the impact of fintech development on enterprise digital transformation is far from enough. There are few literatures on the impact mechanism of fintech development on enterprise digital transformation. At the same time, empirical analysis on this topic is far from enough, and most studies lack relevant theoretical analysis. Therefore, this study provides an in-depth explanation from two aspects of theory and mechanism by analyzing the impact of regional financial technology development on the digital transformation of enterprises. To this end, we put forward a theoretical hypothesis:

(1) The development of regional fintech has significantly promoted the digital transformation of enterprises within its jurisdiction.

(2) The influence of fintech development on the digital transformation of enterprises in different regions is different.

(3) The development of regional fintech can reduce the degree of information asymmetry inside and outside the enterprises, expand the innovation input of enterprises, and promote enterprises to

take continuous innovation strategic decisions, so as to promote the digital transformation of enterprises.

3. Sample description and empirical model setting

3.1 Sample selection and data sources

In order to test the theoretical hypothesis proposed above, and considering the availability of various enterprise indicators and sample representativeness, this paper uses the A-share listed company panel data of Shanghai and Shenzhen Stock exchanges from 2011 to 2018 as the original samples. The original listed company sample data are all from the China Stock Market and Accounting Research (CSMAR) database and are manually merged. The detailed screening process of the samples is as follows: First, because the financial statements of the financial industry are different from those of other enterprises, this paper screens the samples of the financial industry according to the CSMAR industry code, and excludes the samples of the financial industry; Secondly, the samples of ST companies during the study period are excluded. Thirdly, the samples with asset-liability ratio greater than 1 are excluded. Finally, in order to eliminate the influence of extreme values on empirical analysis, all continuous variables were reduced by 1%. After processing, the research sample in this paper contains a total of 17115 observed values from 3008 listed companies.

3.2 Enterprise digital transformation

Referring to the research of Wu et al. (2021) and Li et al. (2022), this paper measures the degree of digital transformation of enterprises through the statistics of the frequency of words in the annual reports of listed companies related to digital transformation of enterprises. The specific processing methods are as follows: First, Python is used to crawl and organize the annual reports of listed companies, and then the annual reports are processed by word segmentation and word frequency statistics based on the Chinese word segmentation function of Jieba, and high-frequency words related to the digital transformation of enterprises are extracted from five aspects: big data and its applications, Internet and its business model, artificial intelligence and its applications, cloud computing and its applications, and modern information system. Second, further narrow down the scope of keywords. Based on the “Special Action Plan for Digital Empowerment of Small and medium-sized Enterprises”, “2020 Digital Transformation Trend Report”, as well as important policy documents and research reports such as the “Government Work Report” in recent years, the Internet, the Internet of Things, cloud computing, information technology, digitization, artificial intelligence big data and other digital technology application vocabularies are included in the characteristic words, expand the lexicon of digital transformation and form the final word segmentation dictionary. Finally, all the samples are processed by word segmentation using Jieba function, the number of keywords disclosed are counted to obtain the index of the digital transformation of listed companies, and add 1 to it for logarithmic processing.

3.3 Measurement of regional fintech development level

According to the definition of the Financial Stability Board (FSB), fintech is a form of technology that integrates finance and technology into financial services. It can improve the efficiency of the traditional financial industry and effectively reduce operating costs through cloud computing, big data, blockchain, artificial intelligence and other emerging technologies. Referring to the calculation method of Song et al. (2021), this paper uses the big data of national industrial and commercial enterprise registration, and identify the key words of enterprise business including "fintech", "cloud computing", "big data", "blockchain", "artificial intelligence" and "Internet of Things" through text analysis, so as to obtain the industrial and commercial registration information of all relevant companies. At the same time, in order to avoid the coincidence character matching in the retrieval, this paper only retains the samples with the above keywords in the company name or business scope. In addition, in order to further prevent the registration of "shell companies" from affecting the

accuracy of fintech development indicators, this paper excludes the samples of companies whose operation time is less than one year or whose operation status is abnormal (such as suspension of business, dissolution, cancellation, etc.). Finally, it is summed up at the city level and the natural logarithm is taken to obtain the number of fintech-related companies in each city as a proxy for the regional fintech development level.

3.4 Empirical model setting

In order to verify the theoretical hypotheses proposed above, this paper intends to construct a two-way fixed effect model to discuss the impact of supply chain concentration on enterprise innovation activities. The specific empirical analysis model is shown in Equation (1):

$$digit_{ict} = \beta_0 + \beta_1 lnfintech_{ct} + \beta_2 X_{it} + YEAR\_FE + Industry\_FE + \varepsilon_{ict} \quad (1)$$

The subscripts$i$, c and t represent the enterprise, the city where the enterprise is registered and the year respectively. The explained variable $digit_{ict}$ is the degree of digital transformation of listed company i in year$t$. $lnfintech_{ct}$ That is the core explanatory variable of this paper, that is, the fintech development degree of the listed company's location c in year$t$. Therefore, β_1 is the core parameter to be estimated in this paper, and it is expected that β_1 is significantly positive based on the previous theoretical hypothesis. In addition, in order to control the macro external environmental shocks, this paper controls the year fixed effect$YEAR_FE$. Considering the interference of the potential individual effect of the industry on the causal inference of this paper, this paper also controls the industry fixed effect$Industry_FE$. Finally, ε_{ict} is the disturbance term of the model? In order to prevent heteroscedasticity problems from affecting the reliability of empirical results in this paper, all statistical inferences in this paper are discussed based on heteroscedasticity robust standard errors.

3.5 Selection of control variables

In terms of control variables, considering the influence of other factors and drawing on the practice of existing literature, the control variables at the enterprise level in this paper include: Size measured by the natural logarithm of the total assets of the listed company at the end of the year, Leverage measured by the proportion of the total liabilities of the listed company at the end of the year to the total assets, Age measured by the company’s listing years, ROA measured by the return on assets of the listed companies in the year, Fix measured by the proportion of fixed assets of the listed company in the year, Cash measured by the ratio of cash held by the listed company in the year, Indratio measured by the proportion of independent directors of the listed companies in the year, Boardsize measured by the shareholding ratio of the board of directors of the listed companies in the current year, Mshare measured by the shareholding ratio of the management of the listed company in the year, Top1 measured by the shareholding ratio of the largest shareholder of the listed company in the year, SOE measured by whether the listed company is a state-owned enterprise. Table 1 shows the definitions and symbols of different variables, and Table 2 lists the descriptive statistical characteristics of each variable in detail.

Table 1. Detailed definitions of different variables.

Variable Types	Variable name	Variable Definition Description
Explained variable	digit	Digital transformation indicators of listed companies constructed using text analysis
Core explanatory variable	lnfintech	Urban fintech development level calculated using the big data of the National Industrial and Commercial Enterprise registration
Enterprise control variable	Size	Natural logarithm of the total assets of the enterprise at the end of the year
	Leverage	The ratio of total liabilities to total assets of the enterprise in the year
	Age	The listed years of the enterprise
	ROA	Return on assets of the enterprise in the year
	Fix	Proportion of fixed assets to total assets in the year
	Cash	Ratio of cash held by the enterprise in the year
	Indratio	The proportion of independent directors in the enterprise in that year
	Boardsize	Shareholding ratio of the board of directors of the enterprise
	Mshare	Shareholding ratio of enterprise management
	Top1	Shareholding ratio of the largest shareholder in the year of the enterprise
	SOE	Dummy variable: if the enterprise is a state-owned enterprise, it is assigned a value of 1; otherwise, it is assigned a value of 0

Table 2. Descriptive statistics of different variables.

	Obs	Mean	Std. dev.	Min	Median	Max
Digit	17115	1.555	1.226	0	1.386	4.673
Lnfintech	17115	3.772	2.392	0	3.332	9.954
Size	17115	22.136	1.283	19.552	21.959	26.231
Leverage	17115	0.418	0.208	0.032	0.407	0.936
Age	17115	9.261	7.104	0	8	26
ROA	17115	0.55	0.449	-0.581	0.471	2.696
Fix	17115	0.222	0.160	0.002	0.189	0.716
Cash	17115	1.2	2.051	0.046	0.571	24.524
Indratio	17115	39.324	10.573	0	37.5	66.667
Boardsize	17115	13.481	19.936	0	0.244	68.606
Mshare	17115	14.307	20.866	0	0.445	70.495
Top1	17115	0.36	0.149	0.082	0.341	0.758
SOE	17115	0.371	0.483	0	0	1

In addition, before the empirical regression analysis, it is necessary to discuss the correlation between the main research variables to prevent the model from being unidentifiable due to the problem of complete collinearity. The correlation coefficient matrix of core explanatory variables and control variables is shown in Table 3. As can be seen from the correlation coefficient matrix in Table 3, the correlation coefficient between each control variable and the core explanatory variable lnfintech is not large, so there is not be systematic errors in the statistical inference of this paper caused by the highly collinear problem.

Table 3. Correlation coefficient test between variables.

	lnfintech	Size	Leverage	Age	ROA	Fix	Cash	Indratio	Boardsize	Mshare	Top1	SOE
lnfintech	1.00											
Size	0.12***	1.00										
Leverage	0.01	0.56***	1.00									
Age	-0.00	0.41***	0.42***	1.00								
ROA	-0.13***	0.01	0.12***	0.03***	1.00							
Fix	-0.22***	0.12***	0.10***	0.12***	0.02***	1.00						
Cash	0.01	-0.29***	-0.53***	-0.27***	-0.10***	-0.18***	1.00					
Indratio	-0.10***	-0.06***	-0.02***	-0.06***	0.15***	-0.03***	0.07***	1.00				
Boardsize	0.09***	-0.38***	-0.37***	-0.56***	-0.09***	-0.18***	0.26***	0.05***	1.00			
Mshare	0.08***	-0.39***	-0.37***	-0.57***	-0.09***	-0.19***	0.27***	0.05***	0.99***	1.00		
Top1	0.05***	0.22***	0.07***	-0.05***	0.09***	0.07***	-0.01	0.05***	-0.12***	-0.13***	1.00	
SOE	0.00	0.39***	0.34***	0.50***	0.09***	0.21***	-0.17***	-0.03***	-0.50***	-0.50***	0.21***	1.00

4. Empirical results

4.1 Analysis of benchmark regression results

The regression results of the benchmark model (1) in this paper are shown in Table 4. The explained variables are all the digital transformation degree of enterprises, digit. Among them, Column (1) does not control any fixed effects and control variables, which is a unitary regression; Column (2) adds control variables at the enterprise level; and Column (3) further adds industry and year fixed effects. It can be seen from the stepwise regression results that no matter under what kind of control is used, the estimated coefficients of lnfintech the core explanatory variable of all models, are significantly positive at the statistical level of 1%. This conclusion shows that the level of local fintech development has significantly promoted the digital transformation of enterprises in its jurisdictions. Taking Column (3) as an example, specifically speaking, every 1% increase in lnfintech will increase the digital transformation degree of enterprises by 0.056% on average. In summary, the previous theory is proved.

Table 4. Benchmark regression: the impact of regional fintech development on enterprises' digital transformation.

VARIABLES	(1) Digit	(2) digit	(3) digit
lnfintech	0.154***	0.120***	0.056***
	(0.004)	(0.004)	(0.004)
Size		0.149***	0.145***
		(0.009)	(0.008)
Leverage		-0.817***	-0.263***
		(0.058)	(0.054)
Age		-0.009***	-0.015***
		(0.002)	(0.001)
ROA		0.006	0.109***
		(0.019)	(0.021)
Fix		-1.508***	-1.279***
		(0.055)	(0.057)
Cash		-0.050***	-0.021***
		(0.005)	(0.005)
Indratio		-0.006***	0.003***
		(0.001)	(0.001)
Boardsize		0.002	0.001
		(0.004)	(0.003)
Mshare		0.001	0.001
		(0.004)	(0.003)
Top1		-0.654***	-0.236***
		(0.063)	(0.055)
SOE		-0.172***	-0.091***
		(0.023)	(0.020)
Industry fixed effects	No	No	Yes
Year fixed effects	No	No	Yes
Observations	17,115	17,115	17,115
R-squared	0.091	0.172	0.375

4.2 Further robustness discussion

Next, this paper will conduct a robustness test on the core conclusion. Since the core explanatory variable is the variable of the city dimension, the potential city-level factors may affect the estimation results of the article. Therefore, this paper further considers the important characteristics of cities to reduce the endogeneity bias caused by missing variables. Specifically, it includes natural log of GDP per capita (lnperGDP), industrial structure (measured by the proportion of the output value of the

tertiary industry, GDP3_ratio), the total population at the end of the year (People) and the total amount of foreign direct investment (FDI). The above city-level data are from China City Statistical Yearbook.

Table 5 shows the estimation results of controlling important characteristics at the city level. Among them, the explained variable is digit, the degree of enterprise digital transformation. All columns control firm characteristics as well as year and industry fixed effects. Column (1) only adds the city's per capita (GDP), Column (2) further adds the industrial structure (GDP3_ratio), Column (3) adds the city's total population at the end of the year (People), and Column (4) considers the total amount of foreign direct investment (FDI). It can be seen from the results that the estimated coefficients of core explanatory variables are still significantly positive, and the coefficient size is highly robust. Therefore, the conclusions of this paper still exist.

Table 5. consider urban characteristics.

VARIABLES	(1) digit	(2) digit	(3) digit	(4) digit
lnfintech	0.055***	0.051***	0.041***	0.041***
	(0.005)	(0.010)	(0.011)	(0.012)
lnperGDP	-0.129***	-0.127***	-0.121***	-0.047
	(0.029)	(0.030)	(0.031)	(0.042)
GDP3_ratio		0.001	0.001	0.001
		(0.002)	(0.002)	(0.002)
People			0.039**	0.068**
			(0.019)	(0.028)
FDI				-0.020*
				(0.012)
Size	0.127***	0.126***	0.127***	0.123***
	(0.010)	(0.011)	(0.011)	(0.011)
Leverage	-0.264***	-0.263***	-0.261***	-0.257***
	(0.071)	(0.073)	(0.073)	(0.076)
Age	-0.011***	-0.010***	-0.011***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)
ROA	0.157***	0.157***	0.157***	0.174***
	(0.029)	(0.029)	(0.029)	(0.030)
Fix	-1.160***	-1.164***	-1.154***	-1.166***
	(0.078)	(0.080)	(0.081)	(0.083)
Cash	-0.023***	-0.024***	-0.024***	-0.022***
	(0.007)	(0.007)	(0.007)	(0.007)
Indratio	0.003**	0.002**	0.002**	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
Boardsize	0.008	0.009*	0.010*	0.013**
	(0.005)	(0.006)	(0.006)	(0.006)
Mshare	-0.006	-0.006	-0.007	-0.010*
	(0.005)	(0.005)	(0.005)	(0.006)
Top1	-0.241***	-0.228***	-0.232***	-0.249***
	(0.074)	(0.076)	(0.076)	(0.079)
SOE	-0.093***	-0.083***	-0.084***	-0.070**
	(0.027)	(0.028)	(0.028)	(0.029)
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	9,901	9,301	9,301	8,709
R-squared	0.377	0.382	0.383	0.383

The second robustness test mainly examines the measurement error of core explanatory variables. In order to ensure the robustness of the results, this paper adopts other two measurement methods: first, the proportion of the number of fintech related companies in each city to all companies (ratiao_fintech) is used to proxy the regional fintech development level; Second, the proportion of the output value of the urban financial industry in GDP (FinDev) is directly used as the proxy variable for the level of urban fintech development. Table 6 shows the regression results of replacing the core

explanatory variables. Similarly, similar to the previous results, the estimated results of the coefficients of the core explanatory variables in all columns are significantly positive, so the results in this paper are highly robust.

Table 6. Change the measurement of fintech development in cities.

VARIABLES	(1) digit	(2) digit
ratiao_fintech	0.280***	
	(0.025)	
FinDev		1.303***
		(0.218)
Size	0.150***	0.152***
	(0.008)	(0.008)
Leverage	-0.281***	-0.268***
	(0.054)	(0.054)
Age	-0.015***	-0.016***
	(0.001)	(0.001)
ROA	0.105***	0.104***
	(0.021)	(0.021)
Fix	-1.383***	-1.397***
	(0.057)	(0.057)
Cash	-0.020***	-0.021***
	(0.005)	(0.005)
Indratio	0.003***	0.003***
	(0.001)	(0.001)
Boardsize	0.002	0.003
	(0.003)	(0.003)
Mshare	0.000	-0.000
	(0.003)	(0.003)
Top1	-0.199***	-0.211***
	(0.055)	(0.055)
SOE	-0.078***	-0.077***
	(0.020)	(0.020)
Industry fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	17,115	17,115
R-squared	0.370	0.367

Third, the estimation model is changed. Since the distribution of the core explained variable digit in this paper cannot be negative, that is, there is truncation. Therefore, this paper further conducts robustness test based on panel Tobit of restricted dependent variable model.

The results of panel Tobit estimation are shown in Table 7. It can be seen from the results in Table 7 that after the model is changed, the conclusion of this paper is still robust: the regional fintech development level is still at the statistical level of 1%, which significantly promotes the digital transformation of enterprises.

Table 7. Panel Tobit estimation.

VARIABLES	(1) digit
lnfintech	0.062***
	(0.007)
Size	0.192***
	(0.012)
Leverage	-0.175***
	(0.058)

Age	-0.018***
	(0.003)
ROA	0.059**
	(0.024)
Fix	-0.747***
	(0.070)
Cash	-0.026***
	(0.004)
Indratio	-0.000
	(0.001)
Boardsize	0.003
	(0.004)
Mshare	-0.001
	(0.003)
Top1	-0.325***
	(0.077)
SOE	-0.124***
	(0.034)
Industry fixed effects	Yes
Year fixed effects	Yes
Observations	17,115
Number of scode	3,008

4.3 Heterogeneity analysis

China has a vast territory, and there are great differences in economic development, social system and business environment among different regions. Compared with the central and western regions, the eastern region of China has more enterprises and is more developed. Then, will there be significant differences in different regions where enterprises are located? Based on these considerations, this paper discusses the heterogeneity of the impact of the location of enterprises in detail.

Columns (1), (2) and (3) of Table 8 respectively examine the heterogeneous impact of fintech development on the digital transformation of enterprises in the eastern region, the central region and the western region. It can be seen from the results that only for the enterprises located in the eastern and central regions, the development of fintech has a significant role in promoting the digital transformation of enterprises. Therefore, to sum up, fintech development has significant regional heterogeneity in the investment efficiency of enterprises. The scope of its impact is concentrated in the eastern and central regions, but has no significant impact on the enterprises in the western region.

Table 8. Regional heterogeneity analysis.

VARIABLES	(1) digit	(2) digit	(3) digit
	The Eastern region	The Central region	The Western region
Lnfintech	0.061***	0.079***	0.029
	(0.004)	(0.015)	(0.018)
Size	0.166***	0.138***	0.085***
	(0.010)	(0.019)	(0.021)
Leverage	-0.225***	-0.452***	-0.289**
	(0.068)	(0.127)	(0.140)
Age	-0.014***	-0.020***	-0.014***
	(0.002)	(0.004)	(0.004)
ROA	0.109***	0.009	0.170***
	(0.027)	(0.046)	(0.066)
Fix	-1.578***	-1.102***	-1.014***
	(0.072)	(0.127)	(0.144)
Cash	-0.021***	-0.010	-0.049***
	(0.005)	(0.013)	(0.017)
Indratio	0.003***	0.000	0.003

	(0.001)	(0.002)	(0.002)
Boardsize	0.000	-0.001	0.004
	(0.004)	(0.007)	(0.013)
Mshare	0.002	0.002	-0.003
	(0.004)	(0.007)	(0.012)
Top1	-0.339***	0.132	0.007
	(0.068)	(0.137)	(0.155)
SOE	-0.148***	-0.036	0.022
	(0.026)	(0.048)	(0.052)
Industry fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	11,750	2,516	2,150
R-squared	0.388	0.369	0.353

5. Mechanism analysis

Why has regional fintech played a significant role in promoting the digital transformation of enterprises? In order to verify the mediating effect of the two, this paper sets the following mediating effect model:

$$Z_{it} = \gamma_0 + \gamma_1 lnfintech_{ct} + \gamma_2 X_{it} + +Year_{FE} + Industry_{FE} + \varepsilon^1_{ict} \quad (2)$$

$$digit_{ict} = \delta_0 + \delta_1 lnfintech_{ct} + \rho Z_{it} + \delta_2 X_{it} + +Year_{FE} + Industry_{FE} + \varepsilon^2_{ict} \quad (3)$$

Among them, Z_{it} is a mediating variable? If the model satisfies both γ_1 in Equation (2) is significant and δ_1 and ρ in Equation (3) are significant, it indicates that Z_{it} has a mediating effect. Based on the previous theoretical analysis and discussion, this paper will conduct mechanism analysis from three perspectives: information asymmetry, R&D investment and continuous innovation strategy.

5.1 Information asymmetry

First of all, fintech uses big data, artificial intelligence and other technologies to "empower" traditional financial institutions, centrally process massive data, and mine more comprehensive user information, which can accurately help enterprises predict market demand and the direction of the next development, and therefore can reduce the degree of information asymmetry inside and outside enterprises.

In order to test the potential mechanism of information asymmetry, this paper refers to the practice of Yu et al. (2012), and uses the microstructure of the financial market and the detailed trading data of individual stocks to extract the first principal component of liquidity ratio (LR), illiquidity ratio (ILL) and yield reversal index (GAM) as the proxy variable of information asymmetry. Referring to the relevant measurement methods of Amihud et al. (1997) and Amihud (2002), the calculation formulas of liquidity ratio and illiquidity ratio are as follows:

$$LR_{it} = -\frac{1}{D_{it}} \sum_{k=1}^{D_{it}} \sqrt{\frac{V_{it}(k)}{|r_{it}(k)|}} \quad (4)$$

$$ILL_{it} = \frac{1}{D_{it}} \sum_{k=1}^{D_{it}} \sqrt{\frac{|r_{it}(k)|}{V_{it}(k)}} \quad (5)$$

Among them, $r_{it}(k)$ represents the stock return rate of enterprise i on the k'th trading day in year t, $V_{it}(k)$ is the total daily trading volume, and D_{it} is the number of trading days of company i in year t. Both liquidity ratio and illiquidity ratio identify liquidity through the interaction relationship

between buy and sell order flow and stock price. The higher the degree of information asymmetry is, the more serious the adverse selection problem is, the lower the stock liquidity is, and the greater LR and ILL are. With further reference to Pastor and Stambaugh (2003), the yield reversal index is calculated by Equation (6):

$$r_{it}^{e}(k) = \theta_{it} + \varphi_{it} r_{it}(k-1) + \gamma_{it} V_{it}(k-1) sign[r_{it}^{e}(k-1)] + \varepsilon_{it}(k) \quad (6)$$

The $r_{it}^{e}(k)$ as the excess yields, yield inverted index take$GAM_{it} = |\gamma_{it}|$. Similarly, when the degree of information asymmetry is higher, the GAM indicator is larger. The first principal component of the three indicators is the information asymmetry index ASY. The larger the value of ASY, the more serious the information asymmetry faced by the enterprise.

The empirical results of fintech development and information asymmetry are shown in Table 9. It can be seen that the coefficients of the core explanatory variable lnfintech in Column (1) are all significantly negative at the level of 1%, indicating that the development of fintech can significantly reduce the degree of information asymmetry between external investors and enterprises. The higher the level of regional fintech development is, the smaller the problem of information asymmetry is. Column (2) shows that ASY also significantly inhibits the digital transformation of enterprises, so the intermediary path is verified: the development of regional fintech alleviates the degree of information asymmetry of enterprises, thus promoting the digital transformation of enterprises.

Table 9. Mediating mechanism Test 1: Information asymmetry.

VARIABLES	(1) ASY	(2) digit
ASY		-0.033***
		(0.012)
lnfintech	-0.006**	0.054***
	(0.003)	(0.004)
Size	-0.349***	0.130***
	(0.007)	(0.009)
Leverage	0.690***	-0.288***
	(0.042)	(0.056)
Age	-0.013***	-0.017***
	(0.002)	(0.002)
ROA	0.011	0.119***
	(0.014)	(0.022)
Fix	0.244***	-1.286***
	(0.045)	(0.058)
Cash	0.003	-0.025***
	(0.003)	(0.005)
Indratio	-0.001**	0.003***
	(0.001)	(0.001)
Boardsize	-0.013***	0.003
	(0.005)	(0.004)
Mshare	0.015***	0.000
	(0.005)	(0.004)
Top1	0.563***	-0.189***
	(0.038)	(0.057)
SOE	0.037**	-0.078***
	(0.015)	(0.021)
Industry fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	15,800	15,800
R-squared	0.325	0.380

5.2 R&D investment

Behind the digital transformation of enterprises is the support for a large number of innovations. For this reason, Table 10 examines the analysis of the mediating effect of innovation investment. The innovation input index is constructed by using the natural logarithm of R&D input disclosed by the enterprise in the current year (RDexp). Firstly, it can be seen from Column (1) that the estimated coefficient of lnfintech is significantly positive at the statistical level of 1%, that is, the development of fintech has expanded the R&D investment of enterprises. Further observing the estimation results in Column (2), the estimated coefficient of RDexp is 0.103, which is significantly positive at the level of 1%, indicating that more innovation input will accelerate the digital transformation of enterprises. Therefore, this mediation path is verified.

Table 10. Mediating mechanism test 2: R&D investment.

	(1)	(2)
VARIABLES	RDexp	digit
RDexp		0.103***
		(0.008)
lnfintech	0.065***	0.060***
	(0.004)	(0.004)
Size	0.855***	0.048***
	(0.011)	(0.011)
Leverage	-0.705***	-0.205***
	(0.068)	(0.061)
Age	-0.018***	-0.010***
	(0.002)	(0.002)
ROA	0.492***	-0.015
	(0.033)	(0.024)
Fix	-0.538***	-1.498***
	(0.077)	(0.065)
Cash	-0.012***	-0.023***
	(0.004)	(0.005)
Indratio	0.002*	0.003***
	(0.001)	(0.001)
Boardsize	-0.010***	0.002
	(0.003)	(0.003)
Mshare	0.010***	-0.001
	(0.003)	(0.003)
Top1	-0.354***	-0.155**
	(0.068)	(0.062)
SOE	-0.085***	-0.130***
	(0.028)	(0.023)
Industry fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	14,231	14,231
R-squared	0.528	0.389

5.3 continuous innovation strategy

In the previous section, R&D input is used as a proxy indicator of a company's innovation activities. However, this index can only reflect the R&D investment level of the company in the current period, but cannot reflect the continuous innovation strategy of the enterprise as a whole. Therefore, in order to further examine the changes in enterprises' strategic decision-making under the empowerment of fintech development, this paper further refers to the practice of Xu (2019) and constructs enterprises' continuous innovation strategy for analysis: If the R&D investment of the listed company is higher

than the average level of the industry for two consecutive years or more, then it is identified that the enterprise has adopted the strategy of continuous high innovation HRD, and the value is 1; otherwise, it is 0, and it is used as a mediating variable for analysis.

Table 11 tests the mediating effect of enterprises' innovation strategic decisions. The models in the two columns control all control variables and two-way fixed effects. Firstly, it can be seen from Column (1) that the estimated coefficient of lnfintech is significantly positive at the statistical level of 1%, that is, the development of regional fintech significantly promotes enterprises to adopt continuous innovation strategies. Further observing the estimated results in Column (2), the estimated coefficient of HRD is 0.023, which is also significantly positive at the level of 1%. This conclusion shows that continuous innovation strategies can promote the digital transformation of enterprises. Therefore, the intermediary path that regional fintech development affects enterprises' sustainable innovation strategic decision-making and thus improves enterprises' digital transformation is supported by empirical evidence.

Table 11. Mediating mechanism test 3: continuous innovation strategy.

	(1)	(2)
VARIABLES	HRD	digit
HRD		0.023***
		(0.002)
lnfintech	0.166***	0.063***
	(0.014)	(0.004)
Size	2.225***	0.084***
	(0.032)	(0.010)
Leverage	-2.375***	-0.222***
	(0.221)	(0.061)
Age	0.036***	-0.012***
	(0.006)	(0.002)
ROA	1.466***	0.002
	(0.103)	(0.024)
Fix	-1.111***	-1.527***
	(0.244)	(0.065)
Cash	-0.114***	-0.022***
	(0.016)	(0.005)
Indratio	0.002	0.003***
	(0.003)	(0.001)
Boardsize	-0.018	0.001
	(0.012)	(0.003)
Mshare	0.006	0.000
	(0.012)	(0.003)
Top1	-2.087***	-0.142**
	(0.227)	(0.063)
SOE	-0.342***	-0.131***
	(0.091)	(0.023)
Industry fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	14,231	14,231
R-squared	0.374	0.386

6. Conclusions and policy implications

Using the panel data of A-share listed companies in Shanghai and Shenzhen Stock exchanges from 2011 to 2018, this paper studies the impact of regional fintech development on the digital transformation of enterprises and analyzes the mechanism. Three main conclusions can be drawn

from our findings. First, the level of local fintech development has significantly promoted the digital transformation of enterprises in their jurisdictions. After further considering the important characteristics of cities, examining the measurement error of core variables, and changing the estimation model to carry out a series of robustness tests, this conclusion is still valid. Second, the development of regional fintech has significant regional heterogeneity in the digital transformation of enterprises. Specifically, the development of fintech mainly has a significant impact on enterprises in the eastern and central regions, but has no significant impact on enterprises in the western region. Third, the development of regional fintech promotes the process of digital transformation of enterprises in a series of ways, such as alleviating the degree of information asymmetry of enterprises, increasing the investment of innovation and R&D of enterprises, and promoting enterprises to adopt sustainable innovation strategic decision-making.

At the same time, based on the above research conclusions, this paper obtains the following enlightenment:

First, in line with the trend of the digital era, we should further strengthen the importance of the development of fintech, vigorously promote the development of artificial intelligence, big data, blockchain, cloud computing and other technologies, strengthen the integration of fintech and real enterprises from the policy aspect, encourage enterprises to combine traditional financial means with the development of emerging technologies, and ensure that fintech gives full play to its technology-oriented role in order to promote the digital transformation process of enterprises.

Second, differentiated policies should be implemented for enterprises in different regions. Due to the unbalanced development among different regions in China, the rapid development of fintech in the eastern and central regions should be maintained, and local enterprises should be encouraged to accelerate the process of digital transformation to promote the development of China's digital economy. At the same time, due to the relatively backward development of fintech in the western region, the construction of fintech related facilities in the western region should be rapidly invested to promote the digitalization process of western enterprises through the development of fintech.

Third, we should make full use of fintech to strengthen the solution of information asymmetry and other problems, increase the investment in innovation and research and development of enterprises, and encourage the strategic decision-making of innovation of enterprises. Through the study of intermediary problems in the development process of fintech, the development of fintech can further guarantee the digital transformation of enterprises.

References

[1] SONG Min, ZHOU Peng and SI Hai-tao." Financial Technology and Enterprise Total Factor Productivity——Perspective of “Enabling” and Credit Rationing. "China Industrial Economics .04(2021):138-155. doi:10.19581/j.cnki.ciejournal.2021.04.006.

[2] Li Wanli, Pan Wendong and Yuan Kaibin." Enterprise Digital Transformation and the Development of China's Real Economy." Journal of Quantitative & Technological Economics39. 09(2022):5-25. doi:10.13653/j.cnki.jqte.2022.09.001.

[3] FANG Mingyue, LIN Jiani and NIE Huihua." Does Digital Transformation Promote Common Prosperity within Firms? Evidence from Chinese A-share Listed Firms." Journal of Quantitative & Technological Economics 39.11(2022):50-70. doi:10.13653/j.cnki.jqte.2022.11.003.

[4] Tang Song, Su Xuesha and Zhao Danni; Fintech and Enterprise Digital Transformation——From the Perspective of Enterprise Life Cycle." Finance & Economics.02 (2022):17-32. Doi: CNKI: SUN: CJKX.0.2022-02-002.

[5] Li Wei, Tan Suyao and Wu Fei;" Fintech Development and Enterprise Digital Transformation: Intermediary Transfer Based on Financing Constraint Relief and Innovation Promotion." Science and Technology Management Research 42.20(2022):28-38. Doi: CNKI: SUN: KJGL.0.2022-20-004.

[6] Luo Sumei, et al. "Does fintech innovation promote enterprise transformation? Evidence from China." *Technology in Society* 68 (2022): 101821.

[7] Daud, Siti Nurazira Mohd, Airil Khalid, and W. N. W. Azman-Saini. "FinTech and financial stability: Threat or opportunity?" *Finance Research Letters* 47 (2022): 102667.

[8] Safiullah, Md, and Sudharshan Reddy Paramati. "The impact of FinTech firms on bank financial stability." Electronic *Commerce Research* (2022): 1-23.

[9] Demir, Ayse, et al. "Fintech, financial inclusion and income inequality: a quantile regression approach." *The European Journal of Finance* 28.1 (2022): 86-107.

[10] Appiah-Otoo, Isaac, and Na Song. "The impact of fintech on poverty reduction: Evidence from China." Sustainability 13.9 (2021): 5225.

[11] Thakor, Anjan V. "Fintech and banking: What do we know?" *Journal of Financial Intermediation* 41 (2020): 100833.

[12] hou, Guangyou, Jieyu Zhu, and Sumei Luo. "The impact of fintech innovation on green growth in China: Mediating effect of green finance." *Ecological Economics* 193 (2022): 107308.

[13] LI Chun-tao, et al." Fintech and Corporate Innovation——Evidence from Chinese NEEQ-Listed Companies." China Industrial Economics .01(2020):81-98. doi:10.19581/j.cnki.ciejournal.2020.01.006.

[14] Cai Puhua, et al." Fintech Development and Digital Transformation of Commercial Banks: Impact and Suggestions." New Finance .11(2021):39-44. Doi: CNKI: SUN: XJRO.0.2021-11-006.

[15] Wang Xinguang." Does Managers' Short-sighted Behavior Hinder Enterprises' Digital Transformation: Empirical Evidence Based on Text Analysis and Machine Learning " Modern Economic Research .06(2022):103-113. doi:10.13891/j.cnki.mer.2022.06.007.

[16] QIU Han, HUANG Yiping and JI Yang." How does FinTech Development Affect Traditional Banking in China? The Perspective of Online Wealth Management Products." Journal of Financial Research .11(2018):17-29. Doi: CNKI: SUN: JRYJ.0.2018-11-002.

[17] Yang Zhen, Li Jizhen and Ling Hongcheng." Policy uncertainty and innovation digitization——A study from the perspective of ambidextrous innovation." Science Research Management 43.04(2022):1-10. doi:10.19571/j.cnki.1000-2995.2022.04.001.

[18] YANG Xianhong, et al." Local Economic Growth Goals and Corporate Digital Transformation: Based on Empirical Evidence of Text Recognition of Listed Companies' Annual Reports." China Soft Science .11(2021):172-184. Doi: CNKI: SUN: ZGRK.0.2021-11-017.

[19] Wu Fei, Chang Xi and Ren Xiaoyi." Government-Driven Innovation: Fiscal Technology Expenditure and Enterprise Digital Transformation." Public Finance Research .01(2021):102-115. doi:10.19477/j.cnki.11-1077/f.2021.01.008.

[20] Wang haochen, and Wen ke." An opportunity in the midst of COVID-19 -- accelerating China's digital transformation." Studies in Science of Science 38.03(2020):393-395. doi:10.16192/j.cnki.1003-2053.2020.03.006.

[21] Zhang Lina, Su Xuesha and Yuan Lei." Supply Chain Finance and Digital Transformation of Enterprises: Heterogeneous Features, Channel Mechanisms, and Effect Differences in an Untrustworthy Environment." Financial Economics Research 36.06(2021):51-67.

[22] Ma Hongjia, and Wang Yajing;" Research on the Impact of Big Data Resources on the Digital Transformation Performance of Manufacturing Enterprises." Studies in Science of Science. doi:10.16192/j.cnki.1003-2053.20221228.001.

[23] TANG Song, LI Qing and WU Fei." Financial Marketization Reform and Enterprise Digital Transformation——Empirical Evidence from the Marketization of Interest Rates in China." Journal of Beijing Technology and Business University (Social Sciences) 37.01(2022):13-27. Doi: CNKI: SUN: BJSB.0.2022-01-002.

[24] YU Dian-fan, WANG Chao and CHEN Lei. "Government Subsidies, Industrial Chain Coordination and Enterprise Digitalization: Evidence from Listed Companies." Business and Management Journal 44.05(2022):63-82. doi:10.19616/j.cnki.bmj.2022.05.004.

[25] Miklosik, Andrej, and Nina Evans. "Impact of big data and machine learning on digital transformation in marketing: A literature review." *Ieee Access* 8 (2020): 101284-101292.